WWF

REPORT

IND

2015

Technical Partner

WISE
WORLD INSTITUTE OF SUSTAINABLE ENERGY

RENEWABLE ENERGY PLAN BY 2030 FOR PALAKKAD DISTRICT, KERALA

Published by WWF-India & WISE

Acknowledgements

WWF-India and WISE are extremely grateful to all the individual experts and specialists for providing useful inputs and insights during the preparation of this report. Special thanks are due to Dr M.P. Parameshwaran and Prof. V.K. Damodaran for providing their useful inputs and insights. We are grateful to Mr G. Vijayraghavan, Member, State Planning Board, Mr M. Sivasankar, Chairman, Kerala State Electricity Board, Mr K. Ramchandran, Former District Collector, Palakkad, Mr Dhresan Unnithan, Director, Energy Management Centre, Kerala and Dr V.S. Vijayan, Former Chairman of the Kerala State Biodiversity Board for their valuable inputs and suggestions. We also acknowledge the contributions and suggestions made by key representatives from the government and private sector, civil society organizations, and academic institutions. Finally, our sincere thanks to Mr G.M. Pillai, Founder Director General, WISE, for his able guidance and leadership in steering the research. We would like to thank Mr Ravi Singh, Secretary General and CEO, WWF-India for his constant support and encouragement. The support by the Norwegian Agency for Development Cooperation (NORAD) and WWF-Norway is also duly acknowledged.

Project Team

WISE

Project Lead: Raiju John, Suhas Tendulkar

Project Team: Kapardhi Bharadwaj, Rohit Bhide, Debarshi Gupta

WWF- India

Jincy Joy, T.S. Panwar, Renjan Mathew Varghese, Sejal Worah

Disclaimer

Designed by: Creative Curve Communication Pvt Ltd

Photo Credit: Cover photo - WWF- India

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACRONYM	DEFINITION
ANERT	Agency for Non-conventional Energy and Rural Technology
ASI	Annual Survey of Industries
BAT	Best Available Technology
BAU	Business As Usual
BEE	Bureau of Energy Efficiency
BOOT	Build-Own-Operate-Transfer (PPP Model)
BPT	Best Process Technology
BTKM	Billion Tonnes Kilometers
BU	Billion Unit
CAGR	Compounded Annual Growth Rate
CAPEX	Capital Expenditure
CARB	California Air Resources Board
CCSP	Centre for Climate and Sustainability Policy, WISE
CEA	Central Electricity Authority, India
CERC	Central Electricity Regulatory Commission
CESS	Centre for Earth Sciences Studies, Thiruvananthapuram, Kerala
CFL	Compact Fluorescent Lamp
CII	Confederation of Indian Industry
COSTFORD	Centre of Science and Technology for Rural Development
CPP	Captive Power Plant
CRB	CRISIL Research Bulletin
CRISIL	Credit Rating Information Services of India limited
CRRI	Central Road Research Institute
CSR	Corporate Social Responsibility
CTCRI	Central Tuber Crop Research Institute
CUF	Capacity Utilization Factor
DIC	District Industries Centre
DNI	Direct Normal Irradiance
ECBC	Energy Conservation Building Code
EER	Energy Efficiency Ratio
EMC	Energy Management Centre, Thiruvananthapuram, Kerala
EPS	Electric Power Survey
ESCO	Energy Services Company
ESMAP	Energy Sector Management Assistance Programme
ESTAP	Energy Technology Systems Analysis Program

ACRONYM	DEFINITION
FIT	Feed-in Tariff
FTL	Fluorescent Tube Lights
GDDP	Gross District Domestic Product
GHI	Global Horizontal Irradiance
GIS	Geographic Information System
GLS	General Lighting System
GRIHA	Green Rating for Integrated Habitat Assessment
GSDP	Gross State Domestic Product
HCV	Heavy Commercial Vehicle
HEP	Hydro Electric Project
HVAC	High Volume Air Conditioner
ICE	Internal Combustion Engine
IEA	International Energy Agency
IPP	Independent Power Producer
IRTC	Integrated Rural Technology Centre
ISRO	Indian Space Research Organization
ITES	Information Technology Enabled Services
KESNIK	Kerala State Nirmithi Kendra
KINFRA	Kerala Industrial Infrastructure Development Corporation
KSEBL	Kerala State Electricity Board Limited
KSECF	Kerala State Energy Conservation Fund
KSERC	Kerala State Electricity Regulatory Commission
KSIDC	Kerala State Industrial Development Corporation
KSRTC	Kerala State Road Transport Corporation
KWA	Kerala Water Authority
LBNL	Lawrence Berkeley National Laboratory
LCV	Light Commercial Vehicle
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
LNG	Liquefied Natural Gas
LPD	Liters Per day
LPG	Liquefied Petroleum Gas
LTD	Limited
LULC	Land Use Land Cover
MCA	Multi-Criteria Analysis
MNRE	Ministry of New and Renewable Energy, India
MOSPI	Ministry of Statistics and Program Implementation
MOU	Memorandum of Understanding

ACRONYM	DEFINITION
MPCE	Monthly Per Capita Expenditure
MSME	Micro, Small and Medium Enterprises
MSW	Municipal Solid Waste
MW	Mega Watt
NASA	National Aeronautics and Space Administration
NEMMP	National Electric Mobility Mission Plan
NHPC	National Hydro Power Corporation
NPC	National Productivity Council
NRDC	Natural Resources Defense Council
NREL	National Renewable Energy Laboratory
NRSC	National Remote Sensing Centre
NSSO	National Sample Survey Organization
NTPC	National Thermal Power Corporation Limited
PAT	Perform, Achieve and Trade
PCI	Per Capita Income
PEUM	Partial End Use Methodology
PJ	Peta Joules
PKM	Passenger Kilometer
PLF	Plant Load Factor
PPP	Public Private Partnership
PWD	Public Works Department
R-APDRP	The Restructured Accelerated Power Development and Reforms Programme
SEA	Super Efficient Appliances
SEEP	Super Efficient Equipment Program
SEZ	Special Economic Zone
SHP	Small Hydro Power
SPO	Solar Purchase Obligation
SPV	Solar Photo Voltaic
SWH	Solar Water Heaters
SWHS	Solar Water Heating System
TERI	The Energy and Resources Institute
TOE	Tonnes of Oil Equivalent
TOR	Terms of Reference
UEC	Unit Energy Consumption
UNEP	United Nations Environment Program
VAT	Value Added Tax
WISE	World Institute of Sustainable Energy
WPD	Wind Power Density
WWF	World Wide Fund for Nature

EXECUTIVE SUMMARY

In 2013, WWF-India and World Institute of Sustainable Energy (WISE) brought out the study *The Energy Report – Kerala: 100% Renewable Energy by 2050*.[1] The report explored the possibility of Kerala meeting 100 per cent of its energy demand by 2050 using renewable sources. The report findings suggested that with focused policy and regulatory interventions, Kerala can meet over 95 per cent of its energy demand through renewable sources across energy carriers like electricity, heating fuels and transport fuels.

As a follow up of the feedback received during stakeholder interactions and to carry out a district-level feasibility study on lines similar to the state-level study, WWF-India and WISE undertook a project study *Renewable Energy Plan by 2030 for Palakkad District, Kerala*, focusing on short- to medium-term implementation oriented action plan at the district level.

The project aims to develop a district-level renewable energy (RE) report that provides a vision of a sustainable energy supply by 2030, by developing a scenario to assess the feasibility of meeting 50 per cent of the district's energy demand through renewable energy sources by 2030.

The study approach involves the following steps:

a. Assessment of the detailed renewable energy supply potential of the district over the projection time frame, i.e., 2030 (including GIS-based analysis).
b. Modelling of a business-as-usual (BAU) demand scenario, based on existing energy share of the district in terms of fuel carriers, i.e., electricity, fuels and heat, by identifying key focus consumption sectors.
c. Modelling of a curtailed demand scenario to assess maximum potential for demand reduction through focused measures in energy conservation and energy efficiency (ECEE) and carrier substitution (CS).
d. Matching the supply options with curtailed demand for electricity, heat and transport fuels.
e. Assessment of policy and financial implications of the proposed renewable energy scenario.

The major finding of the study indicate that 47.7 per cent of the district's total energy (including 100 per cent electricity) can be met by renewable sources by 2030.

RENEWABLE SUPPLY POTENTIAL

The potential of wind and solar was assessed using Geographical Information System (GIS). For the analysis, stringent land use and land availability criteria are considered in addition to standard technical constraints for assessing grid-tied RE potential, while off-grid RE potential assessment is based on a narrative-based exercise. Bio-

[1] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India.254pp.

energy assessment is based on assessment of anticipated future trends in availability and use of agricultural residue. Hydropower potential essentially considers the unexploited small hydro capacity as the only feasible potential.

Based on the above, the summary of the assessed RE supply availability is captured in the Table ES.1.

TABLE ES.1: ASSESSED RE SUPPLY AVAILABILITY OF PALAKKAD DISTRICT

Summary of RE Availability	2015	2020	2025	2030
Electricity (Million Units)				
Solar Energy	2.8	682.6	1,681.9	3,672.2
Wind Energy	30.4	184.6	377.3	568.5
Biomass Electricity	24.05	35.68	46.96	63.49
Small Hydro	15.69	17.83	27.59	41.91
Total Electricity	**73.0**	**920.7**	**2,133.8**	**4,346.1**
Heat Availability (PJ)				
Combustion	0.82	0.96	1.1	1.31
Biogas	0.14	0.15	0.15	0.16
Total Heat	**0.96**	**1.11**	**1.25**	**1.47**

BUSINESS AS USUAL: DEMAND PROJECTION

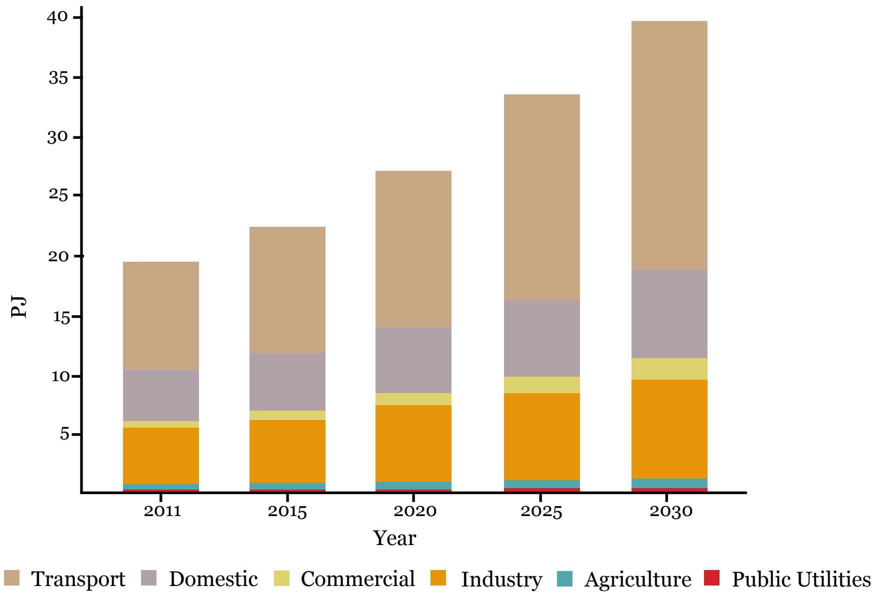
The BAU scenario indicates a doubling of demand by 2030 over the base year, i.e., 2011. The projections indicate that the transport sector accounts for 50 per cent of the total energy demand of the district while the industrial sector accounts for the second highest share of 21 per cent. The high share of the transport sector for Palakkad is consistent with the findings in the state-level report. The high share of industries is also justifiable considering that Palakkad is the second highest industrialized district in the state.

The final BAU projections of total energy demand for the district is shown in the Table ES.2 & Figure ES.1

TABLE ES.2: ENERGY DEMAND (PJ) ACROSS SECTORS FOR THE BAU SCENARIO

District Energy Demand–BAU (PJ)	2011	2015	2020	2025	2030
Transport	9.02	10.68	13.29	17.56	21.27
Domestic	4.26	4.78	5.56	6.37	7.37
Commercial	0.62	0.73	1.01	1.38	1.82
Industry	4.79	5.39	6.40	7.36	8.33
Agriculture	0.67	0.81	0.92	1.01	1.08
Public Utilities	0.11	0.13	0.17	0.21	0.24
Total	**19.47**	**22.51**	**27.33**	**33.87**	**40.11**

FIGURE ES.1:
ENERGY DEMAND ACROSS SECTORS FOR THE BAU SCENARIO



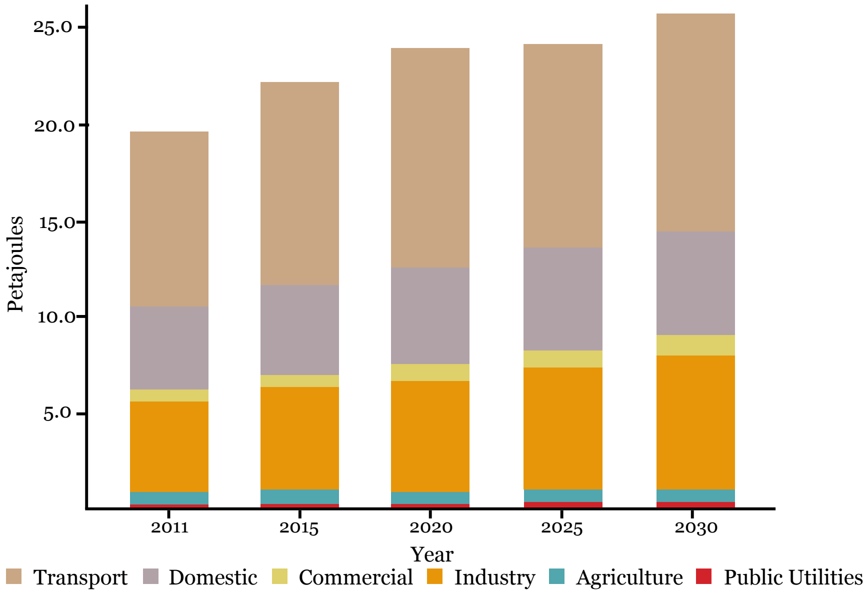
CURTAILED DEMAND PROJECTIONS

The curtailed demand projection for the district is derived after factoring in aggressive interventions in ECEE and CS. The proposed interventions do not assume any reduction in economic output, but factor in advancement in technology, reduction in energy intensity and better resource optimization. The identified interventions indicate a reduction potential of 36 per cent in energy demand by 2030. Table ES.3 and Figure ES.2 below summarize the results of the curtailed demand scenario.

TABLE ES.3:
FINAL CURTAILED DEMAND SCENARIO - SECTOR WISE

District Energy Demand Curtailed (PJ)	2011	2015	2020	2025	2030
Transport	9.02	10.62	11.52	11.41	11.23
Domestic	4.26	4.59	5.13	5.32	5.45
Commercial	0.62	0.67	0.78	0.89	1.08
Industry	4.79	5.39	5.65	6.41	7.04
Agriculture	0.67	0.81	0.79	0.76	0.73
Public Utilities	0.11	0.13	0.16	0.17	0.18
Total	**19.47**	**22.21**	**24.03**	**24.97**	**25.72**

FIGURE ES.2:
FINAL CURTAILED DEMAND SCENARIO - SECTOR WISE



THE RE TRANSITION SCENARIO

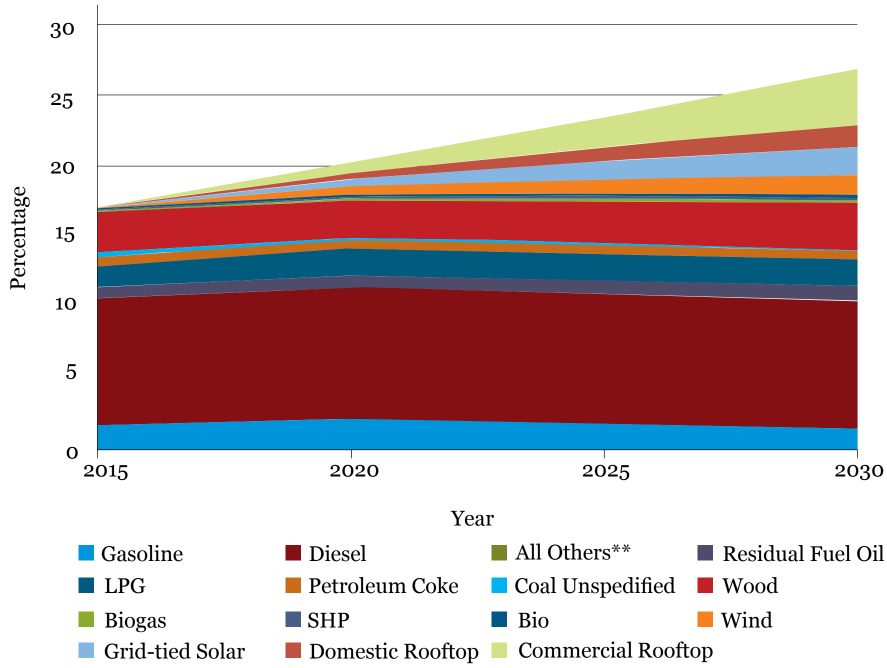
The final energy demand scenario suggests that almost 47.7 per cent of the total energy demand and 100 per cent of the total electricity demand of the district can be met through renewable sources by 2030. Table ES.4 and Figure ES.3 show the final fuel supply scenario that can effect this transformation.

TABLE ES.4:
PALAKKAD 2030 - THE FINAL ENERGY SUPPLY SCENARIO

Final Supply Scenario (PJ)	2015	2020	2025	2030	Percentage Share
Gasoline	1.78	2.26	1.93	1.51	5.62
Diesel	8.91	9.22	9.12	9.02	33.59
All Others**	0.03	0.03	0.03	0.03	0.11
Residual Fuel Oil	0.73	0.78	0.9	1	3.72
LPG	1.46	1.92	1.94	1.89	7.04
Petroleum Coke	0.67	0.58	0.58	0.58	2.16
Coal Unspecified	0.34	0.16	0.12	0	0
Wood	2.81	2.68	3.04	3.41	12.66
Biogas	0.14	0.15	0.15	0.16	0.60
SHP	0.05	0.06	0.1	0.15	0.56
Bio	0.09	0.13	0.17	0.23	0.86
Wind	0.11	0.65	1.04	1.39	5.18
Grid-tied Solar	0	0.5	1.26	2.02	7.52
Domestic Rooftop	0	0.4	1.01	1.51	5.62
Commercial Rooftop	0	0.81	2.02	3.96	14.75
TOTAL	**17.1**	**20.3**	**23.4**	**26.9**	**100**

*Note: ** All others include kerosene, cow dung cakes and other miscellaneous biomass used in cooking.*

FIGURE ES.3:
PALAKKAD 2030 – FINAL FUEL SUPPLY SCENARIO



On a broad level, the project findings indicate that even seemingly high renewable energy potential would be unable to fuel a BAU energy demand growth. This finding would be equally applicable to any larger unit (state, nation), clearly implying that a BAU model cannot be sustained indefinitely. The only way to avert an impending energy crisis is in adopting aggressive policy stances in energy conservation and energy efficiency, renewable energy. In this context, some of the most important findings and associated intervention strategies are covered in the narrative below.

- Based on the study findings, the transport sector accounts for over 50 per cent of the total energy demand of the district. The bulk of the transport energy consumption is on account of road freight (Heavy Carriage Vehicles (HCVs)) and public transport buses. This finding seems to be consistent with the profile of the district with respect to its economic status and demography (high industrial concentration and low income level to support personal transport). However, one of the main reasons for the high share is very high energy intensity of these vehicles, particularly HCVs. In terms of comparison, HCVs are four times as energy intensive as rail freight. The operational efficiency of Indian freight vehicles is also a factor lower than the freight operational efficiencies of advanced countries. Surprisingly, many of the solutions to resolve some of these issues are not based on technology breakthroughs, but on committed and consistent policy push.

  In the given context, some of the interventions proposed for the transport sector include partial shift of road freight from HCVs to rail, implementation of energy efficiency measures and labelling programme for transport vehicles, and supporting, incubating and adopting new transport technologies like hybrid engines and electric vehicles.

- Electricity accounts for the second highest share, about 30 per cent, in the energy mix of the state in the BAU scenario. While the growth in the demand for electricity is considered inflexible, the potential for interventions is also maximum in this sector. While energy conservation may only have a limited potential, technology evolution can lead to step changes in energy intensity. The technology evolution from incandescent bulbs to CFL and further to LEDs has happened in a matter of a decade. The availability of star-rated appliances in recent years offers another possibility of huge reductions in energy use.

  Some of these considerations form the crux of the intervention strategies proposed in the study. The key strategy is an early migration towards super-efficient appliances (SEAs). The Bureau of Energy Efficiency (BEE) has already initiated a super-efficient equipment programme (SEEP). While the availability of SEAs is limited, if we consider the rate of penetration of CFLs in the last decade, high level of penetration of SEAs would be possible by 2030. Another key strategy proposed in the study is a change in building architecture and built structure in order to adopt sustainable architecture or green building techniques. In addition, low investment options like retrofits of old building to replace appliances or enhance natural lighting or ventilation are considered.

  On the supply side, although necessary measures to support renewables are already in place, there are latent hurdles in actual implementation of capacities. Wind power development in the district is stalled because of issues related to land acquisition, and also because of negative public perception. Grid-tied PV may also face similar problems. Rooftop PV development, which is on high priority of the government, will require early resolution of regulatory and implementation related issues (net metering and grid connection standards) to take off on a big scale. Small hydro development, in a limited way, may be desirable, but faces significant public opposition. In the given context, it is important for the state to look at developing renewables as a strategic priority. In this respect, Palakkad can serve as an ideal test case to develop innovative policy approaches and district specific resolutions, like making land available, clearing right of way issues, removing administrative hurdles, resolving regulatory logjams etc.

- The industrial sector in Palakkad also has a good scope for development. While ECEE based reductions may be limited, there may be significant potential in adopting BAT (Best Available Technologies) and BPT (Best Process Technologies) for new industries. One of the intervention measures proposed is the establishment of a technology management committee that can oversee new industrial applications and prioritize specific energy consumption targets for new industries.

In conclusion, it is important to note that the emphasis of many of the proposed interventions is not on breakthrough technological innovations but on gradual adoption of technology and policy push. The policy-level interventions proposed in the study are also not drastic in nature, but are an extension of the state/national level sectoral policies. In this context, it can be assumed that the proposed measures imply a very high potential for implementation.

The financial implications of the proposed policy interventions are captured in terms of a simple cost benefit analysis that estimates state sector investments against direct and indirect benefits. While some of the proposed public sector investment measures, like retrofitting of buildings, solar street lighting etc., have commercial benefits, many other proposed interventions and investments appear to have no obvious monetary benefits, but demonstrate long-term strategic advantages and other indirect benefits.

More importantly, the study attempts to develop a detailed implementation roadmap that can help the state to test the efficacy and effectiveness of the proposed recommendations, particularly in the controlled setting of a district. It is hoped, that the study and the roadmap will act as a catalyst for facilitating a system evolution towards a more sustainable paradigm of economic growth.

PART I
INTRODUCTION

CHAPTER 1
INTRODUCTION AND METHODOLOGY

In 2013, WWF-India and the World Institute of Sustainable Energy (WISE) carried out the study *The Energy Report – Kerala: 100% Renewable Energy by 2050*.[2] The report studied the possibility of Kerala meeting 100 per cent of its energy demand through renewable sources by 2050. The report findings suggested that with focused policy and regulatory interventions, Kerala can meet over 95 per cent of its energy demand across energy carriers like electricity, heating and transport fuels.

As a follow up to the feedback received during the stakeholder interactions, WWF-India requested WISE to carry out a district-level feasibility study focusing on short- to medium-term implementation oriented action plan at the district level.

For this study, Palakkad district was found to be a suitable test case. Palakkad is a predominantly rural district and is considered backward in terms of development. However, Palakkad is also one of the most agrarian districts in Kerala and produces a variety of agricultural crops, like paddy, groundnut, tamarind, turmeric, tuber vegetables, pulses, mango, banana and cotton. Palakkad also has very good renewable energy resources, especially wind and solar. This would make it a very suitable case for construction of an RE-based (off-grid and on-grid) development model. Further, from a land use perspective, Palakkad has relatively large availability of waste land, which can be put to use for infrastructure development (renewable and non-renewable). All this would suggest that the potential for energy self-reliance based on RE could be practical even in a short- to medium-term scenario.

The broad objectives of the district-level study are:

1. To develop a district-level renewable energy report that provides a vision of a renewable and sustainable energy supply by 2030.

2. To develop a policy and implementation roadmap through which the district will be able to meet 50 per cent of its total energy requirements from renewable sources (including 100 per cent electricity supply solely from renewable sources) by 2030.

BRIEF OVERVIEW OF THE STUDY METHODOLOGY

Renewable Energy Plan by 2030 for Palakkad District, Kerala is a starting point to assess the feasibility plans and small-scale pilots at the district level. In this context, *The Energy Report – Kerala*[3] provides a robust framework for a systematic approach strategy that curtails energy demand, optimizes RE supply and moderates fossil fuel-based energy sources.

Considering the specific energy profile of the district, the focus is more on interventions in sectors such as transport, industry and domestic.

[2] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.
[3] Ibid.

The focus of the key interventions proposed in the study is essentially on passive low-investment strategies related to energy conservation and energy efficiency (ECEE) through measures like localization, energy efficiency, and carrier substitution (CS). The following narrative highlights the methodology of the study.

STEP 1: SUPPLY-SIDE ANALYSIS

- Identifying renewable energy supply options in line with *The Energy Report – Kerala*

  The four renewable energy sources assessed in the study are: wind, solar (grid and off-grid), bio energy and small hydro power (SHP). A GIS-based assessment is conducted to assess wind and grid-tied solar photovoltaic (PV) potential of the district. The GIS study has assessed district-level potential at a high resolution using new databases. Attempt is also made to check the suitability of the identified RE potential area by combining GIS results with Google maps. In addition, rooftop PV assessment and solar pumping potential were also estimated. Biomass based potential, mainly from the perspective of biomass heat and electricity, are assessed based on available information on resource availability and use. For hydro, the existing estimates of small hydro potential form the basis for evaluating hydro power availability in the district.

  The methodology used for determining the power potential for RE technologies, factors in the specific land use patterns in Palakkad and excludes all areas that may be environmentally sensitive. In line with *The Energy Report – Kerala*, rigorous and conservative inclusion scenarios are considered for assessing the availability of land for RE sources.

  The year-wise supply potential for all technologies is aggregated in terms of the energy carriers: electricity, heat and fuels.

STEP 2: DEMAND SIDE ANALYSIS

- Estimation of existing energy share of the district in terms of fuel carriers–electricity, heat and fuels – by identifying key focus consumption sectors, based on historical and present consumption patterns

  In line with *The Energy Report – Kerala*, a similar categorization of energy carrier streams–electricity, heat and fuels –were considered for the study. Figure 1.1 below shows the demand estimation units.

  In the context of the study, the terminology 'fuels' implies all fuel used by non-heat and non-electricity end-uses only (e.g., for transportation, diesel pumps etc.). Six sectors were selected for assessing sectoral demands: domestic, commercial, industry, agriculture, public utilities and transport. It is worth noting that each of the focus demand sectors like domestic, commercial, transport and agriculture use more than one kind of energy carrier for meeting all its energy consumption. For example, the industrial sector uses both electricity and heat; similarly, the transport sector uses both electricity (rail) and fuel.

FIGURE 1.1: ENERGY CARRIERS CONSIDERED FOR THE STUDY

Energy Carrier		
Electricity	Heat	Fuels

The study maps the historical and existing demand from these sectors and aggregates the sector-wise findings in terms of the energy carriers: electricity, heat and fuels.

- Developing a curtailed demand scenario for identified sectors up to 2030 assuming two points of intervention: Energy conservation and energy efficiency (ECEE) and carrier substitution (CS)

Going forward, an energy demand scenario up to 2030 for all the focus sectors is plotted based on business as usual (BAU) growth and standard assumptions. This demand scenario for each sector is then scaled back based on identified interventions in ECEE and CS, considering appropriate timelines for substitution initiations and quantum of reduction.

The curtailed demand for all the sectors is then aggregated and converted into the curtailed energy demand in terms of fuel carriers –electricity, heat and fuels.

STEP 3: MATCHING DEMAND WITH SUPPLY

Based on the demand in terms of energy carriers as estimated, the supply side is matched with the curtailed demand across the three carriers. Based on the results of the sectoral development analysis, key intervention strategies and instances are identified on the basis of the assumptions taken during the demand curtailment and supply projection stage. For example, if the demand analysis of the transportation sector has assumed a gradual substitution of traditional transport fuel with electricity (electric vehicles) by a particular year, then the requirement for commercialization of electric vehicles by that year will be identified as a strategy.

Similarly, on the supply side, the technology deployment rates assumed for grid-tied solar PV are translated into the requirement of ensuring the assumed deployment rate and hence are also treated as a strategy.

STEP 4: POLICY CONSIDERATIONS, STAKEHOLDER MANAGEMENT PLAN AND COST-BENEFIT ANALYSIS

Based on the identified intervention strategies, appropriate action plans and policy recommendations are framed for various focus sectors like power, industry, transportation, agriculture etc. Considering the importance of stakeholder management in implementing these strategies, a separate brief on stakeholder identification and stakeholder management plans is included with each strategy. In addition, a simple cost to benefit analysis of each intervention strategy is also done for each identified policy intervention.

STEP 5: IMPLEMENTATION ROADMAP

A representation of identified policy interventions and its associated activities and activity priorities is shown in tabulated format as a simple information and visualization tool for the policymakers. The tabulated representation allows policymakers to see the proposed interventions, associated activities, proposed timelines, assigned responsibilities, and costs and benefits of each identified policy intervention.

CHAPTER 2
BRIEF OVERVIEW OF THE DISTRICT

Palakkad district in one of the fourteen districts of Kerala, situated in the central east of the state. The district lies between 10°21' and 11°14' North latitude and 76°02' and 76°54' East longitude. The total area of the district is 4,480km^2 which is 11.5 per cent of the state's area. Out of the total area of 4,480km^2, about 1,360km^2 of land is covered with forests.[1] The district opens the state to the rest of the country through the Palakkad gap, which is a 30 to 40km wide low mountain pass. The total population of Palakkad is 2,809,934, which is 8.41 per cent of Kerala's total population.[2] It is a predominantly rural district, with only 24.09 per cent of the population living in urban areas.[3] There are five *talukas* (Ottappalam, Alathur, Mannarkkad, Palakkad and Chittur) and 163 villages in the district. The district is divided into 13 Community Development Blocks for the effective implementation of various developmental activities. There are four municipal towns and 91 panchayats in the district. Figure 2.1 shows a simple administrative map of the district.

FIGURE 2.1: PALAKKAD DISTRICT MAP[4]

Agriculture is the main occupation of the people of the district. Palakkad is the land of Palmyrahs and paddy fields. This district produces about one-third of the total rice produced in Kerala. Topographically, the district can be divided into two regions, viz., the low land (comprising the midland) and the high land, constituted by hills. The district has two types of climate. The climate of Ottappalam, Alathur and Mannarkkad is similar to that of other districts of Kerala, whereas Palakkad and Chittur

---

[1] Department of Information and Public Relations. 2003. *District Handbooks of Kerala – Palakkad*. Government of Kerala, Palakkad, Kerala. 46pp.
[2] Census of India. 2012. *Houses, Households and Amenities - 2011*. Office of Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India, New Delhi.
[3] Department of Economics and Statistics. 2011. *Panchayat Level Statistics, 2011 – Palakkad District. Government of Kerala, Palakkad.*
[4] Palakkad District Map, source: http://palakkadwebs.com/map/Palakkad_Map.jpg.

have a rather dry climate similar to Tamil Nadu. However, the average rainfall is good for cultivation.

The district is blessed with many small and medium rivers, which are tributaries of the Bharathapuzha River which is the second longest west flowing river in Kerala that drains into the Arabian Sea. A number of dams have been built across the tributaries of the river, the largest being the Malampuzha dam. The largest in terms of volume capacity is the Parambikulam Dam. Palakkad district also has good irrigation facilities. Dams have been constructed on almost all the important tributaries of the Bharathapuzha to provide irrigation facilities to the district.

BRIEF OVERVIEW OF KEY SECTORS IN PALAKKAD

This chapter includes a brief description of key sectors that are related to energy in Palakkad district. The focus is on the current status of direct and indirect energy use in the district's functioning. The information provided in this chapter forms the basis for analysis and demand projections of the district.

Electricity Sector

Palakkad became India's first fully electrified district in 2010. The consumption pattern of different sectors in 2010 is shown in the Table 2.1 below:

TABLE 2.1: ELECTRICITY CONSUMPTION PATTERN OF PALAKKAD[5]

Sectors	2009-10	
	(MU)	Percentage
Domestic	542.17	41.63
Commercial	117.57	9.03
Agriculture	61.79	4.74
Industrial LT	61.28	4.71
HT	492.24	37.80
Waterworks	5.58	0.43
Public Lighting	21.60	1.66
Total	**1,302.22**	**100.00**

The domestic and industrial sectors are the biggest consumers of electricity in the district. The installed capacity in Palakkad is 2 per cent of Kerala's total electricity generation capacity. The current generation capacity of the district is about 23 MW, with about 5 MW of small hydro capacity (Malampuzha and Meenavallom small hydro plants), one 2 MW of solar PV plant in Kuzhalmandam in Palakkad (the first in Kerala)[6] and two wind power projects (one at Kanjikode, with an installed capacity of 2.025 MW, and another at Agali (IPP) with an installed capacity of 13.8 MW). The National Hydro Power Corporation (NHPC) has recently signed an agreement with the Government of Kerala for setting up an 82 MW wind farm.[7]

---

[5] Data collected from Kerala State Electricity Board (KSEB), ElectricalCircle Offices of Palakkad and Shornur

[6] The Hindu.2013. "ANERT to Set Up 2-MW Solar Farm in Palakkad". *The Hindu* (21 November). http://www.thehindu.com/todays-paper/tp-national/tp-kerala/anert-to-set-up-2mw-solar-farm-in-palakkad/article5374300.ece, accessed on 6 April 2015.

[7] The Hindu. 2014. "Palakkad to Host NHPC's First Wind Farm". *The Hindu* (7 January). http://www.thehindu.com/todays-paper/tp-national/palakkad-to-host-nhpcs-first-wind-farm/article5547790.ece, accessed on 6 April 2015.

A brief overview of key achievements and existing power sector policies is covered in **Annexure 1**.

Commercial Sector

At 9.03 per cent, the commercial sector's energy consumption in Palakkad is low as compared to the energy consumption of commercial sector in other districts of the state. The main commercial activities of the district include tourism, hospitals, offices, retail outlets, educational institutions, government buildings etc. The district is gifted with Nelliampathy hills, Silent Valley National Park, Parambikulam Wildlife Sanctuary and more than half a dozen dams. Tourism plays a big role in the district's economy and has been a priority sector for the government. Education in Palakkad is in bad shape, but is expected to see a major reversal as the state government is planning large-scale infrastructure development in the education sector, with a focus on higher education facilities in the district.

A brief overview of key achievements and existing sectoral policies is covered in **Annexure 1**.

Industrial Sector

Palakkad district was considered as the industrial capital of the erstwhile Malabar district. Its proximity to Coimbatore (one of the major industrial centres in India) and Kochi makes it a favourable location for setting up industries. At present Palakkad is the second most industrialized district in Kerala, with 63 large and medium industries, 13,044 micro, small and medium enterprises (MSMEs), 14 handlooms, 61 industrial cooperatives, 51 khadi and village industries.[8] The industrial development is managed and promoted by the District Industries Centre (DIC), Palakkad. The state government supports industrial development in the form of incentives and resources through the DIC.

Major industries in Palakkad include:

- Iron & steel, mild steel, MS ingots, ferroalloys, steel ingots, structural steel, rods, rounds, flats etc.
- Cotton & textiles, knitted hosiery, fabrication, garments, cotton yarn, printed yarn, bleaching, dyeing clothes, blended yarn
- Engineering control valves, telecom products, power line, electronics and home automation products, communication equipment, fuse, panel board, HT & LT cables, auto injection moulding, patient monitoring system, electro cardiogram
- Information technology, application software, web based solutions, ERPs
- Distilleries, Indian made foreign liquor, beer, alcohol
- Chemicals, potassium, refractories, cements, aluminium oxide, silicon manganese, pharmaceuticals

---

[8] Department of Town and Country Planning. 2013. *Integrated District Development Plan – Palakkad*. Volume I. Special Technical Advisory Group, District Planning Committee, Palakkad, Kerala.p. 238.

- Agro products, rubber products, surgical gloves, heat resistant latex, crumb rubber, latex collection cup
- Plastic products, plastic components, precision parts, PET bottles
- Medical products, medical implants, disposables
- Packaging tapes, cartons

The traditional industries in Palakkad are handloom and coir. Handloom cooperative societies are mainly concentrated in Chittur and Kollengode. Industrial cooperatives are concentrated in Pudussery, Ottapalam and Pattambi. The major problems identified in these industries are lack of working capital, scarcity of expert weavers, credit arrears by societies with district cooperative banks, managerial inefficiencies in the societies, unhealthy competition by power looms.

The state government, with the support of the central government, is promoting large-scale development of industries in the district, with specific focus on less energy and water intensive industries. Some of the proposed measures and existing policy support mechanisms for the industrial sector in the district are covered in **Annexure 1**.

Agricultural Sector

Palakkad is one of the major granaries of Kerala with most of the cultivated land covering palm trees and paddy fields. The district holds 11.5 per cent of the total cropped area of the state, with paddy cultivated area in Palakkad accounting for 41 per cent of the total paddy cultivated area of the state.[9] Table 2.2 shows the area and production of major crops of Palakkad.

TABLE 2.2: MAJOR CROPS, ACREAGE AND PRODUCTION IN PALAKKAD[10]

Crops	Area (ha)		Production (in tonnes)	
	2009-10	2010-11	2009-10	2010-11
Paddy	100,522	87,511	266,231	218,155
Sugarcane	2,966	2,422	5,475	4,678
Pepper	5,758	5,465	1,121	954
Ginger	812	1,256	3,771	6,881
Turmeric	487	515	1,430	1,617
Cardamom	2,754	2,754	330	290
Banana	10,593	14,232	80,068	123,005
Other Plantain	10,384	8,655	95,528	85,770
Cashew	3,002	2,914	1,047	902
Tapioca	2,843	2,475	90,428	68,341
Mango	7,701	7,788	73,313	77,814
Pineapple	123	174	548	830
Cocoa	127	195	104	98
Sesame	63	68	7	9

[9] Ibid.p.95.
[10] Directorate of Economics & Statistics. 2011. *Agricultural Statistics 2009-10,* Government of Kerala, Palakkad, Kerala. pp. 78-81;
Directorate of Economics & Statistics. 2012. *Agricultural Statistics 2010-11,* Government of Kerala, Palakkad, Kerala. pp. 32-39.

Crops	Area (ha)		Production (in tonnes)	
	2009-10	2010-11	2009-10	2010-11
Coconut	57,186	57,094	417(in million nuts)	408 (in million nuts)
Tea	852	852	1,485	1,261
Coffee	4,650	4,650	1,875	2,225
Rubber	35,559	36,430	47,930	49,575
Non Food Crops	128,207	129,739		

Despite good average rainfall, the district is drought prone due to varying landscapes. Water management is the key to a district which is so heavily dependent on agricultural output. Irrigation dams are constructed on almost all the important tributaries of the Bharathapuzha River.

The cultivated area has decreased in the past few years and is worrying trend for the state's food security. The government of Kerala has proposed and implemented many schemes to increase agricultural productivity. Lack of skilled labour, improper water management, obsolete technology and untimely rains contribute to the challenges involved in this sector.

In terms of energy use, the agricultural sector consumes 4.74 per cent of the total electricity consumed in the district. The government has introduced various schemes to improve the efficiency of irrigation equipment, to save energy input into agriculture. Table 2.3 below shows a types and number of agricultural equipment used in the district.

TABLE 2.3: AGRICULTURAL EQUIPMENT USED IN PALAKKAD[11]

Agricultural Equipment	Rural	Urban	Total
Diesel Engine Pump Set	2,184	178	2,362
Electric Pump Set	19,812	788	20,600
Drip Irrigation Set	926	119	1,045
Sprinkler Irrigation Set	754	3	757

Some of the proposed measures and existing policy support mechanism for the agricultural sector in the district are covered in **Annexure 1**.

Transport Sector

Palakkad is connected to other parts of the state and to the country through roads and railway. The nearest airport is Coimbatore International Airport, which is about 52km away from the district. The nearest port is in Cochin, which is 110km away. The existing road network in the district connects to national and state highways, and major district roads, which are maintained by the Kerala Public Works Department and the Local Self Government Department. The total length of roads in the district is 2,172.78km.

[11] Local Self Government Department. 2007. *District Level Database - Palakkad District 2006*. Government of Kerala, Palakkad, Kerala. 54pp.

Palakkad has only 8 per cent of the total registered vehicles in the state. In 2013, the total number of vehicles registered in Palakkad was 670,461; while the total registered vehicles in the state was 8,048,873.

However, the total number of vehicles registered in the district in the past few years has been growing steadily. This is a sign of increasing economic activity in the district as the transport sector is the key to industrial and agricultural growth. Table 2.4 summarizes the growth in the number of vehicles in the past few years.

TABLE 2.4: GROWTH OF TOTAL REGISTERED VEHICLES IN PALAKKAD[12]

Year	Motor Vehicles (Nos)	Percentage Growth
2008-09	313,847	
2009-10	348,248	10.96
2010-11	397,134	14.04
2011-12	445,703	12.23
2012-13	670,461	50.43

There are two major railway stations in Palakkad. Palakkad Railway Junction at Olavakkode, where the office of the Divisional Railway Manager (Palakkad) is located. Pollachi, Dindigul and Madurai are connected to the Palakkad town railway station by the meter gauge line. The Shornur Railway Junction is the biggest in Kerala, this junction is of historical importance because of the "Shornur-Cochin Harbour Section", which was a meter gauge line in the early 1900's where all the cargo was transported from the Cochin port to Shornur.[13]

Description of the on-going projects and transport sector policies are given in **Annexure 1**.

[12] State Planning Board. 2014. *Economic Review 2013*. Government of Kerala, Palakkad, Kerala.See Chapter 5 – "Infrastructure" and Appendix 5.10.
[13] The Hindu. 2004. "Waiting for the Train of Hope". *The Hindu* (24 June). http://www.thehindu.com/mp/2004/06/24/stories/2004062401020100.htm, accessed on 6 April 2015.

PART II
RENEWABLE RESOURCE ASSESSMENT OF PALAKKAD

GENERAL OVERVIEW OF LITERATURE AND METHODOLOGY

To get a good perspective of the differences in methodology and assumptions, both GIS-based and paper-based[1] resource assessments were analysed from Indian as well as international studies. The study methodology also relied on a recent GIS-based resource assessment exercise executed for the state of Tamil Nadu by WISE[2], in which the technical assumptions and GIS methodology are similar to that used in *The Energy Report – Kerala*[3].

Land-Availability Considerations

The main consideration before initiating a GIS analysis was exclusion of all non-available geographies. Non-available geographies were categorized either as the geographical extent that was not available for development or as the geographical extent that was not recommended for development.

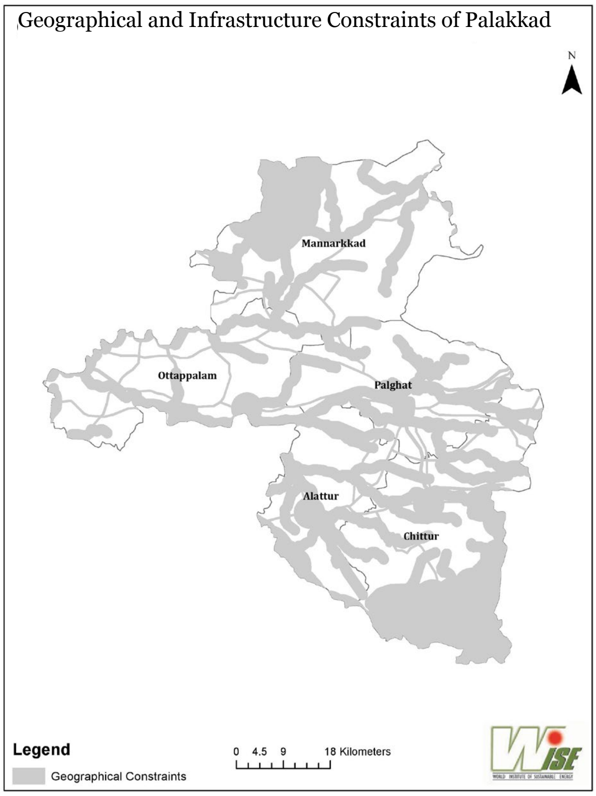
The geographies not available for development included standard geographical features like rivers, other water bodies, protected areas, roads, railroads, cities, settlements, etc. To exclude these features, a proximity criterion was created that excluded a certain extent along the perimeter (called buffering) of all the features and then aggregated these buffered extents to create a common layer of 'permanent exclusions'. All natural features like rivers and other water bodies, protected areas, and infrastructure like roads, railroads, settlements, airports were excluded from all analysis after buffering. The buffer values used are as specified in Table II.1 and Figure II.1 and indicates the final merged areas that are considered as 'permanent exclusions'.

TABLE II.1: BUFFER VALUES FOR FEATURES

Feature	Buffer (m)
Environment	
Water bodies	500
River	1,000
Protected areas	3,000
Infrastructure	
Roads	200
Railroads	300
Urban Areas	1,000
Populated Places	3,000
Airports	2,000

[1] Paper-based assessment here refers to assessment based on tabulated mathematical calculations. The same method was used in *The Energy Report – Kerala*.
[2] WISE. 2012. *Action Plan for Comprehensive Renewable Energy Development in Tamil Nadu*, World Institute of Sustainable Energy, Pune, India. pp. 21-26, 41-46.http://wisein.org/WISE_Projects/TN_ActionPlan_Web.pdf, accessed on 12 April 2015.
[3] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

FIGUREII.1: GEOGRAPHICAL AND INFRASTRUCTURE CONSTRAINTS OF PALAKKAD



Similarly, the geographies not recommended for development include certain land-use categories (protected areas, forest land, etc.). Established resource-assessment methodologies usually consider only wasteland or grassland as land recommended for development.

For the district-level assessment plan, only wasteland and grassland land categories have been considered for development of the wind and solar PV Potential. Table II.2 shows the total area under each land-use category.

TABLE II.2: LAND-USE CATEGORIZATION FOR ASSESSMENT OF WIND AND SOLAR POWER POTENTIAL

LULC Code	Description	Area (km²)	Percentage Inclusion	Scenarios
12	Grassland	107.88	100	Inclusion
13	Other Wasteland	88.3	100	
2	Kharif only	711.93	0	Exclusion
3	Rabi only	185.36	0	
6	Current Fallow	225.46	0	
7	Plantation/ Orchard	1,273.82	0	
1	Built-up	12.4	0	
5	Double/Triple	478.69	0	
8	Evergreen Forest	524.54	0	
9	Deciduous Forest	668.31	0	

LULC Code	Description	Area (km^2)	Percentage Inclusion	Scenarios
10	Scrub/Degraded Forest	106.62	0	Exclusion
16	Water Bodies	71.68	0	
	Total	**4,454.98**	**4.4**	

It should be noted that in addition to the permanent exclusions, because of infrastructure and geographical constraints (Figure II.1), all land-use areas other than wasteland and grassland have been excluded from the analysis. From a land-use perspective, only 4.4 per cent (196.2 km^2) of the total area of the district have been considered as the starting point of the assessment. This exclusion does not include the exclusion due to geographical constraints (refer Figure II.1). All the remaining areas of Palakkad amounting to 95.6 per cent have been completely excluded.

CHAPTER 3
SOLAR ENERGY POTENTIAL IN PALAKKAD

Solar energy potential in Palakkad is assessed for grid-tied solar PV technology and other decentralized solar energy technologies like rooftop PV, solar water heating, solar water pumping and solar process heating.

ASSESSMENT OF GRID-TIED SOLAR PV POTENTIAL

GIS-based solar resource assessment takes into consideration important factors like topography, vegetation, land use, which may be crucial factors for identification of areas with solar power potential. Thus, the main intent of the present exercise is not on just providing a figure of solar potential, but also on identifying the exact location and the quality of the available resources, thus allowing the government and decision-makers to use the results as policy inputs.

As discussed, all other categories except 'other wasteland' and 'grassland' were deemed not suitable for solar power plants and hence excluded from the analysis. *The details of the methodology are covered in Annexure 2.*

Figure 3.1 depicts the solar PV potential area map under grassland and wasteland categories.

FIGURE 3.1:
POTENTIAL FOR SOLAR PV – GRASSLAND AND WASTELAND

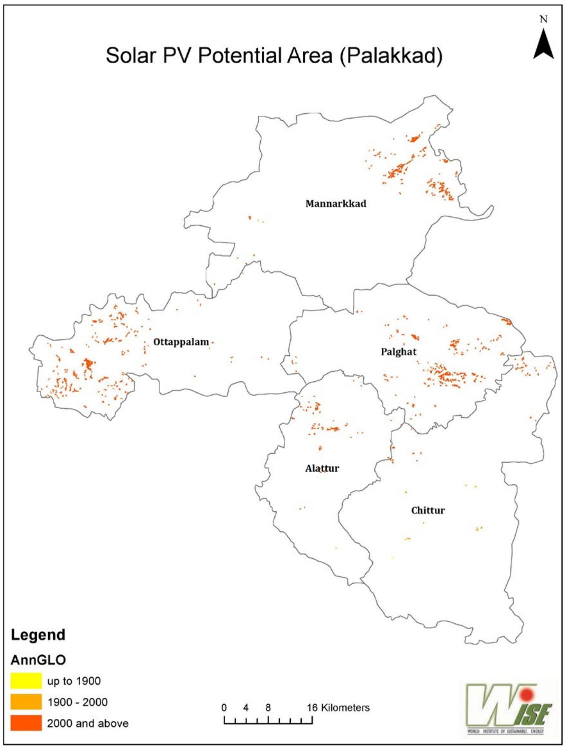


Table 3.1 shows the quantitative potential for solar power across grassland and wasteland categories.

TABLE 3.1: SOLAR PV POTENTIAL OF PALAKKAD

Solar PV Potential	Potential Area (km²)	Potential (MW)
Wasteland	21.98	1,099
Grassland	7.55	377.5
Total	**29.53**	**1,476.5**

The total solar PV potential of Palakkad is 1,476MW. Even assuming development only on wasteland, the total potential is about 1,100MW. According to *The Energy Report – Kerala*, the total potential for solar PV in Kerala was estimated to be around 6,816MW indicating that Palakkad has about 22 per cent of the state's potential. The potential for development of solar PV only in wasteland in the state was found to be 4,273MW, which indicates that a quarter of the state's solar PV potential is in Palakkad. The identified areas in Ottapalam taluka seem particularly interesting considering that the taluka is more inland and is closer to load centres in Palakkad, Thrissur and Kochi.

DECENTRALIZED SOLAR POWER GENERATION POTENTIAL

The decentralized solar energy potential includes potential assessment of technologies like rooftop solar PV, solar water heating, solar water pumping and solar process heating.

Rooftop Solar PV Potential

The Global Horizontal Irradiance (GHI) in the district is reasonably good for deployment of off-grid solar PV. Based on census data related to roof types and standard assumptions related to roof area availability, technical rooftop PV potential is assessed for the domestic (house rooftops) and commercial sectors (rooftops of commercial buildings). *The assumptions, methodology and details of calculation are covered in Annexure 2.*

The assessment indicates that the total exploitable potential for decentralized solar PV power packs for the domestic sector is about 865MW, while that for the institutional/commercial sectors is about 1,507MW. The aggregate potential for decentralized solar PV power packs is assessed at 2,372MW.

Solar Water Heating

Solar water heating systems are used by both households and commercial buildings. However, considering non-availability of data on occupancy levels in commercial/institutional buildings, only domestic potential for solar water heating has been assessed.

In addition, only households with concrete rooftops with 100 per cent shade free area are considered to be suitable for solar water heating systems. Based on assessment done for roof top PV, this translates into an availability of 50 per cent rural houses and 70 per cent urban houses. The data on number of houses with concrete roofs is taken from Census 2011.

Assuming an average requirement of 100 litres per day (LPD) SWH system for a 5 member household; 200 LPD for a 5-10 member household – the area required per house is assumed to be 2m² for 100 litres per day (LPD) SWH system and 4m² for a 200 litres per day (LPD) SWH system.[1] Based on the above assumptions, the total estimated area for Palakkad for solar water heating was found to be 323,870.7m².

Solar Water Pumping

Based on the report "Ground Water Level Scenario in India"[2], majority of the areas in the district are blessed with ground water level of less than 10m below ground level (bgl). The report indicates that for Kerala, about 37 per cent of the wells have water level in the range of 5-10m bgl, and only 12 per cent have water level greater than 10m bgl.

Based on the above observations, it is assumed that in the district, 87 per cent of the irrigated area may have ground water level of up to 10m bgl. As commercially available solar PV pumps (0.5-2hp capacity) easily pump water from a depth of 10 to 12m, it can be assessed that there is significant potential for use of solar PV pumping in Palakkad district.

Based on prevailing norms, it is presumed that 0.9kW capacity solar PV pump is sufficient to irrigate 1ha of land.[3] It is further assumed that 100 per cent of the irrigated area, with a water level of less than 10m bgl (78,564ha) can be converted into using solar PV for irrigation. This translates into a technical potential of about 87MW.

Solar Process Heating

Palakkad has promising potential for utilizing solar energy for process heat requirements. Solar drying systems are used for fish, spices and latex drying. In the absence of authentic data on process parameters, potential assessment for this sector has not been done in this study.

However, there is a large scope for substitution in agro-industries and textiles, particularly in meeting low-grade heat requirements or medium temperature hot water requirements. Some of the key industry sub-sectors that can use solar process heating are: fish and spices drying, and some processes in the textile industry.

SUMMARY OF SOLAR POWER POTENTIAL OF PALAKKAD

The solar power potential was assessed for grid-tied solar PV, off-grid solar PV and solar water heating. Table 3.2 summarizes the solar power potential of Palakkad.

[1]MNRE. 2011. "Minimum Requirements for Installation of Solar Water Heating Systems in Field". Ministry of New and Renewable Energy, Government of India. http://mnre.gov.in/file-manager/UserFiles/minimum_technical_ specicifications_SWHS.pdf, accessed on 12 April 2015.
[2]CGWB. 2012. "Ground Water Level Scenario in India".Central Ground Water Board.Ministry of Water Resources, Faridabad.http://www.cgwb.gov.in/documents/GROUND%20WATER%20LEVEL%20SCENARIO_November-12.pdf, accessed on 13 April 2015.
[3]WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

TABLE 3.2: SUMMARY OF SOLAR POTENTIAL

	Potential	Units
Grid-tied Solar PV Potential		
Wasteland	1,099	MW
Grassland	377.5	MW
Off-grid Solar PV Potential		
Households	865	MW
Institution/Commercial Buildings	1,507	MW
Solar Water Pumping	87	MW
Off-grid Solar Thermal Potential		
Solar Water Heating	323,870	m^2

The total grid connected PV potential sums up to be 1,476.5MW and that of decentralized PV potential is 2,459MW, the total PV potential in the district is 3,935.5MW. However, the actual implementation would depend on various factors like commercial, technology availability etc.

The major challenges to development of grid-connected potential could be land acquisition and costs. However, considering that Palakkad already has a 2MW land-based project, and with the emphasis of the Government of Kerala on solar PV projects, the potential for development, particularly in wasteland, is considered to be high. In the context of the study it is assumed that 100 per cent of the wasteland based potential and 50 per cent of the grassland based potential can be utilized by 2030 starting with a moderate exploitation of 20 per cent of the potential by 2020.

In the case of rooftop PV, the potential for implementation in the commercial sector is considered high. From a commercial perspective, investment in solar PV will be self-paying considering high tariff for commercial electricity. Further, the expected future policy provisions, like solar SPOs for commercial establishments, are expected to further spur higher uptake of rooftop PV projects. However, the main challenge for commercial solar PV is the issue related to right of way and tenant's rights as many commercial building's rooftops are common property or owned by builders and not actual electricity users. New business models will be needed to overcome these challenges and it may require significant alterations in electricity regulations and tenancy rules. Taking into consideration these related issues, a slow uptake of commercial rooftop capacity is assumed starting from 10 per cent in 2020 to 60 per cent in 2030. In the case of domestic rooftop PV, the main deterrents could be the high costs of solar PV systems and the lack of suitable incentives (net metering or feed-in-tariff). Considering the trajectory of solar PV costs and the intent of the state government to implement net metering, it is assumed that domestic solar PV rooftop potential can be tapped to an extent of up to 50 per cent by 2030, starting with a moderate utilization of 10 per cent of the potential in 2020. In addition, as the solar water heating potential assumes the same area availability for development, the actual deployment targets for solar water heating consider the remaining 50 per cent of the available area.

Based on the above assessment, the net energy availability of solar power in Kerala, assuming a 16 per cent capacity utilization factor, is shown in Table 3.3 below.

TABLE 3.3: SOLAR ENERGY AVAILABILITY IN PALAKKAD

	2015	2020	2025	2030
Solar Power Potential				
Wasteland (MW)	2.0	200.0	500.0	1100.0
Energy Availability (MU)	2.8	280.3	700.8	1541.8
Grassland (MW)	0.0	50.0	100.0	185.0
Grassland (MU)	0.0	70.1	140.2	259.3
Commercial Rooftop PV (MW)	0.0	150.0	450.0	900.0
Commercial Rooftop PV (MU)	0.0	210.2	630.7	1261.4
Domestic Rooftop PV (MW)	0.0	87.0	150.0	435.0
Domestic Rooftop PV (MU)	0.0	121.9	210.2	609.7
Total Installed Capacity (MW)	**2.0**	**487.0**	**1,200.0**	**2,620.0**
Total Energy Availability (MU)	**2.8**	**682.6**	**1,681.9**	**3,672.2**

CHAPTER 4
WIND POWER POTENTIAL IN PALAKKAD

Wind potential onshore is assessed for 80m hub height. Based on the review of available literature on the topic, and assumptions made in *The Energy Report – Kerala*, standard exclusion and inclusion criteria related to land-use, wind power density values, land slope, site elevation, were finalized with the objective of arriving at land area available for wind power development. This land area was then multiplied by the turbine density function (7 MW/km²) to estimate the potential.

The detailed methodology and potential assessment process is provided in Annexure 2.

The results of the wind power potential assessment are shown in Figure 4.1 and Table 4.1 below.

FIGURE 4.1: WIND POWER POTENTIAL AT 80M

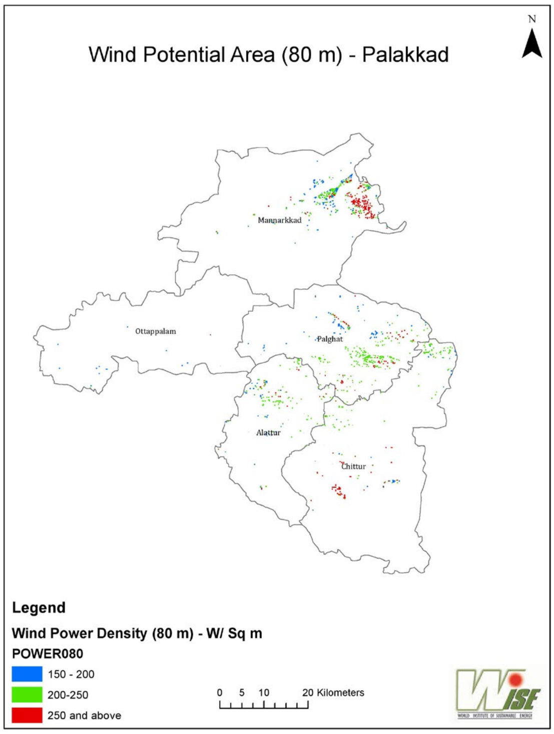


TABLE 4.1: WIND POWER POTENTIAL IN PALAKKAD

Particulars	Potential Area (km²)	Potential (MW)
Palakkad Wind (80m)	42.19	295.33
Wasteland	21.82	152.74
Grassland	20.37	142.59

From the results of the GIS analysis, it can be seen that high resource potential areas are spread across Mannarkkad, Palaghat and some pockets in Chittur taluka. Although the Walayar region in Palakkad is considered largely to have good wind resource, the availability of relatively high-grade potential in Mannarkad and Chittur seem promising and need to be explored in detail.

SUMMARY OF WIND POWER POTENTIAL

As the identified potential is based on wasteland and uncultivated farmland, it is assumed that 100 per cent of the potential can be tapped by 2030. The current installed wind power capacity in the district is about 15.825MW. It is however, expected that the proposed 80MW wind power capacity proposed by NHPC will come on-stream by 2020 and the remaining 200MW capacity will be developed by 2030. Based on these assumptions, the potential energy availability from wind power in the district, assuming a net CUF of 22 per cent, is estimated for all projection years as shown in Table 4.2.

TABLE 4.2:
WIND POWER AVAILABLE IN PALAKKAD

	2015	2020	2025	2030
Wind Power Potential				
Installed capacity (MW)	15.8	95.8	195.8	295.0
CUF (%)	22.0	22.0	22.0	22.0
Energy availability (MU)	**30.4**	**184.6**	**377.3**	**568.5**

CHAPTER 5

SUSTAINABLE BIOENERGY POTENTIAL IN PALAKKAD

The term biomass covers a range of organic materials obtained from living or dead vegetation or organisms. It is often used to mean plant based material, but could equally apply to materials derived from animals or plants, and thus could be concisely defined as the total mass of organisms in a given area or volume. It includes crop residues, forest and wood process residues, animal wastes including human sewage, municipal solid waste (MSW), food processing waste, purpose grown energy crops and short rotation forests.

Biomass classification is usually carried out on the basis of its origin, which could either be agricultural, forest or animal based. The latter comprises industrial waste as well as that arising from animals, in the form of litter, poultry waste, meat etc., and the urban and municipal waste originating from human settlements. For assessing the bioenergy potential of Palakkad the methodology in the *The Energy Report–Kerala*[1] is used here as a reference. However, the study has not considered assessment of biofuel potential, considering the nascent high yield biofuel technologies and the short horizon of the study.

The bioenergy assessment assumes use of limited residues for a variety of end-use energy generation technologies. To avoid resource conflict, it is assumed that Areca nut husk, Coconut fronds, Tapioca stalks, Cashew nut shell, Rice husks and Rice straw are used exclusively for biomass gasification-based electricity generation. Forest wood and rubber wood are considered exclusively for combustion. The organic component of MSW, and animal wastes are considered as feedstock for biogas generation. As the inorganic component of MSW is also a by-product of the MSW pre-treatment process and final disposal, a separate assessment for the inorganic component of MSW is considered for biomass combustion-based electricity generation.

Table 5.1 below shows the various biomass and crop residues considered along with their proposed end use.

TABLE 5.1: END-USE OF BIOMASS AND CROP RESIDUES

Biomass and crop residues	Proposed end-use
Areca nut husk Cashew nut shell Rice straw Rice husk Coconut fronds Tapioca stalks	Biomass gasification for electricity generation
Rubber wood Timber residues (forest)	Biomass combustion for heat applications
Organic fraction of MSW animal waste	Biogas generation for heat applications
Inorganic fraction of MSW	Biomass combustion for electricity generation

[1]WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

Based on the available information, an elaborate methodology is used to estimate the resource availability and the final energy generation potential for each end-use. *The details of the assumptions, methodology and mathematical calculations are covered extensively in Annexure 2.*

Based on the assessment, the results of the sustainable bioenergy potential for the district are shown in Table 5.2.

TABLE 5.2: BIOMASS RESOURCE POTENTIAL OF PALAKKAD

	2015	2020	2025	2030
Gasification Potential –Electricity (MU)				
Rice Husk	0.59	0.98	1.37	1.96
Rice Straw	3.95	6.58	9.22	13.17
Areca Nut Husk	0.32	0.49	0.64	0.84
Cashew Nut Shell	0.028	0.041	0.050	0.063
Tapioca Stalks	2.20	3.67	5.13	7.33
Coconut Fronds	9.67	15.60	21.14	29.48
Total	**16.76**	**27.37**	**37.55**	**52.84**

Combustion Potential –Electricity (MU)				
MSW Inorganic	7.29	8.31	9.41	10.65

Combustion Potential –Heat (PJ)				
Rubber Primary Wood	0.16	0.28	0.41	0.62
Forest Residues	0.67	0.68	0.69	0.69
Total	**0.82**	**0.96**	**1.10**	**1.31**

Biogas Potential –Heat (PJ)				
Organic Fraction MSW	0.033	0.038	0.043	0.048
Animal Wastes	0.110	0.110	0.110	0.110
Total	**0.143**	**0.148**	**0.153**	**0.158**

CHAPTER 6
HYDRO POWER POTENTIAL IN PALAKKAD

The history of hydropower development in Kerala began with the commissioning of the Pallivasal Hydro Electric Project in 1940. This project had an installed capacity of 37.5MW. In due course, several other hydro power projects like Sabarigiri and Idukki came up. Later, with the commissioning of more projects, Kerala achieved the status of a "power surplus" state, which lasted till the 1980's. During this power surplus period of 1969-85, the state resolved to set up power intensive industrial units.

In the late 1980's, Kerala experienced intermittent power deficits, which were attributed to "monsoon failure". However, the explanation of "monsoon failure" was too simplistic and overlooked several factors, which had led to the reversal. The momentum to set up more hydropower projects was not carried forward owing to increased environmental objections and inter-state differences. Furthermore, no provisions were made to protect the catchments of the reservoirs to ensure water availability in the reservoirs, which would have guaranteed consistent power generation.

PROSPECTIVE FUTURE POTENTIAL FOR HYDRO POWER IN PALAKKAD

The prospects of meeting the ever increasing power demand through more centralized state-based generation look bleak. With no coal or gas reserves of its own, the best bet for Kerala is in tapping the available hydro resources for power generation. However, large-scale hydro development in Palakkad also seems a distant possibility considering the strong environmental opposition and public sentiment.

The best way for the district could be to optimize existing resources to their fullest. It is known that existing facilities like dams, weirs, barrages, which were basically constructed in the past for meeting irrigation requirements can be used for power generation by setting SHP units without making any significant constructional changes in the original structure. Under the Energy Sector Management Assistance Programme (ESMAP) 2001, of the World Bank,[1] the possibility of using existing irrigation facilities for power generation was assessed. The study indicates that the water release sluices provided at the dam embankment could be utilized for power generation. The programme has recommended the design/construction methodology and turbine configuration for such schemes. A siphon penstock could be installed if the conditions are suitable, to convey water over the top of the dam for power generation without disturbing the existing dam. However, actual assessment at all the irrigation sites will require a separate study and an assessment of SHP potential in the existing irrigation facilities is beyond the scope of the study.

[1] Saxena, Praveen. 2007. "Small Hydro Development in India". International Conference on Small Hydropower - Hydro Sri Lanka, 22-24 October 2007. pp. 1-6. http://www.ahec.org.in/links/International%20conference%20on%20SHP%20Kandy%20Srilanka%20All%20Details%5CPapers%5CPolicy,%20Investor%20&%20Operational%20Aspects-C%5CC27.pdf, accessed 13 April 2015.

In the context of the present study, small hydro potential identified by KSEBL and vetted by EMC is taken as the basis of available potential. Currently, Palakkad has two SHPs, viz., Malampuzha and Meenavallom, having a cumulative capacity of 5.5 MW. However, based on discussions with EMC, some other new project sites considered promising include few sites in Attle, Chembakutti, Koodam and Lower Vattappara. Table 6.1 shows the identified SHP sites.

TABLE 6.1: MAJOR IRRIGATION SCHEMES IN PALAKKAD

Sr. No	Name of the scheme	Basin	Installed Capacity (MW)	Annual energy generation (MU)	Status
1	Malampuzha	Bharathapuzha	2.5	5.6	Commissioned
2	Meenvallom	Bharathapuzha	3	10.09	Commissioned
3	Attle I & II	Bharathapuzha	12	30	Proposed
4	Gayatri Stage I	Bharathapuzha	0.28	0.45	Proposed
5	Gayatri Stage II	Bharathapuzha	0.37	0.64	Proposed
6	Pallakuzhi mini	Bharathapuzha	1	2.14	On-going
7	Chembukatti	Palakkuzhipuzha	6.5	14.32	In pipeline
8	Koodam	Siruvani/ Kallanthode	4	9.76	In pipeline
9	Lower Vattappara	Bharathapuzha	3	21	In pipeline
		Total MW/MU	**32.65**	**94**	

SUMMARY OF HYDRO ENERGY POTENTIAL

Although, the actual hydro energy potential is assessed at 32.65MW, we assess only the most promising potential for realizing deployment by 2030. The actual hydro energy potential of the district could be about 11.5MW from sites such as Palakuzzi, Koodam and Chembakutti. For the current study, this potential is assessed as the available potential that can be tapped by 2030.

Based on this above assessment, the energy availability from small hydro power in Palakkad is shown in Table 6.2 below.

TABLE 6.2: SMALL HYDRO POWER POTENTIAL OF PALAKKAD

Small Hydro Power Potential	2015	2020	2025	2030
Installed capacity (MW)	5.5	6.5	10.5	16.5
Energy availability (MU)	15.69	17.83	27.59	41.91

CHAPTER 7

SUMMARY OF RENEWABLE ENERGY POTENTIAL ASSESSMENT OF PALAKKAD

The results of the potential assessment based on the derived methodology, assumptions and base data are striking. Table 7.1 captures the final numbers of the assessed RE potential of the district.

TABLE 7.1:

SUMMARY OF ENERGY AVAILABILITY FROM RE BY 2030

	2015	2020	2025	2030
Electricity (MU)				
Solar Energy	2.8	682.6	1,681.9	3,672.2
Wind Energy	30.4	184.6	377.3	568.5
Biomass Electricity	24.05	35.68	46.96	63.49
Small Hydro	15.69	17.83	27.59	41.91
Total Electricity	**73.0**	**920.7**	**2,133.8**	**4,346.1**
Heat Availability (PJ)				
Combustion	0.82	0.96	1.1	1.31
Biogas	0.14	0.15	0.15	0.16
Total Heat	**0.96**	**1.11**	**1.25**	**1.47**

PART III
RENEWABLE ENERGY SCENARIO FOR PALAKKAD

CHAPTER 8
DISTRICT ENERGY DEMAND PROJECTIONS: BUSINESS-AS-USUAL SCENARIO

This chapter assesses the future growth trajectory of economic activities and energy use in Palakkad, assuming a BAU growth scenario up to 2030. A BAU growth in this context means a market guided growth that takes existing policy interventions into consideration, but does not make any aggressive assumptions about future market disruptions, policy changes, technology improvements etc. BAU growth represents the automatic growth that happens without the interference of any new intervention.

The demand estimation has been done utilizing an energy modelling software, the Long Range Energy Alternatives Planning (LEAP) systems [Version: 2014.0.1.18].[1] LEAP model has been utilized to link future activity levels with energy demand using both bottom-up and top-down demand estimation approaches.

PALAKKAD DISTRICT: DEVELOPMENT TREND

Palakkad is witnessing a growth powered mainly by industrial and domestic sectors. The Gross District Domestic Product (GDDP), which represents the economy of the district, has increased at a CAGR of 7.56 per cent from 2004-05 to 2010-11. However, the population of the district has increased by only 0.58 per cent over the same period. The population density of Palakkad is 584km^2, which is substantially less than the state's average of 819km^2. Growth rate of population is declining significantly for the last three decades. Hence, it can be presumed that there would not be much increase in the population density of the district. The average household size of the district is 4.4 in 2011, and it is expected to decrease due to the decreasing trend in population. *The details of assumptions and methodology used for the base projections of parameters like GDP, population, household, etc., are covered in Annexure 3.*

FUTURE ENERGY PROJECTIONS

The sectors considered for demand estimation are domestic, commercial, industrial, agriculture, public utilities (public lighting, water works) and transport. The energy use estimated here includes electricity, heat (cooking and industrial heat) and fuels (transport fuels).

The following sections in this chapter attempt to project the economic activities in these sectors, and the associated energy demand.

---

[1]C.G. Heaps. 2012. Long-range Energy Alternatives Planning (LEAP) System. Stockholm Environment Institute, Somerville, MA, USA. www.energycommunity.org.

Domestic

The domestic sector in Palakkad presently consumes about 42 per cent of the total electricity consumed in the district, and a lion's share of total cooking fuels consumed across different sectors in the district. The BAU scenario for domestic sector is based on assessment of electricity and heating (cooking) demand.

- Electricity

A bottom up methodology is used for assessing domestic electricity demand. Appliance ownership data from Census 2001 and 2011 for households in the district is used to project appliance ownership level up to 2030 using per capita income (PCI) as an independent variable. Appliance energy consumption levels and their evolution are based on standard studies. The mathematical equation for assessing the domestic electricity demand is shown in Equation 1 below

Total energy demand for the domestic sector $DD_i = NoH_i \times \Sigma AO_{ij} \times N_j \times UEC_{ij}$ **(Equation 1)**

Where,

DD_i is the domestic electricity demand in Year i

NoH_i is the number of Households in Year i

AO_{ij} is the appliance ownership level of appliance j in year i

N_j is the number of appliance j in one household

UEC_{ij} is the unit energy consumption of appliance j in year i

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4A.

Based on the above equation, the estimated electricity demand for the domestic sector is shown in Table 8.1 below:

TABLE 8.1: ESTIMATED DOMESTIC ELECTRICITY DEMAND UP TO 2030

Domestic Electricity Demand (MU)	2015	2020	2025	2030
Domestic Electricity (BAU)	593.3	798.0	1,012.1	1,284.8

- Cooking

The cooking energy demand is assessed using a bottom up methodology. The state-level data from the National Sample Survey Organization (NSSO) on historical domestic fuel share was utilized to project future fuel share across households. The fuel requirements across the sector were derived assuming per capita cooking energy consumption of 620 Kcal/per capita per day.

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4A.

Based on the above methodology, the final energy demand for the domestic sector in PJ in the BAU scenario is shown in Table 8.2.

TABLE 8.2: ESTIMATED FINAL ENERGY DEMAND FOR THE DOMESTIC SECTOR UP TO 2030

Domestic Energy Demand (PJ) – BAU	2015	2020	2025	2030
Electricity	2.13	2.87	3.64	4.62
Cooking	2.65	2.69	2.73	2.75
Total	**4.78**	**5.56**	**6.37**	**7.37**

Commercial

The commercial sector in Palakkad mainly includes retail, tourism, hospitals, offices and other commercial establishments. Commercial establishments mainly use two forms of energy, viz., electricity and heating. Heating is mainly used for cooking and water heating purposes. However, there are considerable gaps in the data in assessing the current energy usage trends within sub-sectors making a bottom-up energy estimation of this sector difficult. Available literature on commercial energy demand estimation has mostly used a top-down analysis. In view of the data gaps and the difficulty in actually simulating usage and appliance pattern variations, a top-down analysis of energy demand for the commercial sector is undertaken in the study.

- Electricity

The electricity demand for the commercial sector is assessed using a top-down methodology. Historical data of commercial sector electricity consumption is projected by using regression with respect to GDDP (tertiary sector) to derive future electricity demand for the commercial sector. To understand the share of different sub-sectors (hotels, hospitals, shops, malls, etc.), *The Energy Report– Kerala*[2] is referred and suitable modifications in sub-sector shares are assumed.

The details of the assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4B.

Based on the above methodology, the projected electricity consumption of the commercial sector for Palakkad district is shown in the Table 8.3.

TABLE 8.3: ESTIMATED ELECTRICITY DEMAND FOR THE COMMERCIAL SECTOR UP TO 2030

Electricity Consumption (MU)	2015	2020	2025	2030
Commercial	145.56	202.26	275.35	364.82

- Heat

A top-down methodology is used to assess the commercial sector heating demand. A similar methodology to the one used in *The*

[2]WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

Energy Report– Kerala[3] is considered to assess the total cooking demand in terms of fuel.

The details of the assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4B.

The final energy demand for the commercial sector in the BAU scenario in PJ is shown in Table 8.4 below.

TABLE 8.4: ESTIMATED FINAL ENERGY DEMAND FOR THE COMMERCIAL SECTOR UP TO 2030

Commercial Energy Demand (PJ) – BAU	2015	2020	2025	2030
Electricity	0.53	0.73	0.99	1.31
Heat	0.20	0.28	0.39	0.51
Total	**0.73**	**1.01**	**1.38**	**1.82**

Industry

The industrial sector in Palakkad is dominated by few large/medium industries and a large number of SMEs. Consequently, energy estimation using the bottom-up methodology was not possible considering the fact that energy consumption in the sector is spread across different kinds of industries –starting with few large metals and minerals, textile, industrial and engineering goods, to huge number of small-scale engineering and industrial goods manufacturers, plastic and ceramics manufacturers, to food processing and agro industries. A bottom-up approach would have necessitated availability of sectoral production data and specific energy consumption data for each industry accounting for the differences in product variations. Review of available literature on industry demand projections[4] indicated that energy demand could be assessed only for a handful of industries using a bottom up methodology. The sectors covered in these studies included only a small portion of the industry sectors in Palakkad, leaving out scope for a bottom-up demand estimation for complex industry sectors like engineering and industrial goods, food processing, etc., which also play a major role in the overall industrial ecosystem. In view of the above, a top-down analysis was used to project electricity demand in the industrial sector in the district.

Based on the ASI survey, the industrial sector was segregated into ten major industry clusters, viz.,(1) agro and food processing, (2) textiles, (3) paper and pulp, (4) petrochemicals, (5)chemicals (including fertilizers), (6) rubber products, (7) minerals and materials (including cement and abrasives), (8) metals and alloys, (9) engineering and industrial goods, and (10) others. Based on the above categorization, the electricity and heat demand for the industrial sector was determined separately.

- ### Electricity

Future industrial electricity demand is projected by extrapolating historical data of usage of electricity in the industrial sector. The share of electricity consumption across the ten industry clusters is

[3]Ibid.
[4]See Trudeau, Nathalie, Tam, Cecilia, Graczyk, Dagmar and Peter Taylor. 2011. *Energy Transition for Industry: India and the Global Context*. International Energy Agency, Paris, France. https://www.iea.org/publications/freepublications/publication/india_industry_transition_28feb11.pdf, accessed on 12 April 2015; TERI. 2006. *National Energy Map for India: Technology Vision 2030*. Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 12 April 2015.

derived by assuming the same share across sub-sectors as that of actual HT sub-sector consumption share.

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4C.

Based on the above analysis, the total electricity demand for the industrial sector (High Tension (HT) and Low Tension (LT)) is shown in Table 8.5.

TABLE 8.5: ESTIMATED ELECTRICITY DEMAND FOR THE INDUSTRIAL SECTOR UP TO 2030

Sector Electricity Demand (MU)	2015	2020	2025	2030
Industry LT	85.80	115.72	143.83	172.53
Industry HT	491.2	592.9	693.3	793.3
Total	**577**	**708.6**	**837.13**	**965.83**

- Heat

The industrial heat demand for the start year is aggregated from the actual fuel use data available across different industry clusters from the input survey. The start year heat demand of each industry cluster is linked to the electricity demand of that cluster to project future heat demand.

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4C.

Based on the above assumptions, Table 8.6 shows the heat demand from the industrial sector.

TABLE 8.6: ENERGY (HEAT) DEMAND OF THE INDUSTRIAL SECTOR

Sector Heat Demand (PJ)	2015	2020	2025	2030
Industry	3.31	3.85	4.34	4.85

Based on the above methodology, the final energy demand for the industrial sector in the BAU scenario in PJ is shown in Table 8.7 below.

TABLE 8.7: ESTIMATED FINAL ENERGY DEMAND FOR THE INDUSTRIAL SECTOR UP TO 2030

Industry Energy Demand (PJ) – BAU	2015	2020	2025	2030
Electricity	2.08	2.55	3.02	3.48
Heat	3.31	3.85	4.34	4.85
Total	**5.39**	**6.40**	**7.36**	**8.33**

Agriculture

Energy use in agriculture is mainly spread across electricity and diesel requirements for irrigation, and fuel requirements for tractors.

- Electricity

Historical demand of electricity in agriculture is projected using a simple linear extrapolation. *The details of assumption, base data* *and projections, actual calculation and narrative description of the methodology are covered in Annexure 4D.*

Based on the methodology discussed above the electricity demand for irrigation is summarized in the Table 8.8 below.

TABLE 8.8: ELECTRICITY DEMAND FOR IRRIGATION

Electricity Consumption (MU)	2015	2020	2025	2030
Irrigation	93.7	106.6	116.73	125.32

- Fuel

The main fuel demand in the agricultural sector is for pumps and tractors. *The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4D.*

Based on the methodology, the final energy demand for the agricultural sector in the BAU scenario in PJ is shown in Table 8.9 below.

TABLE 8.9: ESTIMATED FINAL ENERGY DEMAND FOR THE AGRICULTURAL SECTOR UP TO 2030

Agricultural Energy Demand (PJ) – BAU	2015	2020	2025	2030
Electricity	0.35	0.42	0.44	0.46
Fuel	0.46	0.50	0.57	0.62
Total	**0.81**	**0.92**	**1.01**	**1.08**

Public Utilities

Electricity Demand: Input

Public utilities mainly cover electricity consumption of utilities and state entities towards street/road lighting, water supply and non-domestic connections. Future consumption of electricity from street lighting has been derived from linear projection of historical data.

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in detail in Annexure 4E.

Table 8.10 below shows estimations of electricity for public lighting and water works. No heating or fuel requirement is separately assessed for this sector.

TABLE 8.10: ESTIMATED ELECTRICITY DEMAND FOR PUBLIC UTILITIES

Sector Electricity Demand (MU)	2015	2020	2025	2030
Public Lighting	30.72	39.51	48.29	57.08
Public Water Works	6.47	7.50	8.69	10.08

Transport

This section tries to assess the total volume and energy demand in the transport sector by using a bottom-up methodology. The section covers passenger and freight transport separately. Within each branch, the traffic volumes are estimated for different transport modes, including road and rail. The units used for estimating transport volumes are Passenger Km (pkm) for passenger transport and Tonnes km (tkm) for freight transport. The projections for the BAU traffic volumes for roads covered in this chapter are derived on the basis of growth in vehicle population.

The assessment of transport technologies is mainly based on empirical data or available studies. The major vehicle categories considered for the assessment are cars, taxi cars, jeeps, auto rickshaws/three wheelers, two wheelers, buses (stage carriages), buses (contract carriages), goods vehicles (four wheelers & above) and goods vehicles (three wheelers including tempos). Data on category-wise growth of motor vehicles from 2004 to 2012 in Palakkad district have been assessed from the transport section of Economic Review, published by the Kerala State Planning Board.[5]

- Passenger Transport

  In the face of rapid growth (urbanization and industrialization) in personal modes of transport, passenger transport in Palakkad is expected to account for a major share of the energy consumed in the district. The following narrative captures the methodology of demand estimation across different modes of travel.

  - Road Transport

    For predicting the number of motor vehicles of different categories, a simple linear regression model has been used for each category of motor vehicles. For each vehicle category, different fuels and technologies are considered (e.g., car with petrol and car with diesel).

    The basic methodology for projecting passenger volumes (pkm) involves four steps

    Step 1: Projection of registered vehicle population based on regression (X_{ij})

    Where X_{ij} is the number of registered vehicles of type i in year j

    Step 2: Estimating the number of in-use vehicles assuming standard retirement age or per cent fleet utilization (Y_{ij})

    Where Y_{ij} is the number of in-use vehicles of type i in year j

    Step 3: Assigning average annual kilometres run based on standard literature (Km_{ij})

    Where Km_{ij} is the average annual kilometre run for category of vehicle i for year j

    Step 4: Assigning average passenger carried (P_{ij})

[5]The data is collection from the *Economic Review* published by the State Planning Board for the years 2004 to 2012. See State Planning Board. *Economic Review*. State Planning Board, Government of Kerala.

Where P_{ij} is the average passenger occupancy rate for category of vehicle i for year j

Based on the above, the total road passenger traffic is estimated by the following equation

Total passenger traffic in passenger kilometre (pkm) =
$Y_{i,J} \times Km_{ij} \times P_{ij}$ **(Equation 2)**

The total passenger kilometre for each vehicle category is multiplied by the energy intensity of the particular vehicle category and fuel type to arrive at the energy demand, which is aggregated across each vehicle category to arrive at the final demand.

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4F.

Based on the above assumptions, the total passenger road transport activity level and energy demand is shown in Table 8.11.

TABLE 8.11: TOTAL PASSENGER ROAD TRANSPORT ACTIVITY LEVEL AND ENERGY DEMAND

Road Passenger Transport Activity and Energy Demand	Unit	2015	2020	2025	2030
Two Wheelers	Billion pkm	1.8	2.7	3.1	3.5
	PJ	0.49	0.74	0.85	1.01
Three Wheelers	Billion pkm	1.9	2.4	2.7	3.0
	PJ	0.81	0.99	1.11	1.21
Jeeps	Billion pkm	0.01	0.01	0.01	0.01
	PJ	0.02	0.01	0.01	0.01
Taxi Cars	Billion pkm	0.5	0.7	0.8	0.9
	PJ	0.46	0.65	0.87	1.17
Cars	Billion pkm	0.4	0.6	0.7	0.8
	PJ	0.74	1.16	1.82	2.14
Short Distance Buses	Billion pkm	9.0	10.5	12.2	13.9
	PJ	1.30	1.53	1.69	1.79
Long Distance Buses	Billion pkm	5.1	6.0	6.6	7.1
	PJ	0.74	0.87	0.96	1.04
Total Activity Level (Billion pkm)	**Billion pkm**	**18.6**	**22.9**	**26.1**	**29.2**
Total Energy Demand (Peta Joules)	**PJ**	**4.57**	**5.95**	**7.31**	**8.37**

- Rail Transport

The rail transport traffic data projections for Kerala, derived from *The Energy Report – Kerala*,[6] are converted into rail passenger traffic for Palakkad assuming that the passenger kilometre share of Palakkad will be equal to the track share percentage of Palakkad.

The assessed rail traffic is multiplied by railway energy intensity data to arrive at the total energy demand.

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4F. Table 8.12 below shows the energy demand of rail transport in the district.

TABLE 8.12: ENERGY DEMAND FOR RAIL TRANSPORT

Year	2015	2020	2025	2030
Rail Passenger(Billion pkm)	2.4	2.6	2.6	2.6
Energy Intensity MJ/pkm)	0.12	0.12	0.12	0.12
Total Energy Demand (PJ)	**0.29**	**0.31**	**0.31**	**0.31**

- Freight Transport

Freight transport in Kerala is expected to increase at a high rate mainly due to the imminent transition of Kerala from a subsistence economy to a consumerist economy. The following sub-sections try to capture the demand across different transport modes.

Road Freight Traffic: Methodology

The basic methodology for projecting freight volumes for roads is shown below:

Step 1: Projection of registered vehicle population based on regression (X_{ij})

Where X_{ij} is the number of registered vehicles of type i in year j

Step 2: Estimating the number of in-use vehicles assuming standard retirement age or per cent fleet utilization (Y_{ij})

Where Y_{ij} is the number of in-use vehicles of type i in year j

Step 3: Assigning average annual kilometre-run based on available literature (km_{ij})

Where km_{ij} is the average kilometre-run for category of vehicle i for year j

Step 4: Assigning average tonnage based on available literature (T_{ij})

Where T_{ij} is the average tonnage for category of vehicle i for year j

Based on the above, the total road freight traffic is calculated as shown in equation 3.

Total freight traffic in tonnes kilometre = $Y_{ij} \times km_{ij} \times T_{ij}$ **(Equation 3)**

[6] WWF-India and WISE. 2013. The Energy Report – Kerala: 100% Renewable Energy by 2050. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

The total tonne kilometre for each vehicle category is multiplied by the energy intensity of the particular vehicle category and fuel type to arrive at the energy demand, which is aggregated across each vehicle category to arrive at the final demand.

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4F.

Based on the above assumptions, the total passenger road transport activity level and energy demand is shown in Table 8.13.

TABLE 8.13: ROAD FREIGHT TRANSPORT ACTIVITY AND ENERGY DEMAND

Road Freight Transport activity and energy demand	Units	2015	2020	2025	2030
HCVs	Billion tkm	4.3	5.1	7.2	9.1
	PJ	5.06	6.06	8.58	10.86
LCVs	Billion tkm	0.26	0.32	0.47	0.59
	PJ	0.67	0.85	1.20	1.49
Total Road Freight Activity (Billion tkm)	**Billion tkm**	**4.51**	**5.41**	**7.67**	**9.69**
Total Road Freight Energy (Peta Joules)	**PJ**	**5.74**	**6.91**	**9.78**	**12.35**

- Rail Freight

Rail transport traffic data projections for Kerala, derived from *The Energy Report – Kerala*,[7] are converted into rail passenger traffic for Palakkad, assuming that the tonne kilometre share of Palakkad will be equal to the track share percentage of Palakkad. The assessed rail traffic is multiplied by railway energy intensity data to arrive at the total energy demand.

The details of assumption, base data and projections, actual calculation and narrative description of the methodology are covered in Annexure 4F.

Based on the above assumptions, the activity level and the final energy demand for the sector are shown in Table 8.14 below.

TABLE 8.14: RAIL FREIGHT ENERGY ESTIMATION

Rail Freight Energy Estimation	2011	2015	2020	2025	2030
Rail Passenger(Billion tkm)	1.02	1.34	1.88	2.63	3.69
Energy Intensity (MJ/tkm)	0.064	0.064	0.064	0.064	0.064
Total Energy Demand (PJ)	**0.07**	**0.09**	**0.12**	**0.17**	**0.24**

Based on the above estimation, the total transport energy demand for the district in PJ is shown in Table 8.15.

[7] Ibid.

TABLE 8.15:
TRANSPORT SECTOR – TOTAL ENERGY DEMAND

Transport Demand Scenario (PJ)	2011	2015	2020	2025	2030
Transport	9.02	10.68	13.29	17.56	21.27

FINAL BAU DEMAND SCENARIO IN PALAKKAD

The final BAU projections for total energy demand for the district are shown in the Tables 8.16 and 8.17 and Figures 8.1 and 8.2 below.

TABLE 8.16:
FINAL ENERGY DEMAND – SECTOR WISE

District Energy Demand–BAU (PJ)	2011	2015	2020	2025	2030
Transport	9.02	10.68	13.29	17.56	21.27
Domestic	4.26	4.78	5.56	6.37	7.37
Commercial	0.62	0.73	1.01	1.38	1.82
Industry	4.79	5.39	6.40	7.36	8.33
Agriculture	0.67	0.81	0.92	1.01	1.08
Public Utilities	0.11	0.13	0.17	0.21	0.24
Total	**19.47**	**22.51**	**27.33**	**33.87**	**40.11**

FIGURE 8.1:
FINAL ENERGY DEMAND – SECTOR WISE

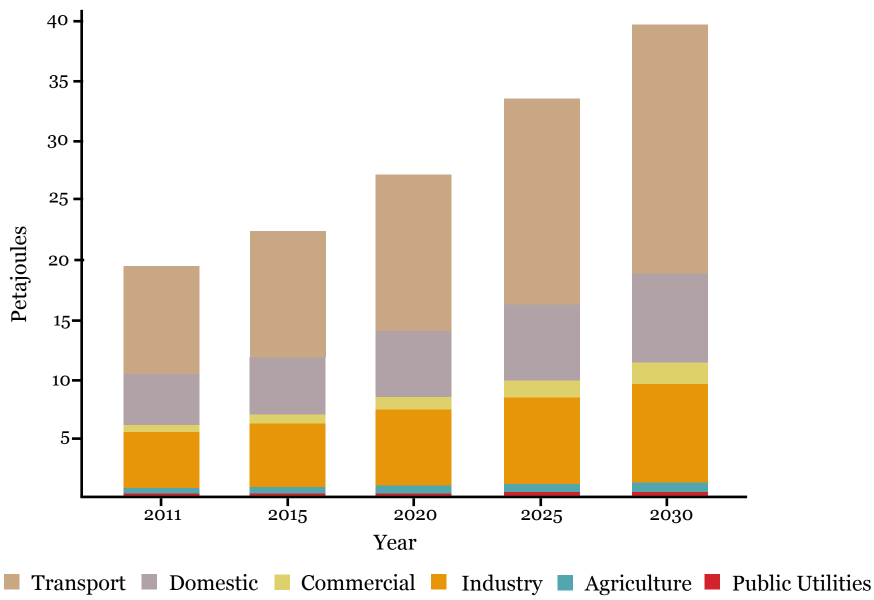


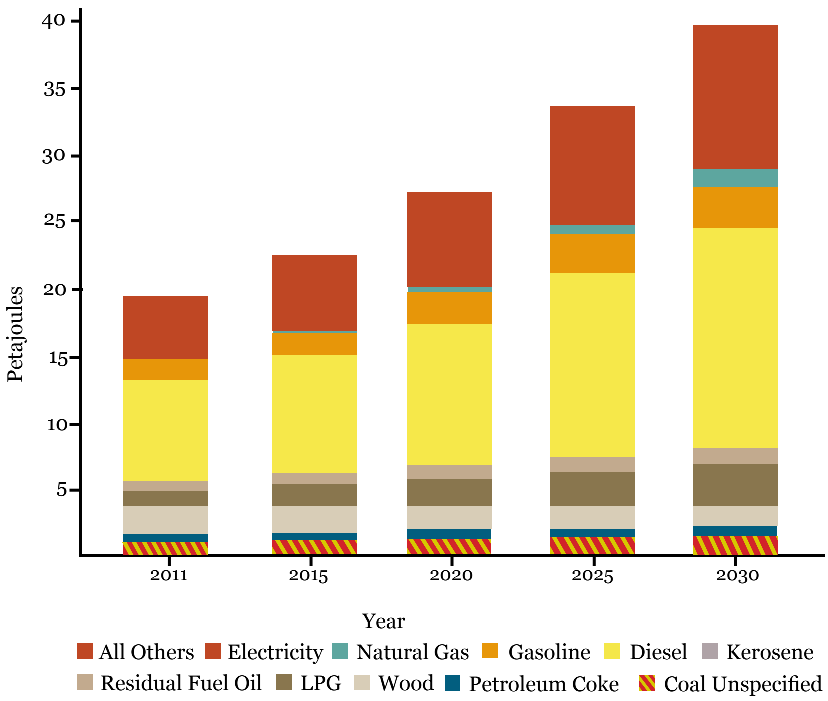
TABLE 8.17:
ENERGY DEMAND BY FUEL SOURCE

Demand – BAU (PJ)	2011	2015	2020	2025	2030
All Others	0.00	0.00	0.00	0.00	0.00
Electricity	4.74	5.58	7.15	8.79	10.78
Gasoline	1.53	1.83	2.56	3.26	3.77
Diesel	7.58	8.94	10.81	14.38	17.47
Kerosene	0.02	0.02	0.01	0.02	0.01
Residual Fuel Oil	0.65	0.73	0.90	1.06	1.22
LPG	1.25	1.59	2.13	2.59	3.06
Wood	2.08	1.99	1.78	1.66	1.55

Demand – BAU (PJ)	2011	2015	2020	2025	2030
Biogas	0.01	0.01	0.01	0.01	0.01
Petroleum Coke	0.60	0.67	0.68	0.68	0.69
Coal Unspecified	1.02	1.16	1.29	1.42	1.54
Total	**19.47**	**22.51**	**27.33**	**33.87**	**40.11**

The BAU scenario shows a doubling of energy demand by 2030 from the base year (2011). In line with the findings in the state-level report, the projections of Palakkad also indicate transport sector's share of over 50 per cent in the total energy demand of the district. The industrial sector accounts for the second highest share in the total energy demand. This seems to be a realistic estimate as Palakkad is the second highest industrialized district in the state with fairly high consumption level.

FIGURE 8.2: ENERGY DEMAND BY FUEL SOURCE



CHAPTER 9
THE CURTAILED DEMAND SCENARIO

The curtailed energy demand modelling is done using the modelling software Long Range Energy Alternatives Planning (LEAP).[1] With the BAU scenario as the base, two new scenarios are created representing energy conservation and energy efficiency (ECEE), and carrier substitution (CS).

Energy conservation and energy efficiency are both measures for energy savings, but energy conservation refers to any behaviour and practice that result in not using energy at all, such as turning off the lights when leaving a room. Energy efficiency is a technological approach to using less energy – requiring less energy to perform the same function, such as switching to efficient appliances. Carrier substitution is considered when the end-use activity is transferred from one energy carrier to another, such as switching to electric or solar pumps instead of diesel pumps.

The first intervention scenario titled 'Intervention Scenario 1 – Energy Conservation and Energy Efficiency' (IS1–ECEE) inherits its characteristics from the BAU scenario, while 'Intervention Scenario 2–Carrier Substitution' (IS2–CS) derives its characteristics from IS1–ECEE. In effect, the tiered scenario approach helps to establish the energy reduction potential across each scenario individually and also helps to identify the cumulative energy reduction potential with the proposed sequence of interventions.

DOMESTIC SECTOR INTERVENTIONS

The domestic sector in Palakkad accounts for the major share of electricity and cooking heat. The two main intervention strategies, ECEE and CS, considered here, primarily focus on the energy curtailment potential of these two carrier fuels.

Intervention Scenario 1–ECEE

The main intervention strategies considered for the domestic sector under this scenario are a move towards sustainable building practices, architectural designs, material management, switching to efficient domestic equipment and better practices of operation of energy intensive appliances.

- Move Towards Sustainable Building Architecture and Retrofitting

A sustainable architectural design of future buildings has a very high energy saving potential. These eco-friendly housing designs are not only sustainable, but in many cases cost effective in terms of capital expenditure and energy requirements. Bamboo-based and other wood-based architectural concepts have been adopted only on a very limited

[1] C.G. Heaps. 2012. Long-range Energy Alternatives Planning (LEAP) System. Stockholm Environment Institute, Somerville, MA, USA. www.energycommunity.org.

level in Kerala. Interactions with practicing architects indicated that the use of naturally available material substantially reduced lighting and space cooling requirements, besides imparting an exotic look to the built facade. There are also modern architectural concepts (green buildings) that draw heavily on integrated planning and modern material use. Many of these designs have in fact achieved huge energy savings. Fortunately, many of these aspects are taken cognizance of and are covered in the state's Green Building Policy. A strengthened policy with aggressive targets and compliance norms will be able to affect an aggressive intervention in target-based compliance in energy use standards of existing and new buildings.

Retrofitting of existing houses is another area of action that may be critical. Apart from change in lighting and electric fixtures, retrofitting can also include activities like installing windows with high or low heat gain, depending on wind direction and shading of the region; white vinyl roofing (inherently reflective), changes in orientation and house compound for enhancing natural lighting and cross ventilation of rooms etc. Even though, the energy saving potential of residential structures is very much site and plan specific, a study by TERI titled *India's Energy Security: New Opportunities for a Sustainable Future*[2] suggests that 30 per cent reduction in energy demand is possible through aggressive retrofits and new building standards.

It is assumed that by 2030, 70 per cent of the new houses constructed will comply with sustainable building techniques and energy efficiency and conservation retrofits. This would translate into an overall saving potential of 10 per cent by 2030 starting from 2020.

- Use of Super-Efficient Appliances

Recent studies of appliance sales in Kerala indicate that consumers have become more quality conscious and sensitive to operational costs of appliances.[3] Considering this, it is assumed that the move to super-efficient appliance can be very successful in Kerala. Based on recent studies, the possibility of energy intensity reduction by using super-efficient appliances in the domestic sector is mapped to assess the potential of energy intensity reduction across each appliance category.

The detailed assessment of this mapping is captured in Annexure 5A.

Based on this mapping, it is assumed that 100 per cent penetration of CFL/LED and energy rated/super-efficient fans can be achieved by 2030. For all the other appliances, a policy guided accelerated adoption of super-efficient appliances (air conditioners, refrigerators, televisions etc.), is assumed with a 2030 penetration level of 60 per cent.

- Sustainable and Efficient Cooking

On the domestic cooking side, a move towards more sustainable and efficient cooking appliances is projected. A counter trend by shifting cooking fuel share towards sustainable fuel source, namely biogas is also proposed. The general perception is that biogas

[2] TERI. 2009. *India's Energy Security: New Opportunities for a Sustainable Future*. The Energy and Resource Institute, New Delhi, India. pp. 15. http://www.teriin.org/events/CoP16/India_Energy_Security.pdf, accessed on 13 April 2015.
[3] Winrock International and EMC. 2010. *Survey and Collection of Data Concerning Manufacturing, Sales of Household Appliances and Other Equipment at Kerala State Falling under the EC Act and Other Selected Equipments/Appliances and Submission of Data, Analysis, Presentation and Report complete. Final Report (Task 1).* Winrock International, India and Energy Management Centre, Kerala. (March) pp. 11. http://www.keralaenergy.gov.in/emc_reports/Survey%20of%20Appliances%20and%20Equipments%20falling%20under%20EC%20Act%202001.pdf, accessed on 13 April 2015.

availability in normal household biogas digesters is not sufficient to meet all the cooking requirements. Field interaction with experts, biogas users and local households revealed that daily biogas generation could just about sustain a maximum of two hours of cooking on a single burner. Households with biogas were generally using it for water heating or other non-essential activities.

Furthermore, the major problem cited by households in installing new biogas systems was the quality of work and the cost of labour for installing underground systems. To overcome these constraints, a number of manufacturers have come up with portable biogas systems. Portable plants enable the users to install the plants anywhere on the ground or on the roof top without much effort. Besides household wastes and bio-wastes can be disposed of in a useful manner and the slurry obtained from the digester is a good source of manure and can substitute the demand for fertilizers. Furthermore, as majority of the residences in Palakkad are independent houses, where there is huge scope for installing new individual household-level systems. Even a partial use of biogas can significantly reduce dependence on LPG. It is also assumed that future demand would spur more R&D leading to better efficiencies and yield. Considering improved penetration and better future yields, 11 per cent substitution of LPG with biogas by 2030 is assumed. (Shift to biogas also considers availability of biogas. A detailed resource assessment of biogas potential is covered in Part II of the study).

The second sustainable resource for cooking considered in the study is wood. Wood and wood residues are available in almost all households with moderate land size. In the case of shift to LPG, this sustainably generated wood (mainly natural fallings) is not often used and is allowed to rot away. The difficulties related to labour availability and wages also preclude the possibility of collecting wood and bringing it to a centralized location. This would suggest that fulfilling some cooking requirements through wood (counter to the present trend) would, in fact, be a very good localization strategy. A policy driven push for including sustainable wood fallings as a cooking fuel with efficient biomass-based cook stoves can be very useful. One of the strategies for adopting this measure is by creating groups at the community level to collect such potential wood fallings, process it as per requirements in cook stoves and distributing it to the houses within the community. It is assumed that such an organized system will be available by 2020 and wood consumption for cooking can be stabilized afterwards till 2030. In addition, using improved cook stoves in place of traditional cook stoves can save about 40 per cent of fuel wood and 100 per cent penetration of efficient wood stoves is assumed by 2030. It is further assumed that wood used in cooking would remain stable after 2020.

The Energy Management Centre with the support from the Department of Science and Technology has developed a new model of Thermal Cooker called "Urja-II".[4] This thermal cooker has higher

[4] Energy Management Centre.n.d. "New Thermal Cooker". Department of Science & Technology, Government of India, New Delhi. http://www.keralaenergy.gov.in/pdf/urja2.pdf, accessed on 13 April 2015.

thermal efficiency and reduces energy requirement from cooking fuel by almost 70 per cent. It is assumed that at least 10 per cent households could adopt energy saving thermal cookers by 2030. This would translate into a total energy savings of 8 per cent.

Intervention Scenario 2–CS

The two major interventions in CS for electricity demand include a small switch to electricity-based and solar-based cooking.

- Increased Use of Electricity in Cooking

  In line with the change in living standards, a move towards increasing use of electricity for cooking is also factored in. In general, electric cook stoves (induction heaters, microwave) are significantly more efficient than simple combustion-based gas stoves. According to research conducted by EMC, Kerala, the thermal efficiency of induction plates is about 23 per cent more than that of an efficient LPG stove.[5] This would result in quicker heating and may prompt working families to migrate to electricity. Even though this may be desirable from the point of view of total energy demand, the switch may create electrical load balancing problems as the cooking demand generally coincides with system peaks. In view of the same, a moderate level of penetration of electric heating of about 7 per cent by 2030 is assumed. It is assumed that the increase in electric cook stoves displaces other cooking fuels (LPG, wood, biogas).

- Increased Use of Solar Cookers and Solar Water Heaters

  Another possible intervention is using solar water heaters for pre-heating the water, especially used for cooking rice, which is the staple food of the district. This pre-heated water, combined with the use of efficient thermal cookers, can reduce cooking fuel demand by a substantial amount. Since there are no qualitative justification for the LPG demand reduction through this strategy, this intervention is not factored in the demand curtailment process.

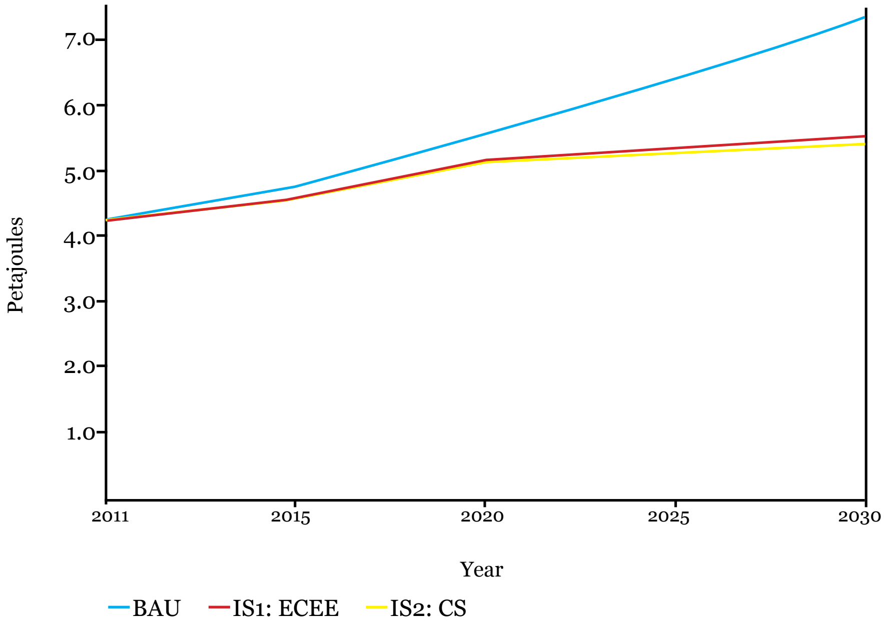
Based on the proposed interventions, the final demand evolution and curtailed demand for the domestic sector is shown in Table 9.1.

TABLE 9.1: DOMESTIC SECTOR — ENERGY DEMAND EVOLUTION

Domestic Energy Demand Evolution (PJ)	2011	2015	2020	2025	2030
BAU	4.26	4.78	5.56	6.37	7.37
IS1–ECEE	4.26	4.59	5.15	5.35	5.52
IS2–CS	4.26	4.59	5.13	5.32	5.45

[5] Harikumar, R. n.d."Induction Cooker – A Brief Investigation".Energy Management Centre, Kerala. http://www.keralaenergy.gov.in/emc_reports/Induction%20Cooker_a%20brief%20investigation.pdf, accessed on 15 April 2015.

FIGURE 9.1:
DOMESTIC SECTOR — ENERGY DEMAND EVOLUTION



COMMERCIAL SECTOR INTERVENTIONS

Commercial sector electricity requirements currently form 9 per cent of the total requirements of the district. However, this sector may experience growth considering the plans of the government on developing new infrastructure in the district.

Intervention Scenario 1 –ECEE

The three main strategies considered for the commercial sector are accelerated adoption of green building norms, retrofitting and super-efficient appliances.

- Increased Penetration of Green Buildings

  There is huge scope for green/environment friendly buildings in the commercial sector. Two cases in the energy-efficient buildings include Wipro's and ITC's Gurgaon office complexes, having a floor area of nearly 1,70,000 ft^2. The percentage reduction in electrical energy consumption of these two buildings as compared to conventional buildings is to the tune of 40 per cent and 45 per cent respectively.[6] Even at a smaller scale, CII Godrej's building with a floor area of 20,000 ft^2 is 63 per cent less energy intensive as compared to a conventional building of the same size. The main difference comes from integrated planning and better use of materials. Even though these buildings generally cost at par with conventional buildings, these levels of energy footprints can help them achieve breakeven very early. The move to green buildings can perhaps be the most effective way to manage future energy without compromising the growth of the services sector that is going to be the centre piece of the state's economy.

[6] Kumar, D. Sendil and Pugazhvadivu, M. 2012. "Green Buildings: Prospects and Potential". *Journal of Engineering Research and Studies*. http://www.technicaljournalsonline.com/jers/VOL%20III/JERS%20VOL%20III%20ISSUE%20IV%20OCTOBER%20DECEMBER%202012/Article%202%20Vol%20III%20Issue%20IV.pdf, accessed on 13 April 2015.

The state government has already defined these objectives in the Housing Policy 2011[7] and the Green Building Policy 2011[8]. It is assumed that these policies are strengthened further by formulation of progressive regulations that specify compliance targets for all new and old buildings. It is assumed that all new malls, IT parks, large commercial buildings and hotels are encouraged to adopt green building norms starting 2020. Consequently, a 20 per cent reduction in electricity demand is assumed for all new building from 2020. Effectively, this is factored as a reduction of 20 per cent in additional electricity demand every year after 2020 without assuming any reduction in the base demand.

- Retrofitting of Existing Buildings

There is also a great scope for energy reduction in existing buildings through retrofit. One case in point is the Godrej Bhavan Building in Mumbai, where retrofit involving new lighting, glazed windows, roof garden and other measures reduced energy consumption by about 12.3 per cent.[9]

Fortunately, the Government of Kerala is also particularly active in supporting energy efficiency measures through retrofits. Energy Management Centre (EMC) is the state's designated agency to implement the Energy Conservation Act, 2001. EMC has encouraged energy auditing of government and private office buildings by financing 50 per cent of the auditing fees, which is done for identification of cost-effective energy savings and relative measures.[10] In 2014-15, the outlay of funds allocated is 105 lakh for the purpose of identification and implementation of energy conservation activities.[11]

For government offices and other public sector buildings the Performance Contracting Scheme has been introduced under KSECF for identifying, construction, implementation and maintenance of buildings for complying with the efficiency norms. Performance contracting allows private energy service companies to design, construct, implement and maintain the buildings offering performance guarantees in terms of cost reductions for saving energy consumed. A similar scheme has been launched for energy efficiency projects where the government will provide grant for 50 per cent of the costs of the project.[12]

For commercial sector consumers the Interest Buy Down Scheme provides the opportunity for replacing technologies/equipment with cost and energy saving equipment, at 4 per cent lower rate than the market interest rate for the first five years of the repayment period.[13] The move to green buildings can perhaps be

---

[7] GoK. 2011. "Kerala State Housing Policy (Draft)". Department of Housing, Government of Kerala. (August). http://www.kerala.gov.in/docs/policies/drafthpolicy11e.pdf, accessed on 13 April 2015.
[8] GoK. 2011. "Green Building Policy (Draft)". PWD Architecture Wing, Government of Kerala. http://www.keralapwd.gov.in/keralapwd/eknowledge/Upload/documents/1599.pdf, accessed on 13 April 2015.
[9] Planning Commission. 2014. *The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth*. Planning Commission, Government of India, New Delhi. pp. 54. India. http://planningcommission.nic.in/reports/genrep/rep_carbon2005.pdf, accessed on 13 April 2015.
[10] International Resources Group and EMC. 2009. *Kerala State Energy Conservation Fund (KSECF) Financing Schemes*. International Resources Group Ltd. and Energy Management Centre, Department of Power, Kerala. (November) pp. 8.http://www.keralaenergy.gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20CONSERVATION%20FUND%20%28KSECF%29%20FINANCING%20SCHEMES.pdf, accessed on 13 April 2015.
[11] GoK. 2014. *Annual Plan Write-up 2014. Chapter V. "Energy". Kerala Budget 2014-15*. Finance Department, Government of Kerala. pp. 151. http://www.finance.kerala.gov.in/index.php?option=com_docman&task=doc_download&gid=6378&Itemid=57, accessed on 13 April 2015.
[12] International Resources Group and EMC. 2009. *Kerala State Energy Conservation Fund (KSECF) Financing Schemes*. International Resources Group Ltd. and Energy Management Centre, Department of Power, Kerala. (November) pp. 21. http://www.keralaenergy.gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20CONSERVATION%20FUND%20%28KSECF%29%20FINANCING%20SCHEMES.pdf, accessed on 13 April 2015.
[13] Ibid.

the most effective way to manage future energy demands without compromising the growth of the services sector.

Assuming efficacy of strong policy measures and increased commercial electricity prices, it is assumed that 50 per cent of all old buildings will be retrofitted by 2030. A conservative target of 10 per cent energy reduction is assumed from retrofitting.

- Increased Penetration of Energy-Efficient Equipment

For factoring in aggressive intervention, targeted changes in appliance shares and appliance energy intensities have been factored over the BAU share projections. Even though the relative shares of end-use activities (lighting, space conditioning and refrigeration) have been assumed to be constant throughout the projection period, it is further assumed that 65 per cent of the total lighting demand is met by tube lights (FTL) and 30 per cent by CFLs in the base year (2011). The space conditioning demand is assumed to be met from fans and air conditioners. For fans and air conditioners, categorization is done in terms of efficiency of a normal air conditioner vis-à-vis a super-efficient air conditioner. Refrigeration is also categorized as existing and super-efficient.

The energy intensity values of different appliances are normalized assuming a value of 1 for the lowest efficiency device. The reference for appliance efficiency is taken from Prayas Energy Group's study on potential saving from super-efficient appliances in household.[14]

It is assumed that commercial establishments will be quick to migrate to energy-efficient equipment considering their huge cost and energy saving potential. Table 9.2 shows the appliance penetration and energy intensity levels for the future based on above assumptions.

TABLE 9.2: APPLIANCE PENETRATION LEVELS AND ENERGY INTENSITY EVOLUTION – COMMERCIAL SECTOR

Lighting Share	EI Scale	2015	2020	2025	2030
FTL	1	65	25	0	0
CFL	0.58	30	45	35	25
LED	0.29	5	30	65	75
EI Evolution		0.84	0.60	0.39	0.36
Fans Share	**EI Scale**	**2015**	**2020**	**2025**	**2030**
Existing	1	95	80	65	40
Super-Efficient	0.68	5	20	35	60
EI Evolution		0.98	0.94	0.89	0.81
ACs Share	**EI Scale**	**2015**	**2020**	**2025**	**2030**
Existing	1	80	50	30	10
Super-Efficient	0.65	20	50	70	90
EI Evolution		0.93	0.883	0.76	0.69
Refrigeration Share	**EI Scale**	**2015**	**2020**	**2025**	**2030**
Existing	1	90	75	60	40
Super-Efficient	0.5	10	25	40	60
EI Evolution		0.95	0.88	0.8	0.7

[14] Chunekar, Aditya, Kadav, Kiran, Singh, Daljit and GirishSant. 2011. *Potential Savings from Selected Super-Efficient Electric Appliances in India: A Discussion Paper*. Prayas Energy Group, Pune, India.

Intervention Scenario 2 – CS

- Increased Use of Biogas

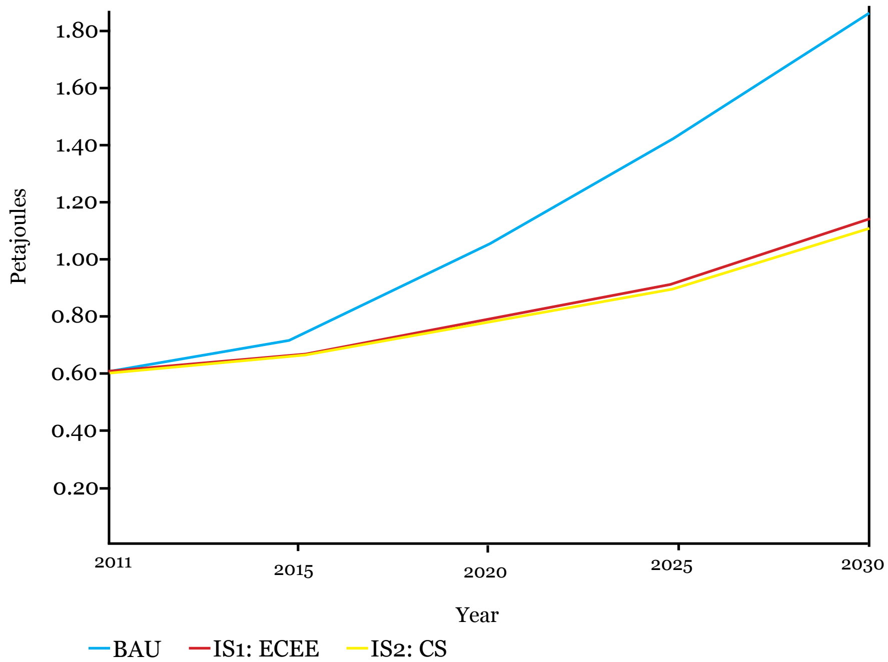
A major intervention for commercial cooking purposes is the adoption of biogas. This can be an effective step for both LPG saving and managing waste. Portable bio digesters of different sizes are available. These types of digesters can be used in canteens and hotels, as a substantial amount of waste is also generated in these establishments. On an average 10 kg of waste can produce 3 cum of biogas, which can provide 6-8 hours of gas supply for cooking in a single burner.[15] This can effectively reduce LPG needs up to 50 per cent. It is assumed that 10 per cent of the establishments having fuel demand for cooking will switch to biogas by 2030. Considering these, an effective 5 per cent reduction in total LPG use in the commercial sector is assumed by 2030.

Based on the above interventions, the final demand evolution for the commercial sector is shown in Table 9.3.

TABLE 9.3: COMMERCIAL SECTOR — ENERGY DEMAND EVOLUTION

Commercial Energy Demand Evolution (PJ)	2011	2015	2020	2025	2030
BAU	0.62	0.73	1.01	1.38	1.82
IS1–ECEE	0.62	0.67	0.79	0.91	1.11
IS2–CS	0.62	0.67	0.78	0.89	1.08

FIGURE 9.2: COMMERCIAL SECTOR DEMAND EVOLUTION



[15] SEC. n.d. "Green Energy Portable Bio Gas Plant for Homes, Restaurants, Canteens etc.". http://www.southelectric.in/PORTABLE%20BIOGAS-Mailer.pdf, accessed on 13 April 2015.

INDUSTRY SECTOR INTERVENTIONS

In Palakkad, large energy intensive industries are represented by a handful of units, spread across small-scale and medium-scale enterprises involved in metals and alloys, engineering, minerals and metals, textiles, metals, food processing etc. For the study, the two main strategies assumed are that of energy conservation and efficiency and a limited level of carrier substitution. For some industry sectors, even less capital intensive technologies may be more effective than others. Base-level strategies on energy conservation could start from something as simple as switching off excess lights, optimizing space condition/refrigeration temperature, better heat insulation, better material use etc. The next level of strategies could be oriented towards equipment efficiency involving equipment upgradation/replacement aimed at increasing process efficiency: switch to efficient motors, efficient lighting solutions, variable frequency drives for motors, waste heat recovery system etc. The highest level of intervention would involve an overhauling of the entire process or unit and reduction in energy intensity of manufacturing through natural technological evolution.

In the intervention strategy for the industry, energy saving potential through all the two levels of strategies is factored. But considering the fact that the industrial sector is capital intensive and capacity intensive, the inertia associated with changing industrial processes will be large and not all sectors and industrial units will be in a position to shift to better process technologies in the near future because of multiple constraints in capital availability, technology availability, future plans etc. In cases, where strategies involve process level interventions, a time lag in adoption of new technologies is assumed to factor in slow pace of process overhauls in existing industries and adoption of these technologies in new greenfield projects.

Intervention Scenario 1 – ECEE

The two key measures considered under this strategy are energy conservation targets for existing industries and energy efficiency targets for new industries.

- Energy Conservation for Existing Industries

  Considering the diversity of industries in Kerala, the best option to understand intervention possibility in energy conservation measures is through local/state-based and national-level studies. The main inputs included some actual case studies of industries in Kerala and other studies by the Energy Management Centre, Kerala and BEE. The estimation of the conservation potential in heat demand is derived from numerous other sector-specific studies and other independent case studies. Based on assessed literature and energy audit studies, specific energy conservation targets ranging from 10 to 20 per cent are assumed across electricity and heat used across the ten industrial clusters.

The detailed assessment of the base energy conservation potential across the ten industrial clusters is covered in the Annexure 5B.

- Establishment of Energy-Efficiency Standards for New Industries

  In addition to the proposed energy conservation measures, it is also proposed that all new manufacturing units, particularly in the four key sectors –agro and food processing, textile, metals and alloys, and engineering and industrial goods–to be established after 2022 will be mandated to have the best available technology as on date. Studies suggest that the current best available technologies are at least 20 per cent less energy intensive than the current industry benchmark (*The Energy Report: 100% Renewable Energy by 2050*).[16] Applying a new energy intensity benchmark of 80 per cent in terms of specific electricity and heat consumption for these four industry sub-sectors over current industry benchmarks (only to new capacities coming up after 2022) will help in reducing total industrial energy requirements. This intervention has also been explicitly factored in this intervention scenario.

Intervention Scenario 2 –CS

The main intervention considered is the use of solar heating application. The main strategy considered in this scenario is the vast potential for use of solar energy devices/systems in industries for process heat and other thermal applications. Solar air heating systems based on flat plate collectors have been found to be useful in food processing industries for drying of various food products. These industries generally require hot air at low temperature (50-80°C) as process heat for drying of products such as tea leaves/coffee beans, and also for processing of fruits, spices, cereals, mushroom, vegetables, fish, seafood etc. Hot air is also required in industries such as leather, textiles, chemicals, rubber, paper, pharmaceuticals etc.

The study by MNRE on solar process heating potential for industry[17] assessed process heat requirements across various industry sub-sectors and has identified low-grade process heat requirements (up to 90° C) that can be supplied by commercially available Evacuated Tube Collector (ETC) and Flat Plate Collector (FPC) technologies. The study identifies agro and food processing, textile, and paper and pulp as the three major industries, where low-grade heat requirements, mainly for hot water or steam, can be replaced with solar process heating to the extent of 25 per cent.

For industries such as textile, chemical, rubber, paper and pulp, and food processing, which mostly use low-grade heating, a displacement of 20 per cent in heat use by solar heating applications is assumed by 2030.

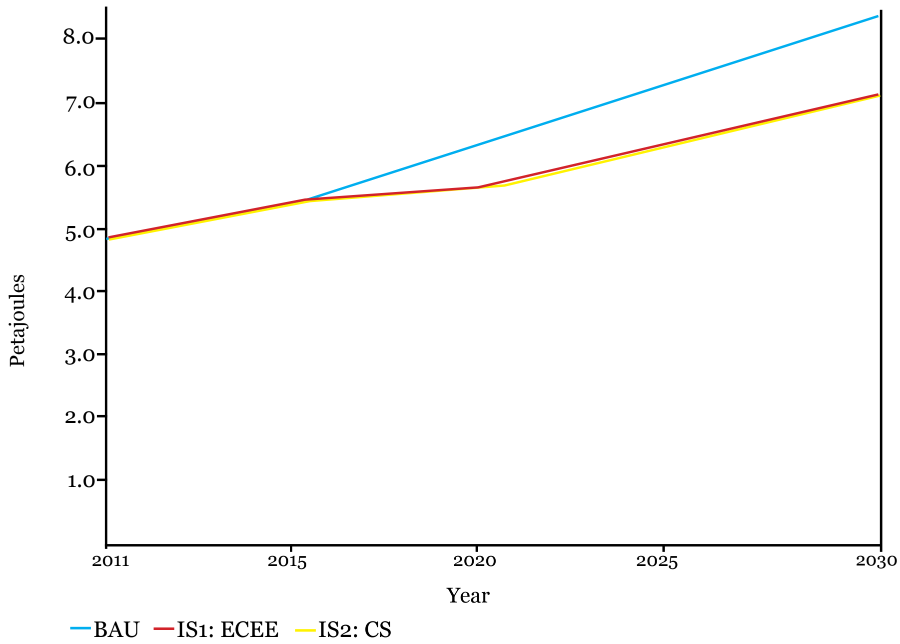
[16] WWF International. 2011. *The Energy Report: 100% Renewable Energy by 2050*. Avenue du Mont-Blanc, Switzerland.
[17] MNRE. 2011. *Identification of Industrial Sectors Promising for Commercialization of Solar Energy*. Ministry of New and Renewable Energy, Government of India. http://mnre.gov.in/file-manager/UserFiles/identification_of_insdustrial_sectors_promising_for%20_commercialisation_of_solar_energy_ComSolar.pdf, accessed on 13 April 2015.

Table 9.4 below shows the industrial sector demand evolution.

TABLE 9.4:
INDUSTRIAL SECTOR - ENERGY DEMAND EVOLUTION

Industry Energy Demand Evolution(PJ)	2011	2015	2020	2025	2030
BAU	4.79	5.39	6.40	7.36	8.33
IS1–ECEE	4.79	5.39	5.66	6.43	7.08
IS2–CS	4.79	5.39	5.65	6.41	7.04

FIGURE 9.3:
INDUSTRIAL SECTOR - ENERGY DEMAND EVOLUTION



AGRICULTURAL SECTOR

Irrigation for agricultural usage requires considerable amount of electricity and diesel fuel for pumping, tillage and transport requirements. In Palakkad agricultural electricity consumption is approximately 30 per cent of Kerala's irrigation consumption. Reducing energy consumption while maintaining or improving on productivity requires efficient pumps and efficient water usage systems. However, agricultural pump-sets and system sizing are typically based on local norms, availability and price. The pumps utilized for agricultural purposes are mostly of 5HP standards, locally manufactured with efficiencies ranging between 20 to 30 per cent.[18] Technically, for a given head and a required discharge, a customized design of pump size, pump type and piping size can actually give an efficiency of 50 to 60 per cent.

As electricity supply to agriculture is mostly subsidized or unmetered, there is no incentive for the farmers to install efficient equipment or use less water. Most of the strategies in addressing energy use in agriculture have focused on pump-set improvement scheme and water use management schemes.
Tractors account for the major fuel use in this sector. The used of tractors in agriculture are increasing in Palakkad. Studies indicate that through operational improvements, there is a possibility of improvement in fuel

[18] Saini,Sarabjot Singh. 2013."Pump Set Energy Efficiency: Agricultural DSM Program". *International Journal of Agriculture and Food Science Technology* 4 (5): 493-500.

efficiency. This possibility is also considered as a demand curtailment strategy. Based on this understanding the key strategies proposed under the two intervention scenarios are covered below.

Intervention Scenario 1 –ECEE

- Increased Use of Micro-Irrigation

  Agricultural Development Policy (Draft) 2013, Government of Kerala identifies micro-irrigation as one of the focus areas. The policy draft section on micro-irrigation includes aspects like reduced conveyance loss, reduced evaporative loss and allowing deep percolation. However, the actual implementation potential for such a scheme is dependent on the choice of crops.

  The National Mission on Micro Irrigation launched by the Government of India provides subsidy to farmers drip or sprinkler irrigation systems for crops like coconut, cashew, pepper, areca nut, cocoa, cardamom, banana, medicinal plants, other fruits and vegetables etc. The design specifications and the technology for micro-irrigation have been specified by the central government, which could potentially save 40 to 50 per cent energy consumption for irrigation of that area[19] because of reduced water requirement and pumping. This scheme has already been launched in Kerala in 2012.

  Based on the above considerations it is assumed that 50 per cent of the irrigated land will adopt micro-irrigation technique by 2030. This will translate into a 25 per cent reduction in energy requirements for agriculture by 2030.

- Increased Penetration of Efficient Pump Sets

  According to the report on the impact of Energy Conservation Act by Winrock,[20] the efficiency of irrigation pumpsets can be enhanced up to 50-52 per cent (30-40 per cent energy saving) by adopting BEE star-labelled agricultural pumpsets. In line with the study, replacement of 40 per cent agricultural pumpsets with BEE star-labelled pumpsets (assuming 35 per cent lower energy intensity) is assumed during the study period.

- Better Fuel Efficiency of Tractors

  The use of tractors in agriculture is increasing in Palakkad. A study on user guide for the agricultural sector,[21] by 2031, 22 per cent of fuel reduction is possible by better operational practices, following good maintenance practices, combining operations to reduce trip over the fields. In line with this study, a 22 per cent reduction in energy use in tractors is assumed by 2030.

Intervention Scenario 2 –CS

The major substitution proposed is the utilization of solar powered

---

[19] Directorate of Agriculture. 2013. "National Mission on Micro Irrigation (NMMI) – Implementation of the Scheme 2013-14". Government of Kerala.http://www.keralaagriculture.gov.in/pdf/wi_16012014_02.pdf, accessed on 13 April 2015.
[20] Winrock International and EMC. n.d. *Impact of Energy Conservation Act in State of Kerala*. Winrock International, India and Energy Management Centre, Kerala. pp. 36. http://www.keralaenergy.gov.in/emc_reports/Impact%20of%20Energy%20Conservation%20Act%20in%20the%20State%20of%20Kerala.pdf, accessed on 13 April 2015.
[21] Planning Commission.n.d. *User Guide for Agricultural Sector*. India Energy Security Scenario, 2047. Government of India, New Delhi, India. http://indiaenergy.gov.in/doc/d9_deatledAgriculture.pdf, accessed on 13 April 2015.

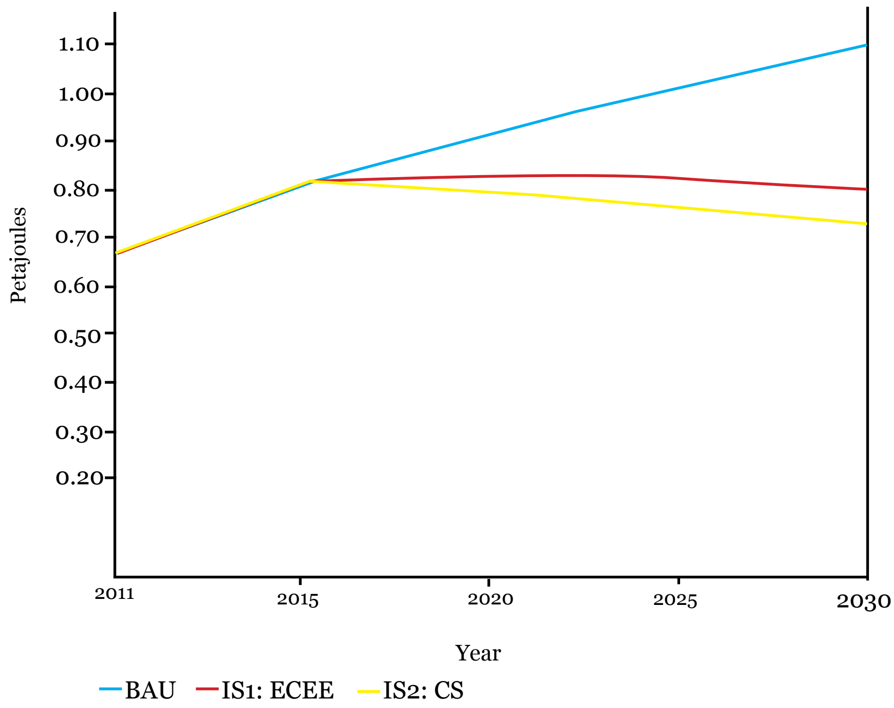
water pumps for irrigation. The ground water level in Palakkad varies from 2 to 12m bgl (pre-monsoon) and 1 to 8m bgl (post-monsoon). Coincidentally, solar PV pumps available in market with the capacities ranging from 0.5HP to 2HP can easily pump water from a depth of 10 to 12m maximum for irrigation. This is highly favourable for disseminating solar PV pumps on a large scale in Palakkad.

With expected cost reductions in solar panels and increase in electricity price, it is expected that farmers will increasingly opt for solar water pumping. It is assumed that a concerted push for adoption of solar pumping can help achieve a penetration of 60 per cent of solar water pumps by 2030. It is further assumed that branded solar pumps will have efficiencies similar to those of BEE start-rated agricultural pumps. Based on the above assumption, the demand evolution of the agriculture sector is shown in Table 9.5 and Figure 9.4 below.

TABLE 9.5:
AGRICULTURAL SECTOR – ENERGY DEMAND EVOLUTION

Agriculture Energy Demand Evolution(PJ)	2011	2015	2020	2025	2030
BAU	0.67	0.81	0.92	1.01	1.08
IS1–ECEE	0.67	0.81	0.83	0.82	0.80
IS2–CS	0.67	0.81	0.79	0.76	0.73

FIGURE 9.4:
AGRICULTURAL SECTOR – ENERGY DEMAND EVOLUTION



PUBLIC UTILITIES

The main interventions that are proposed in these sub-sectors are changing street lighting technologies, adoption of energy efficient pumps and reduction in water transmission losses.

Intervention Scenario 1–ECEE

- Intervention in Water Supply Networks

  The report on the Integrated District Development Plan[22] of Palakkad indicates that a number of LSG areas are severely affected by old pipelines in the distribution system. However, available data from Kerala Water Authority indicate that about 20 to 30 per cent distribution loss took place from 2006 to 2010 in Kerala. *The Energy Report– Kerala* identified that a target based reduction by line renovation and pumping can result in saving potential of 17 per cent by 2025.

  However, considering the large rural spread of the population in Palakkad, conservative targets with a reduction potential of 5 per cent by 2020, 10 per cent by 2025, and 15 per cent by 2030 are assumed.

- Street Lighting

  According to the report, *Energy Savings Potential for Street Lighting in India*, use of LED street lights and efficient linear fluorescent lights have the potential to reduce energy use by 36 per cent.[23] However, according to a report from Energy Management Centre, the energy savings potential for street lighting is assessed up to 25 per cent.[24]

  In line with the EMC study, a target of 25 per cent energy savings by 2030 in street lighting is modelled.

Intervention Scenario 2–CS

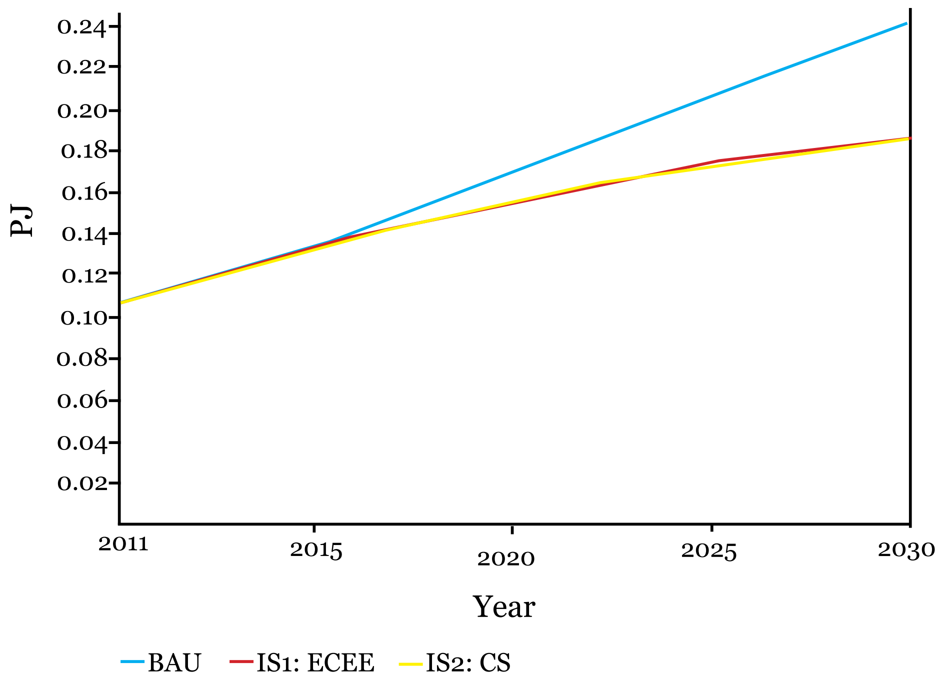
The main strategy considered under this intervention is the replacement of 50 per cent of the conventional street lights with solar street lights by 2030. Table 9.6 and Figure 9.6 below show the energy demand evolution of public lighting.

TABLE 9.6: PUBLIC LIGHTING – ENERGY DEMAND EVOLUTION

Public Lighting Energy Demand Evolution (PJ)	2011	2015	2020	2025	2030
BAU	0.11	0.13	0.17	0.21	0.24
IS1–ECEE	0.11	0.13	0.16	0.17	0.18
IS2–CS	0.11	0.13	0.16	0.17	0.18

[22] Department of Town and Country Planning. 2013. *Integrated District Development Plan – Palakkad*. Volume I. Special Technical Advisory Group, District Planning Committee, Palakkad, Kerala.
[23] Johnson, Alissa, Phadke, Amol and Rue du Can, Stephane de la. 2014. *Energy Savings Potential for Street Lighting in India*. Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory. pp. 13. http://eetd.lbl.gov/sites/all/files/lbnl6576e.pdf, accessed on 13 April 2015.
[24] Winrock International & EMC. n.d. *Impact of Energy Conservation Act in State of Kerala*. Winrock International, India and Energy Management Centre, Kerala. pp. 36. http://www.keralaenergy.gov.in/emc_reports/Impact%20of%20Energy%20Conservation%20Act%20in%20the%20State%20of%20Kerala.pdf, accessed on 13 April 2015.

FIGURE 9.5:
PUBLIC LIGHTING – ENERGY DEMAND EVOLUTION



TRANSPORT SECTOR INTERVENTIONS

The BAU scenario seems to confirm what many experts have already consider to be a major problem: high energy and economic cost of transport in Kerala. The actual results suggest a share of over 50 per cent energy use in transport at the state as well as district levels. However, there is an important difference in the transport energy demand pattern in the district as compared to the state. At the state level, the bulk of the energy used comes from personal vehicle use (car, motorcycles, etc.), whereas in the case of the district, the bulk of energy used comes from heavy freight transport followed by public passenger transport (buses).

Taking into consideration the pattern of energy consumed in the transport sector in Palakkad, the main focus of the strategies is on freight and public transport systems. The intervention scenarios covered in this section try to structure a transition that is different from the BAU growth model.

Intervention Scenario 1–ECEE

The main strategies considered under ECEE include freight traffic shift from road to rail, developing energy efficiency measures for commercial transport, increased use of hybrid technologies, focus on energy conservation measures in trucking and public transport, freezing the share of personal transport at 2020 level, resource pooling through shared transport use and travel avoidance by reducing the need for transport.

- Freight Modal Shift from Road to Rail

The energy intensity of road freight is an average 10-18 times the energy intensity of rail freight travel. Although the freight share of rail in the BAU scenario is approximately 27.5 per cent in 2030, an even higher share is technically possible considering that most of the freight transport is for industrial clusters, which are spread close to the east-west spread of the rail network. It is assumed that measures like facilitating dialogue between the industries and railways, and augmenting rail network can effectively allow the railway to cater to increased freight share, reaching 30 per cent in 2020, 45 per cent in 2025 and 50 per cent in 2030. The proposed values of modal shift across the years are covered in Table 9.7.

TABLE 9.7: BAU AND PROPOSED MODAL SHIFT FROM ROAD TO RAIL

	2015	2020	2025	2030
BAU (percentage of tkm)				
Rail	22.9	25.7	25.5	27.5
Road	77.1	74.3	74.5	72.5
Proposed (percentage of tkm)				
Rail	22.9	30	45	50
Road	77.1	70	55	50

Although the proposed shift would result in an additional freight traffic handling of 3.01 billion tkm, it is assumed that this can be managed by suitable augmentation of railways signalling system, creation of new cargo depots and investment in cargo handling facilities. It is further assumed that the displaced road freight traffic can be utilized as a high frequency last mile delivery system from railway depots to industrial premises.

- Formulating New Energy-Efficiency Measures for Commercial Transport

The trucking industry in India is very energy intensive and is also very inefficient in terms of energy conservation and energy savings. The current maximum annual running distance of HCVs in India is to the tune of 75,000km as against an annual running distance of 175,000 to 200,000km by HCVs in advanced countries. Even in terms of energy efficiency, the best estimates of fuel efficiency values in the Indian trucking industry are significantly lower than those in advanced countries. A recent study by the Central Road Research Institute (CRRI),[25] suggested that there is significant potential for reduction of fuel intensity of HCVs, LCVs and transport buses. Based on case studies of successful monitoring and labelling programmes in Japan and the USA, the study assessed the potential for energy intensity reduction of these three transport modes in India up to 2030. The study findings suggested a reduction potential of 40 to 50 per cent. *The detailed efficiency scenarios for commercial vehicles are covered in Annexure 5C.*

- Increased Use of Hybrid Technologies

[25] CRRI. 2014. *Fuel Efficiency Standards of Heavy Duty Vehicles in India*. Central Road Research Institute, New Delhi. http://shaktifoundation.in/wp-content/uploads/2014/02/Fuel-Efficiency-Standards-of-HDV-in-India.pdf, accessed on 13 April 2015.

In addition to the potential for energy intensity reduction in these categories, another focus area is hybrid vehicles. In the reference scenario, the vehicle technology penetration of hybrid technologies was curtailed at 20 per cent to reflect technological changes through market forces without any policy intervention. However, a focused policy migration towards early adoption of more efficient technologies is identified as a key intervention. Technology adoption is a slow process in developing economies, but government and institutional support in technology transfer, target-based regulation, capacity building and media campaigns have the potential to significantly accelerate technology adoption. It is assumed that this happens in the form of a new transport technology policy that defines technologies of choice and stipulates timeframes for addition of new technologies. Considering the same, it is assumed that penetration of hybrid technologies in 2030 is assumed to be 65 per cent for cars and taxis, 50 per cent for jeeps and taxis, and 55 per cent for three-wheelers. *The detailed assumptions on penetration of vehicle technologies are covered in Annexure 5C.*

- Energy Conservation Measures in Trucking and Public Transport Sector

Past studies on India trucking industry's efficiency consistently point out that the reasons for low kilometrage include bad roads, inefficient loading/unloading practices, bad driving and excessive waiting times at check points and other clearance points.

For goods vehicles, maximum vehicle speeds, rate of accelerations and decelerations, frequencies of stop and start, idling time and total duration apart from actual driving pattern, are very important factors that affect the efficiency of vehicles.

In addition, past studies also emphasized that better driving practices have the potential to reduce energy intensity by about 10 per cent.[26] It is assumed that a combination of better road surface, better check post management and mandatory driving courses for trucking industry can effect a reduction of 15 per cent in fuel consumption.

In line with these studies it is assumed that 20 per cent reduction can be achieved by better maintenance and proper driving practices. *The detailed efficiency scenarios for all vehicles are covered in the Annexure 5C.*

- Freezing the Share of Personal Transport at 2020 Values

The main strategy considered under this intervention is to freeze the share of personal vehicles in total passenger volume in 2030 at 2020 values. This can be done provided public transport is strengthened, improved and overhauled to absorb the migration. In line with the delineated strategies, it is assumed that the share of cars in the total passenger transport traffic can be brought down

[26] Dalkmann, Holger and Sakamoto, Ko. 2011. *Transport: Investing in Energy and Resource Efficiency. Transport Research Laboratory, UK. United Nations Environment Program.* http://www.unep.org/transport/lowcarbon/newsletter/pdf/GER_10_Transport.pdf, accessed on 13 April 2015.

to 2020 levels by 2030. For two-wheelers, a more ambitious target of freezing the two-wheeler share to 11.9 per cent from 2020. It is further assumed that along with the decrease in the share of two-wheelers, travel by cars will be replaced by short distance buses and shared rickshaws. *The details of the proposed modal shift are covered in the Annexure 5C.*

- Resource Pooling and Shared Transport Use

One of the main strategies for optimal usage pattern for vehicles is resource pooling. Resource pooling, mainly car-pooling, bus-pooling are a very effective way of reducing energy intensity. Considering the growth in urbanization, increasing growth of industry and service sector, even a shift of 1 per cent of total personal on-road car transport into a car pool and 2 per cent into a pooled bus service by 2022 would have substantial impact. In terms of the number, this would mean a diversion of about 1,385 cars in 2022 (considering a car pool of 4 passengers and vanpool of 20 passengers). At the district level, this would translate roughly into a 77.5 per cent reduction in on-road traffic density. In line with the proposed strategy, a target-based achievement of converting 1 per cent of car transport into car pool and 2 per cent into bus pool is assumed by 2022. This would mean an effective reduction of 3 per cent of cars on account of car pool.

Another workable resource pooling strategy could be shared rickshaws/taxi services. Shared rickshaws are actually working very effectively in large urban areas and provide better frequency and a comfortable last-mile travel on high density routes, which cannot be otherwise frequently serviced by buses. The focus strategy here is development of such a hub and wheel shared transport infrastructure that connects bus/rail passengers from hub locations to last-mile destinations through shared rickshaw transport. Development of such an infrastructure would be the starting point of large-scale modal migration, especially from two-wheelers to shared bus and rickshaw transport. It is assumed that 5 per cent of the rickshaw population can be converted into a pooled rickshaw service by 2020. This would mean a reduction of 2 per cent in the distance travelled in 2020.

- Travel Avoidance by Reducing the Need for Energy-based Transport

A moderate level of voluntary shifting from personal motorized transport to non-motorized transport or walking is also assumed. This shift would not necessarily mean a reduction in consumption, but would mean a reduction in intensity of use. (Even though in reality, there could be involuntary shifts from motorized transport on account of increasing fuel prices or medium-term disruptions in supplies, such changes have not been factored here. A shift of 5 per cent of motorized transport (mainly cars) to non-motorized modes is assumed to take place by 2030.

This level of travel reduction can be achieved as for short trips, bicycling and walking can be viable alternatives as more healthy and clean travel options. The main requirement in this regard would be the local government's support to improve public infrastructure and adopt necessary administrative and traffic systems to facilitate cycling and walking. Many cities in the West use street marking to define bike lanes, and some cities provide dedicated bicycling and walking trail systems. In addition, they also encourage cycling and walking by improving safety features, such as crosswalks, sidewalks and streetlights. A similar strategy for select panchayat areas, as a start, can help achieve this target.

Intervention Scenario 2 – CS

The main strategy for this intervention is migration towards electric mobility. Electric vehicles are already a reality. Tesla motors in the USA has already developed and commercialized luxury electric sedan model (Model S) that has a range of 480kmph, a top speed of 192kmph, and a fuel efficiency of 0.15kWh/km at a speed of 80kmph. In energy terms this translates into an energy intensity that is 20 per cent of the energy intensity of a gasoline based car currently available in the market.

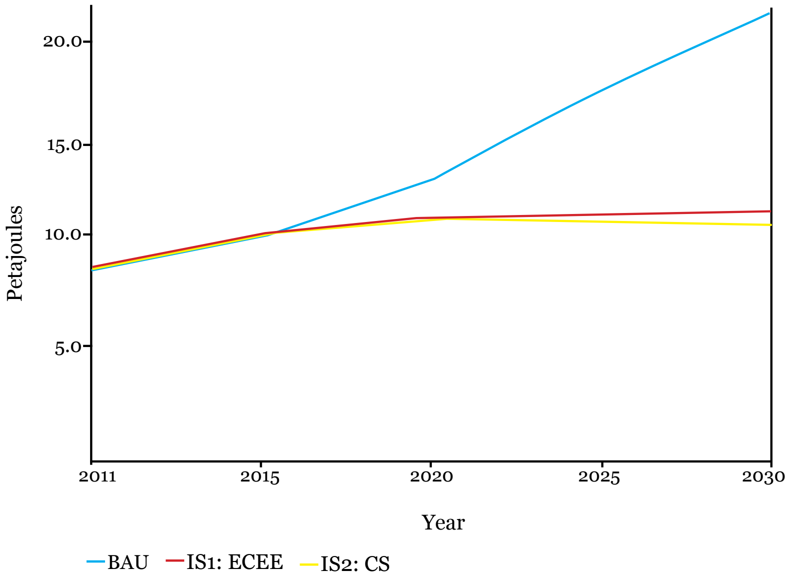
Considering Kerala's industrial policy focus on non-polluting and value creating industries, Kerala could be one of the best states to promote manufacturing of EVs and formulate a state mission for EV penetration. For this scenario, it is assumed that aggressive penetration targets for EVs are met only by 2030 considering the long gestation of technology development and commercialization. The main thrust modes for promoting EVs are two-wheelers, three-wheelers, cars, stage carriages and light commercial vehicles. It is assumed that penetration of hybrid technologies by 2030 will be 10 per cent for LCVs, 15 per cent for short distance buses, 20 per cent for cars, 30 per cent for rickshaws and 55 per cent for two-wheelers. *The detail on the proposed penetration of electric vehicles is covered in the Annexure 5C.*

Based on the above interventions, the final transport energy requirements for the district is shown in Table 9.8 and Figure 9.6.

TABLE 9.8: TRANSPORT SECTOR - ENERGY DEMAND EVOLUTION

Transport Energy Demand Evolution(PJ)	2011	2015	2020	2025	2030
BAU	9.02	10.68	13.29	17.56	21.27
IS 1: ECEE	9.02	10.68	11.68	11.79	11.94
IS 2: CS	9.02	10.62	11.52	11.41	11.23

FIGURE 9.6:
TRANSPORT SECTOR - ENERGY DEMAND EVOLUTION



SUMMARY OF THE CURTAILED DEMAND SCENARIO FOR PALAKKAD

Table 9.9 and Figure 9.7 summarize the results of the interventions.

TABLE 9.9:
FINAL ENERGY REDUCTION EVOLUTION THROUGH THREE-STEP INTERVENTION

District Demand Evolution	2011	2015	2020	2025	2030
BAU	19.47	22.51	27.33	33.87	40.11
IS 1: ECEE	19.47	22.27	24.26	25.48	26.62
IS 2: CS	19.47	22.21	24.03	24.97	25.72

FIGURE 9.7:
FINAL ENERGY REDUCTION EVOLUTION THROUGH THREE-STEP INTERVENTION

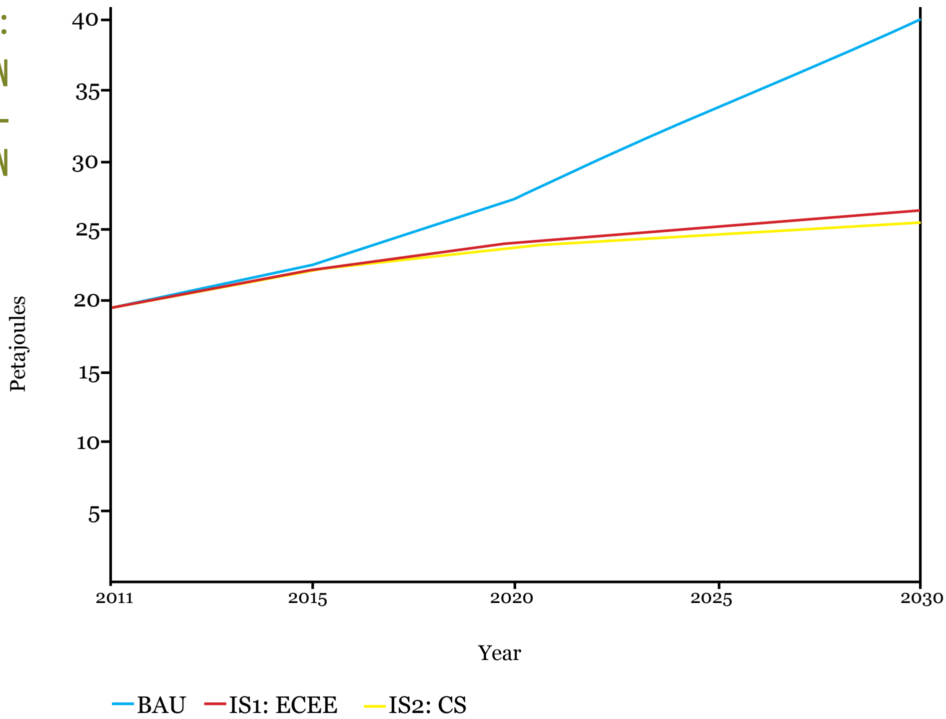


Table 9.10 and Figure 9.8 below show final demand of all sectors.

TABLE 9.10: FINAL CURTAILED DEMAND - SECTOR WISE

District Energy Curtailed Demand Scenario(PJ)	2011	2015	2020	2025	2030
Transport	9.02	10.62	11.52	11.41	11.23
Domestic	4.26	4.59	5.13	5.32	5.45
Commercial	0.62	0.67	0.78	0.89	1.08
Industry	4.79	5.39	5.65	6.41	7.04
Agriculture	0.67	0.81	0.79	0.76	0.73
Public Utilities	0.11	0.13	0.16	0.17	0.18
Total	**19.47**	**22.21**	**24.03**	**24.97**	**25.72**

FIGURE 9.8: FINAL CURTAILED DEMAND- SECTOR WISE

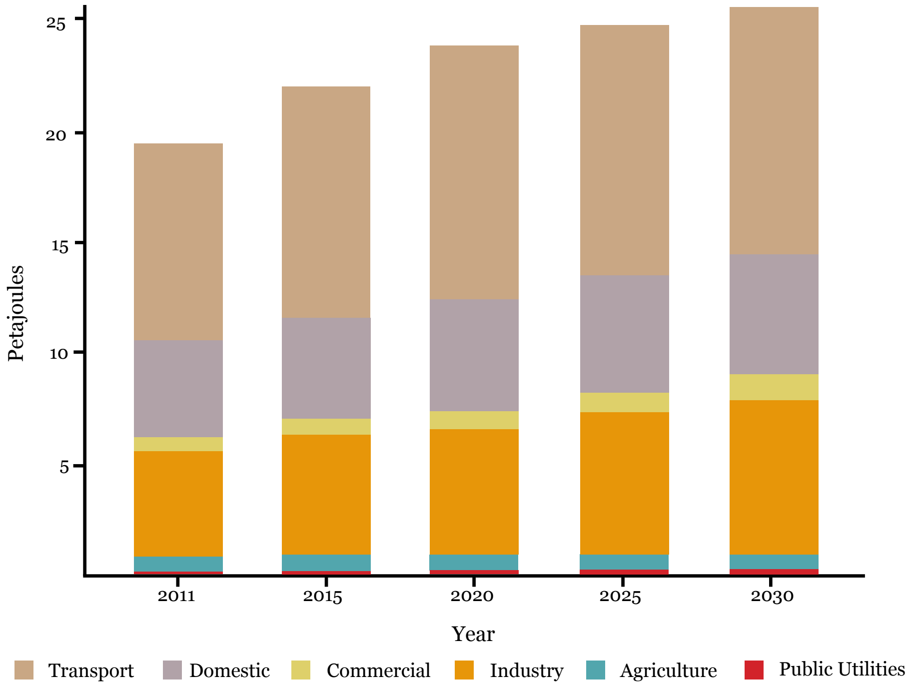


Table 9.11 and Figure 9.9 below indicate final curtailed energy demand according to fuel type.

TABLE 9.11: FINAL CURTAILED ENERGY DEMAND BY SOURCES

District Energy Demand (Fuel-Wise) (PJ)	2011	2015	2020	2025	2030
All Others	0.02	0.03	0.03	0.03	0.03
Electricity	4.74	5.35	6.17	6.94	7.73
Gasoline	1.53	1.78	2.26	1.93	1.51
Diesel	7.58	8.91	9.22	9.12	9.02
Residual Fuel Oil	0.65	0.73	0.78	0.90	1.00
LPG	1.25	1.59	1.91	1.9	1.89
Wood	2.08	1.99	1.72	1.94	2.11
Biogas	0.01	0.01	0.15	0.15	0.15
Solar		0.00	0.09	0.22	0.39
Petroleum Coke	0.60	0.67	0.58	0.58	0.58
Coal Unspecified	1.02	1.16	1.12	1.22	1.29
Total	**19.47**	**22.21**	**24.03**	**24.97**	**25.72**

FIGURE 9.9: FINAL CURTAILED ENERGY DEMAND BY SOURCES

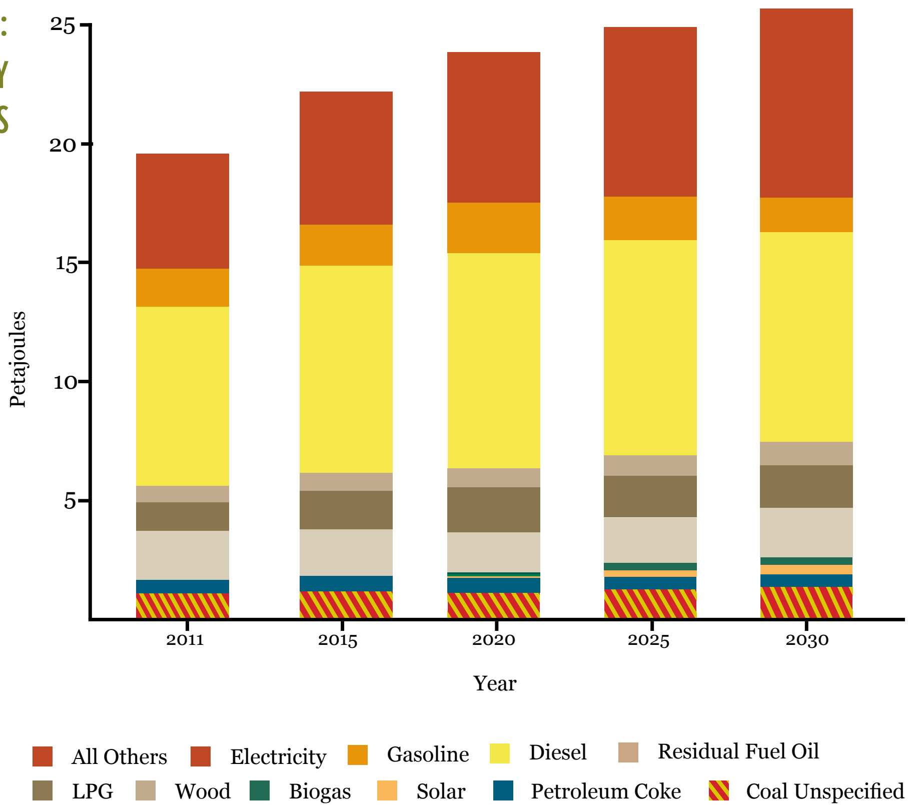


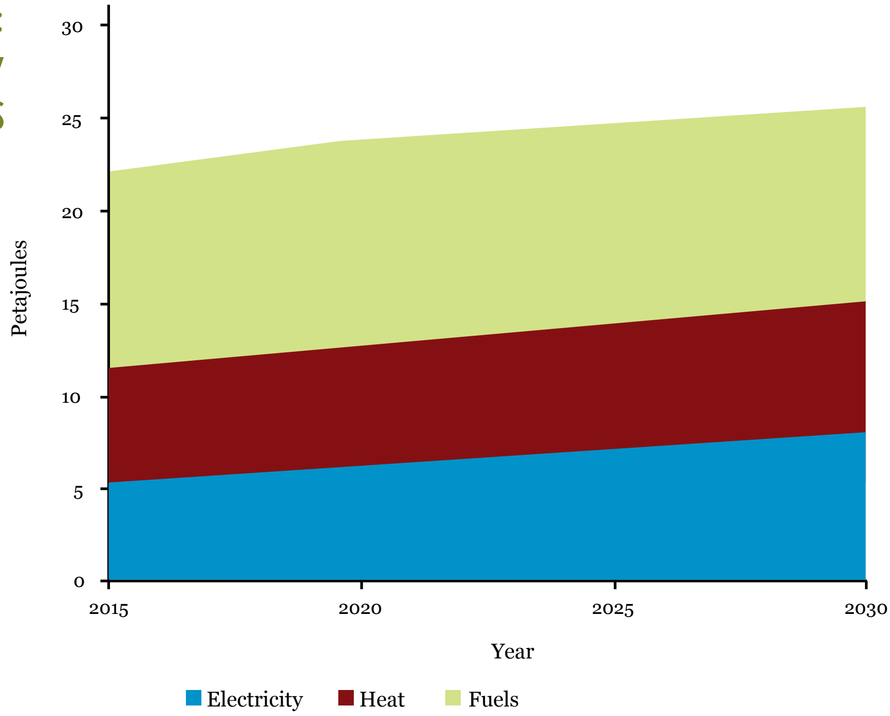
Table 9.12 and Figure 9.10 show the final curtailed demand by energy carriers.

TABLE 9.12: FINAL CURTAILED DEMAND BY ENERGY CARRIERS

Carrier - Wise Energy Mix (PJ)	2015	2020	2025	2030
Electricity	5.35	6.26	7.17	8.13
Heat	6.17	6.29	6.75	7.07
Fuels	10.69	11.48	11.05	10.53
Total	**22.21**	**24.03**	**24.97**	**25.72**

The proposed interventions indicate a reduction potential of 36 per cent in energy demand by 2030. In this background, the possibility of meeting the required demand would mean assured availability of energy supply sources, and this assurance can come only from renewable resources.

FIGURE 9.10: FINAL CURTAILED DEMAND BY ENERGY CARRIERS



CHAPTER 10

THE RENEWABLE ENERGY 2030 SCENARIO FOR PALAKKAD

Based on the earlier assessments, the supply and demand scenarios are as shown in Table 10.1

TABLE 10.1: DEMAND REQUIREMENTS AND SUPPLY POTENTIAL FOR PALAKKAD

DEMAND REQUIREMENTS	2015	2020	2025	2030
Electricity Demand (BU)	1.49	1.74	1.99	2.26
Heat Demand (PJ)	6.2	6.3	6.7	7.1
Transport Fuel (000' toe)	255.4	274.3	264	251.5
SUPPLY POTENTIAL	**2015**	**2020**	**2025**	**2030**
Electricity Supply (BU)	0.073	0.92	2.13	4.34
Heat Supply (PJ)	0.96	1.11	1.25	1.47
Fuel Supply (000' toe)	0	0	0	0

Based on the above assessment, the proposed demand supply scenario is discussed separately for each carrier.

ELECTRICITY

The above table indicates the electricity supply requirements corresponding to the curtailed demand scenario. However, these values do not consider T&D losses which would inflate the actual supply side requirements.

To assess the actual electricity supply requirements, T&D losses have been projected up to 2030 by extrapolating the T&D losses projections made by CEA in the 18th EPS report.[27] Based on the results, the estimated T&D losses and the actual supply requirements for electricity are calculated in Table 10.2 below.

TABLE 10.2: TOTAL ELECTRICITY REQUIREMENTS AFTER INCLUDING T&D LOSSES

Demand Requirement at Source	2015	2020	2025	2030
Electricity Demand (BU)	1.49	1.74	1.99	2.26
T&D losses (%)	17	14.8	13.46	12.13
Supply Requirement (BU)	1.79	2.04	2.30	2.57

The final electricity demand is more than the actual demand capacity because of the system losses and hence the final energy scenario in 2030 requires a gross supply capacity of about 2.57BU. Considering the total RE supply capability of 4.34BU, it is assessed that 100 per cent of the electricity demand can be easily be met with renewables.

Considering the constraints in developing small hydro, a maximum development of 11 MW of new hydro capacity are envisaged over an existing capacity of 5.5MW. The total energy availability of small

[27] CEA. 2011. *Report on Eighteenth Electric Power Survey of India*. Central Electricity Authority, New Delhi.

hydro considered is 0.041BU (see Chapter VI). The second RE supply option that is considered is the assessed biomass gasification and MSW combustion-based generation resource of 11.15MW. Full development of this capacity is assumed by 2030.

In addition, onshore wind resource is considered as another option. It is worth noting that the assessed figures consider potential only across identified tracts of wasteland and grassland, and does not consider potential over agricultural land, forests or built-up areas. Out of a total onshore wind potential of about 296MW only 200MW is proposed for development by 2030. This capacity includes 80MW wind power being proposed by NHPC in the district.

Grid-tied PV potential for wasteland is assessed at 1,100MW with an additional 378MW assessed to be available over grassland areas. Under the proposed scenario, development of about 400MW of grid-tied PV is assumed, mostly in identified wasteland tracts. This level of capacity deployment envisages development of only about 40 per cent of the total wasteland based potential instead of the proposed 100 per cent (see Chapter III).

Similarly, out of a total rooftop PV potential of 2,372MW (1,507MW in institutional buildings and 865MW in domestic building), only about 1,100MW is proposed for deployment by 2030, with about 300MW target for domestic rooftops and 785MW target for institutional rooftops.

Based on the above assessment, the final deployment targets and supply scenario for the power sector is shown in the Table 10.3 below.

TABLE 10.3: ELECTRICAL ENERGY AVAILABILITY FROM RE SOURCES

RE Supply Availability	Unit	Proposed Deployment			
		2015	2020	2025	2030
Small Hydro	MW	5.50	6.50	10.50	16.50
	BU	0.02	0.02	0.03	0.04
Biomass Generation	MW	4.21	6.27	8.25	11.15
	BU	0.02	0.04	0.05	0.06
Wind	MW	15.80	95.80	150.00	200.00
	BU	0.03	0.18	0.29	0.39
Grid-tied Solar	MW	2.00	100.00	250.00	400.00
	BU	0.00	0.14	0.35	0.56
Domestic Rooftop	MW	0.00	80.00	200.00	300.00
	BU	0.00	0.11	0.28	0.42
Commercial Rooftop	MW	0.00	160.00	400.00	785.00
	BU	0.00	0.22	0.56	1.10
Total Electricity	**BU**	**0.07**	**0.71**	**1.55**	**2.57**

Considering the RE source-wise energy availability shown in the Table 10.3, it can be seen that wind and solar will have to play a major role in the future energy scenario as the availability of existing technologies as large hydro is not assumed to increase. It has to be noted that the proposed level of RE development in Palakkad will be feasible even from a grid integration and power management perspective, mainly because the proposed RE supply for Palakkad would still represent small share of RE in the context of the state grid. At the regional level this penetration would not have any major impacts on the system. Another advantage of Palakkad is that the RE integration with the grid will be relatively simpler considering the availability of electrical infrastructure, due to the presence of large industrial clusters in the district.

Conventionally, operational procedures for matching demand with supply involve detailed technology suitability assessment related to dispatch amenability, technical flexibility, costs, etc., to decide on priority of generation allocation. In the conventional format, where demand driven sources dominate, supply sources are dispatched and not allocated. However, in the present context, the focus is on energy supply and availability, and not on operational feasibility and hence annual energy availability based allocation is done.

One important observation is that 100 per cent electricity from renewable is in the context of the annual power requirements. In actual practice, seasonal and diurnal variations will have to be managed through intrastate and interstate settlements or open access. For example, solar generation will be low in peak monsoons and even with an increase in wind power generation in that season, Palakkad will have to rely on importing power from the state/regional grid. However, in summer months or slack monsoon season actual solar and wind generation could be more than the state level demand and in this case, the surplus can be exported to other parts of the state.

HEAT

The main demand for heat is from cooking and industry. The fuel-wise demand availability for heat is first split across three sectors: domestic, commercial and industrial. This sectoral availability is then matched with available sustainable sources, mainly biogas and biomass heat. In the supply scenario, it is assumed that biogas generation potential (0.158PJ) is achieved by 2025 while that of biomass heat (1.31PJ) is achieved by 2030. The main reason for the slow increase of biomass heat takes into the account the gradual acceptance of biomass heat as industrial process heat fuel.

Table 10.4 below shows the demand and supply potential for heat.

TABLE 10.4: DEMAND REQUIREMENTS AND SUPPLY POTENTIAL FOR HEAT IN PALAKKAD

	2015	2020	2025	2030
Curtailed Domestic Heat Demand (PJ)				
LPG	1.4	1.64	1.58	1.42
Biogas	0.01	0.15	0.15	0.15
Wood	1.21	0.79	0.82	0.86
Kerosene	0.01	0.01	-	-
Biomass	0.01	0.01	0.01	0.01
Total	**2.64**	**2.6**	**2.56**	**2.44**

	2015	2020	2025	2030
Curtailed Commercial Heat Demand (PJ)				
LPG	0.2	0.27	0.36	0.47
Kerosene	-	0.01	0.01	0.01
Total	**0.2**	**0.3**	**0.4**	**0.5**
Curtailed Industrial Heat demand (PJ)				
Coal	1.16	1.12	1.22	1.29
Petroleum Coke	0.67	0.58	0.58	0.58
Residual Fuel Oil	0.73	0.78	0.9	1
Wood	0.77	0.93	1.11	1.25
Total	**3.33**	**3.41**	**3.81**	**4.13**
Supply Potential (PJ)				
Rubber Primary Wood	0.16	0.28	0.41	0.62
Forest Residues	0.67	0.68	0.69	0.69
Combustion Total	**0.82**	**0.96**	**1.1**	**1.31**
Organic Fraction MSW	0.033	0.038	0.043	0.048
Animal Wastes	0.11	0.11	0.11	0.11
Biogas Total	**0.143**	**0.148**	**0.153**	**0.158**

The assessed combustion-based supply potential considers only rubber wood and wood industry residues. The demand for domestic firewood (natural fallings in house compound) is not assessed as it is assumed the firewood for domestic cooking will be available in sufficient quantities to meet the domestic sector's fuel wood requirements. In addition, the availability factor assumed in estimating resource availability for rubber wood and timber residues considers alternative uses (mainly in the industry) for these residues (*see Annexure 2*). Considering this, it can be assumed that the supply potential from combustion is available as additional fuel and can be utilized as in industrial processes.

In this context, industrial processes were studied to understand the possibility of substituting other industrial fuels with available wood-based combustion. It was assessed that pet coke use was unique for most of the industrial processes, where it was not only used as heat source, but also as a chemical reducing agent for raw materials. However, the use of coal and fuel oil in industrial processes was mainly for fire boilers and meet other auxiliary heat requirements through direct combustion route. Based on the consultations with experts and the study of available literature, it was assessed that all the available biomass combustion energy (1.31PJ in 2030) can be diverted for industrial use mainly as a replacement for coal.

As for biogas, the demand requirement of 0.15PJ in 2030 could be met by the supply availability of 0.158PJ. Based on the above assumptions, the final supply scenario for cooking and industrial heat is given in Table 10.5.

TABLE 10.5:
FINAL SUPPLY SCENARIO FOR COOKING AND INDUSTRIAL HEAT

Fuels (PJ)	2015	2020	2025	2030
All Others	0.03	0.03	0.03	0.03
Residual Fuel Oil	0.73	0.78	0.90	1.00
LPG	1.59	1.91	1.94	1.89
Wood	2.81	2.68	3.04	3.41
Biogas	0.01	0.15	0.15	0.15
Petroleum Coke	0.67	0.58	0.58	0.58
Coal Unspecified	0.34	0.16	0.12	
Total	**6.17**	**6.29**	**6.75**	**7.07**

TRANSPORT FUELS

The transport fuels (diesel and gasoline) requirements are considered to be irreplaceable by 2030 because of the unavailability of high-yield sustainable biofuel technologies by 2030. The current generation biofuel technologies based on land-based plantations are grossly inefficient and costly, and may not be recommended for Palakkad considering the food vs. fuel perspective. Current development in biofuel technologies suggests commercial availability of high-yield water algae based biofuels only after 2030.[28]

Considering the above, no substitution is envisaged for final transport fuel demand. However, it should be noted that minimization of transport fuels through carrier substitution (electric locomotion), efficiency evolution (automobile technology evolution) have been considered and are factored in the final demand scenario.

Based on the above assessment the final supply scenario is as shown in Table 10.6 and Figure 10.1.

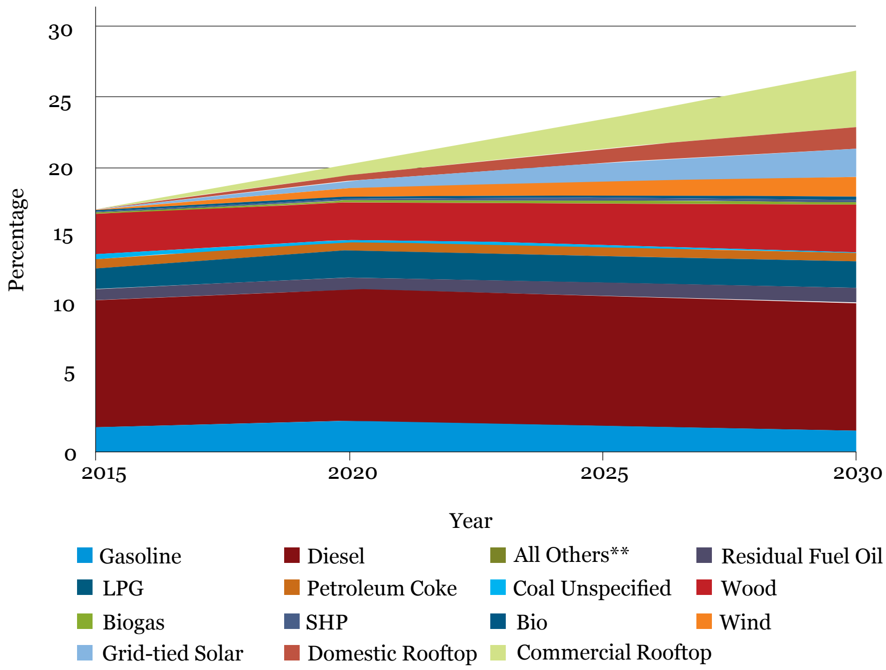
TABLE 10.6:
FINAL SUPPLY SCENARIO

Fuels(PJ)	2015	2020	2025	2030
Gasoline	1.78	2.26	1.93	1.51
Diesel	8.91	9.22	9.12	9.02
All Others	0.03	0.03	0.03	0.03
Residual Fuel Oil	0.73	0.78	0.90	1.00
LPG	1.46	1.92	1.94	1.89
Petroleum Coke	0.67	0.58	0.58	0.58
Coal Unspecified	0.34	0.16	0.12	
Wood	2.81	2.68	3.04	3.41
Biogas	0.14	0.15	0.15	0.16
SHP	0.05	0.06	0.10	0.15
Bio	0.09	0.13	0.17	0.23
Wind	0.11	0.65	1.04	1.39
Grid-tied solar	0.00	0.50	1.26	2.02
Domestic Rooftop	0.00	0.40	1.01	1.51
Commercial Rooftop	0.00	0.81	2.02	3.96
Total	**17.11**	**20.33**	**23.40**	**26.85**

[28] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

Slight increase in the total energy supply as compared to the total energy demand is because of consideration of T&D losses in electrical supply system. Based on the above table, the final energy demand scenario suggests that almost 47.7 per cent of the total district energy demand can be met through renewable sources by 2030.

FIGURE 10.1: FINAL SUPPLY SCENARIO



PART IV
POLICY APPROACH AND IMPLEMENTATION ROAD MAP

CHAPTER 11

POLICY IMPLICATIONS, STAKEHOLDER ENGAGEMENT AND INVESTMENT ASSESSMENT FOR TRANSITION

The developed curtailed energy scenario is an indication of what could be achieved in future. However, it is obvious that naturally evolving market transformation alone would not be sufficient to implement this change. The key to implementing these interventions is in presenting a comprehensive picture of the interventions and their possible implications to policymakers, planners and people's representatives. In this context, the three key focus areas in this chapter are: policy approach, stakeholder engagement and cost-benefit analysis.

While policy approach presented in this chapter focuses on strategies and intervention activities required from the state, the stakeholder engagement activities identify key stakeholders, focuses on encouraging dialogue and enhancing government- stakeholder interactions.

The third focus area, investment and cost-benefit analysis, considered in this chapter, attempts to assess the level of direct investments required from the state in developing new infrastructure and other capital investments required to facilitate the transition.

It is assumed that the envisaged role of the government/state is to be an initiator, incubator and a facilitator; it should play a role only if investments deemed essential. These investments may not have immediate economic benefit or would be considered risky and hence would not be taken up by the private sector under normal circumstances. The focus is on infrastructure and large capital investments in equipment. It is assumed that for most of the other strategies, where state sector investment is not earmarked, the bulk of the investments will come from the private sector, which will find business opportunities in these strategies under the new business environment created by the policy and regulatory framework.

The methodology for determining investment implications at the district level involves determination of state investments (CAPEX (capital expenditure) and OPEX (operational expenditure), and the revenue realization potential/savings accrued, if any, for the investments.

CAPEX and OPEX are estimates based on available literature/empirical data. Revenue realized and savings accrued are dependent on the technical and commercial impacts of the interventions.

Based on the above narrative, the sector-based assessment is covered in the following sections.

TRANSPORT SECTOR

Policy Objectives

- Enacting fuel efficiency norms
- Shifting to sustainable transport modes
- Encouraging use of bicycles and walking for short distances
- Shift to electric vehicles
- Increase of shared resource use

Policy Targets

- Increasing rail freight share from 26 to 50 per cent by 2030.
- Achieving a reduction in energy intensity of buses, HCVs and LCVs by 30 to 35 per cent by 2030.
- Increasing share of EVs: Short distance buses by 15 per cent, cars by 20 per cent, 3-wheelers by 20 per cent, 2-wheelers by 50 per cent and LCV's by 10 per cent, by 2030.
- Freezing passenger personal road traffic vehicles at 2020 level (3 per cent for cars, 12 per cent for 2-wheelers).
- Conversion of 1 per cent of car population into car pools and 2 per cent into bus pools by 2022.
- Conversion of 5 per cent of auto rickshaw population into a pooled service by 2020.
- Conversion of 5 per cent of motorized (majority from cars) transport to non-motorized transport by 2030.

The key take away from the study is the finding that the transportation sector has the largest share in the energy consumption of the district as compared to other sectors. In the case of Palakkad, this share is mainly on account of public transport buses and freight vehicles. Although the share of personal passenger transport mode is also expected to see a large jump, the bulk of energy consumed in the transport sector comes from freight vehicles. In the context of the state, the key strategies are: facilitating freight modal shift from road to rail, focus on energy efficiency of freight vehicles and transport buses, increase the use of electric vehicles for small distances, and passive measures, like resource pooling and travel avoidance.

Interestingly, all the proposed focus areas have already been covered extensively in the Draft Transport Policy of the Government of Kerala. The measures proposed in this section just extend the policy intent into action and help shape targets and areas of action. In this background, the first and foremost step in the transition could be early notification of the transport policy.

Once the policy is notified, it is strongly recommended that the state designate a nodal agency for the district transport for taking ownership of implementation of suitable interventions. In this context, it will be important to clearly define the role of the District Transport Nodal Agency (DTPA), so that it can work under an ad hoc mandate. Some of the functions of the DTPA can include:

- Taking ownership of the transport policy implementation, and providing administration and budgetary support for identified schemes through KSECF or the Department of Transport.
- Directly conducting transport studies or contract appropriate transport studies to independent consultants.
- Pro bono consulting and support directly or through an empanelled consultant to government and private agencies to develop a transport energy management plan for large entities.
- Coordinating with other government departments and private agencies to facilitate implementation of progressive policy measures and their monitoring and verification.
- Disseminating information on transport policy, policy schemes, transport technologies and energy conservation through mass and targeted outreach activities.
- Autonomy in taking budgetary decisions on the policy schemes and allocated budget.

The specific action points required for focus area intervention are covered in subsequent paragraphs.

Facilitating Freight Modal Shift from Road to Railways

The key strategy in modal shift would be to increase the freight share of railways in freight transport to 50 per cent. This level of freight shift may be possible in Palakkad considering that the main industrial belts in Palakkad are spread very close to the east-west spread of the railway network. Most of the industrial freight originates and ends outside the district as many raw materials and finished products are imported or supplied to markets in Tamil Nadu, Karnataka and West Kerala. The necessary freight transport reorientation can work on the principle of transferring long-distance freight to railways and short-distance freight to road transport. Essentially, the railway can bring in industrial raw materials from distant locations and HCVs can subsequently provide the last-mile transport from the railway cargo depot to the industry.

However, to effect this change, the railway and the industries will have to work together on a common ground. On one hand, industries will have to be persuaded to shift their long-distance cargoes to the railway and in turn the railway will have to provide a competitive rate for freight services. The commercial agreement may not be difficult considering that the high energy efficiency of the rail network will make freight rate competitive on cost plus basis. However, an additional requirement from the railway will be to construct the necessary infrastructure for cargo handling and loading operations. Available railway yards or track diversions outside populated areas can be an ideal location for setting up these cargo handling facilities.

One of the key focuses of the central government, especially the Ministry of Railways, is also on increasing the freight capacity and share of the railway in the transport sector. Considering the existing rail network and industrial development in Palakkad, the district can be a very good test case for studying modal shift possibilities from road to rail. However, a comprehensive study of operational intricacies (route availability, two-track systems, communication, additional electrification requirements, etc.), in addition to financial impacts (revenue realization, traffic forecast study, possibility of passenger/freight shift) has to be undertaken to assess the actual possibility of implementing such a system. The government will have to approach the Centre and the Ministry of Railways to consider Palakkad as a test case for freight modal shift from road to rail.

- Stakeholder Engagement Activities

  In this context, the district transport agency (DTPA) could play the role of a facilitator of exchanges and interaction between key stakeholders in the process, viz., the railway, the industry and road transporters. The first step could be to interact with the industry to understand their freight movement and assess barriers to switch the freight to the rail network. In the second step, a separate interaction with railway officials can be arranged to understand key infrastructural and commercial challenges for managing increased freight volume.

  In the second stage, it will also be important to clearly communicate this strategy and seek constructive inputs from other stakeholders like transporters, labour unions and active civil society groups. Once a common understanding is evolved with respect to the basic technical and commercial feasibility, the DTPA can then approach and work with the Ministry of Railways to seek budgetary support for infrastructure augmentation.

- State Investment and Cost-Benefit Analysis

  The key investments related to the strategy would be the augmentation cost for rail infrastructure (separate depot, loading and cargo points, tracks, signalling, etc.), which would mainly come from the Department of Railways. The cost components to the state will mainly be expenditure on conducting independent studies, seminars/workshops.

  The key benefits will include lower input costs to the industries. Apart from this there would be significant savings in carbon emissions, reduced road traffic and vehicular pollution in the district. In addition, the district will also benefit from added employment generation mainly in the labour sector.

- Implementing Stringent Fuel Efficiency norms:

In a recent study, the Central Road Research Institute (CRRI), New Delhi[1] has indicated that there is very high potential for improvements in fuel efficiency, especially in the heavy vehicles category. According to the study, energy intensity of HCVs, LCVs and buses (the three largest energy consuming vehicle categories) can be reduced by about 40 to 50 per cent by 2030 (*see Annexure 5C*). These levels of reduction represent huge savings in energy use not through technology alone but also through proper policy framework, and regulatory and monitoring mechanisms. In this context, the key role of the transport nodal agency will be to consult CRRI for identifying necessary policy and regulatory measures to support progressive reduction in fuel intensities, especially for road freight and public transport, which are considered to be grossly inefficient as compared to those in advanced countries.

For other vehicle categories, hybrid technologies seem to have great potential. Even current breed of hybrid technologies are as much as 20-40 per cent less energy intensive as compared to existing technologies. To support gradual penetration of these technologies, the district nodal agency can first identify the preferred technology for each vehicle category, record its actual performance in terms of key parameters and set the performance parameters of these models as standards that are to be achieved by some future year (2025). At the district level, the transport authorities can constitute a consulting group to help the department to set these standards. Transport authorities can assign certain time-based targets to vehicle manufacturers to improve vehicle fuel efficiency. In consultation with CRRI, measures like labelling, taxes and incentives can be introduced to boost vehicle fuel efficiency and accelerate market penetration of new efficient vehicle technologies. Future measurements for fuel efficiency achievements can then be simply based on the vehicle technology in use and a small levy can be collected from vehicle owners of old technologies. This will kick start the process of new technology adoption. Subsequent spread of new technologies will then be voluntary as increasing fuel costs would bring down the payback period of new technologies.

Another focus of the policy measures in this area could be on enhancing traffic management and inculcating the knowledge of best driving practices in the freight and passenger transport industry. For example, freight productivity is significantly affected by waiting time at check posts and other official stops and traffic congestion points. The state can ease these congestions by smoothening the workflow at check posts (faster turnaround time by quicker collection and essential checks) and better traffic management on major freight corridors.

[1] CRRI. 2014. "Fuel Efficiency Standards of Heavy Duty Vehicles in India". Central Road Research Institute, New Delhi, India. http://shaktifoundation.in/wp-content/uploads/2014/02/Fuel-Efficiency-Standards-of-HDV-in-India.pdf, accessed on 16 April 2015.

Another major area could be to train the drivers to use more fuel efficient and safe driving practices. The state can, after a discussion with the trucking industry, ask for 100 per cent driver training through approved courses by professional agencies over a 10-year period. This can be kick started at Palakkad. Such large-scale dissemination would lower the cost of trainings, incentivizing the trucking industry to participate. This course can be further extended to other passenger public transport systems.

Interestingly, all of these measures including installation of smart systems in check posts, dedicated freight corridors, driver's training are not new measures, but are already a part of the Draft Transport Policy of the state. The policy needs to be implemented in the right spirit, as a policy experiment in the district.

- Stakeholder Engagement Activities

The key stakeholders for this strategy are the vehicle manufacturers, the regional transport office, freight transporters, bus operators, civil society organizations/citizen groups, transport unions and others. The transport management agency will first have to identify clear cut intervention measures by working with CRRI to develop a comprehensive technology standard, and labelling and monitoring programme that can be implemented at the district level. In addition, the agency can also work with a reputed transport technology consultant to map available hybrid vehicle technologies, their operational performance, retail and service delivery structures, and commercial feasibility. Once these interventions are identified, a multi-stakeholder workshop/ seminar can be conducted to discuss the proposed policy measures with key stakeholders and solicit their inputs before formalizing the policy for transport standards on labelling and hybrid vehicles.

Once this is streamlined, the implementing agency will have to conduct large-scale awareness programmes to generate mass support for policy on efficient vehicles. Further, specific training programmes for the RTO and transporters should be conducted to institutionalize monitoring and verification systems. The state will also have to look at subsidizing or supporting driver training programmes for transporters and bus operators. Over time, granting of driving licenses and vehicle permits can be linked to the proof of training. A separate study is also required for assessing the potential for smart checks and automated machines at state check points and kiosks to facilitate quick traffic movement.

- State Investment and Cost-Benefit Analysis

No major infrastructure investments are proposed in this strategy. The main costs involved are related to independent studies and dissemination and training activities as all new associated infrastructure facilities will come through private participation. The key benefits of the strategy are significant reduction in vehicular emissions by 2030.

Introduction of Electric Vehicle Technology in the District

The spatial spread of the population and the predominance of independent houses make Kerala very amenable to electric transport. An electric vehicle is a factor more efficient than existing ICE or even hybrid vehicles.

In particular, two-wheeler models currently available in the market from reputable manufacturer like Hero Electric/Oreva Bike offer a mileage of 60km from a single charge that utilizes 1.2kWh.[2] Assuming an electricity cost of Rs. 4/unit, this translates into a cost of Rs. 0.08/km as against a per kilometre petrol vehicle cost of Rs. 1.4 (assuming a mileage of 50km/litre and a petrol cost of Rs. 70/litre). Even accounting for an annual levellized battery replacement cost of Rs. 0.53/km,[3] the total running cost per km comes to Rs. 0.62. Based on the manufacturer's data, the cost of standard two-seater e-bikes ranges from Rs. 40,000 to Rs. 50,000.[4] This would suggest that on a cost and run basis, e-bikes offer better savings than petrol bikes. It is also to be noted that there are additional savings in the form of carbon emissions and SPM.

Even in the case of electric cars, Mahindra's e20 T2 model is a fully electric four-seater car with a full charge mileage of 120km and a maximum speed of 80kmph.[5] According to an independent report, the running cost is assessed to be Rs. 0.5/km. However, this does not include maintenance and battery replacement costs. The cost of a new T2 variant is close to Rs. 5.5 lakh (on road in Bangalore), but the key aspect of car ownership is in the unique service delivery model of Mahindra, which gives complete service support and maintenance for a nominal monthly charge. According to the cost calculator on the company's website, e20 can save Rs. 4,000/month as compared to a petrol car with the same cost. The monthly savings include standard EMIs, maintenance and running charges. Although the model is not currently available in Kerala, Mahindra is open to cater to new markets.

Even beyond Mahindra's e20, Tesla Motors in USA has already developed and commercialized luxury electric sedan model (Model S) that has a mileage of 300miles per charge, and a top speed of 120miles/hr, with a fuel efficiency of about 0.245kWh/mile (0.15kWh/km) at a speed of 50miles/hr. In energy terms, this translates into an energy intensity that is 20 per cent of the energy intensity of current breed of gasoline-based cars. All electric buses are also commercially available today. BYD, a European manufacturer, has already rolled out an all-electric bus with a capacity of about 60-70 passengers and fuel efficiency of 1.04kWh/km; about twice as efficient as existing diesel buses in energy terms.

In the given context, the three biggest barriers to adoption of EVs are technology awareness, cost of ownership and lack of service delivery models. The best strategy to overcome these barriers is to incentivize a shift to EVs by reducing taxes, spreading awareness and by making sure

---

[2] Areva E-bike (advertisement).http://oreva.com/images/pdf/bike_catalog.pdf, accessed on 14 April 2015.
[3] Ibid.
[4] Hero Electric e-bikes, http://heroelectric.in/products-page, accessed on 14 April 2015.
[5] Mahindra Reva, http://mahindrareva.com/faqs/savings, accessed on 14 April 2015.

that EV technologies are available at the retail level and have adequate servicing facilities. For Kerala, a switch to electric two-wheelers can be more easily achieved as many e-bikes are already available in retail stores in the state.

The short-term measures to facilitate this transition can be to create large-scale awareness campaigns, where the manufacturers can be provided support and encouragement to organize awareness campaigns and workshops to disseminate information about their technologies and performance. However, the most effective dissemination strategy would be the actual uptake of EVs by local residents as this would create large-scale awareness and do away with performance concerns among potential buyers. It is proposed that the state can provide a limited subsidy amounting to 15 per cent of the total e-bike costs to the first hundred buyers of the district. Based on the success of this scheme, the government may then consider providing limited subsidy to e-rickshaws and cars.

A strong EV manufacturing base would also be in line with the state's industrial policy's preference to high-tech and engineering industries. Once technologies are available, have servicing infrastructure and are used, further penetration will be voluntary and automatic.

From the perspective of implementation, the state transport nodal agency can identify EV manufacturers in India and abroad, and complete a comprehensive technology assessment of available EV technologies, mainly in the two-wheeler, car and LCVs segments. In addition, in terms of technology performance statistics and power needs, the technology assessment study should also include the suitability of the vehicles with the load profile and the terrain profile of the district. Once a promising EV technology (preferably Indian) is identified, the nodal agency can devise a direct limited-subsidy scheme for EVs with support from MNRE. The nodal agency can further invite dealerships and service centres for the approved technologies and help set them up with support from the OEM and the Department of Industries. The subsidy can be released subject to suitable undertaking from the beneficiary to utilize non-peak hours for charging.

- Stakeholder Engagement Activities

  The key stakeholders involved in this strategy are individuals and electric vehicle manufacturers. The key short-term management strategy in this case will be to create awareness about the need for a shift to electric mobility by manufacturer-funded and state-supported awareness campaigns and disseminating information about limited subsidies for electric two-wheelers.

  The long-term aspect of the stakeholder management plan will be to engage with EV manufacturers and understand critical barriers and assess policy imperatives to create an eco-system for EV manufacturing.

- State Investment and Cost-Benefit Analysis

  The main cost inputs proposed for these strategies are limited subsidy mechanism for buying e-bikes (electric two-wheelers). Assuming a cost of Rs. 46,000[6] (actual cost of E-Sprint model in Kerala), a 15 per cent subsidy will work out to be Rs. 6,900 per vehicle. If this subsidy is offered only to the first 100 bikes in the district, the total subsidy outlay for the state would be Rs. 6.9 lakh.

  Going forward, if the state wishes to partly subsidize electric cars by providing a subsidy support of 5 per cent for the first 25 cars, the actual subsidy outlay would amount to Rs. 27,750 per vehicle, assuming a cost of Rs. 5.55 lakh/vehicle,[7] which for 25 vehicles would translate to about Rs. 6.94 lakh.

  Although there would be no direct monetary benefits to the state from providing these subsidies, the proposed subsidy investment should be seen from the perspective of the state's strategic priority to promote a clean and energy efficient technology, in addition to better energy management in the transport sector. A shift to EV in this sense would have two advantages: one, the ownership level of e-bikes and e-cars that come through the subsidy will force the manufacturer to set up more retail stores for sales and services delivery, effectively building an ecosystem. Second, at a system level, the cost to the utility for supply would also be low, as the vehicle charging would mostly happen at night (at the times of low load).

Policy Measures for Effecting Passenger Transport Inter-modal Shifts

The main strategy considered is to freeze the share of personal vehicles in the total passenger volume to 2020 levels by 2030. In policy terms, this shift essentially means policy reforms to curtail use of personal vehicles – incentivizing public transport and dis-incentivize personal transport. The disincentives can work in a top-down level as higher taxes for personal vehicles to a bottom-up level like congestion charges for identified routes. The incentives for public transport can be in the form of lower taxes, better right of way (Bus Rapid Transport) etc. These interventions will essentially have to be identified as a part of the comprehensive mobility plan for the district. One clear role for the state could be to make capital investments in public transport systems.

- Stakeholder Engagement Activities

  The main stakeholders for this strategy would be individuals. The key management strategy will have to be based on creating awareness about the economic, social and environmental benefits of the public transport system as compared to the personal transport system.

---

[6]Hero Electric, e-sprint 2, http://heroelectric.in/e-sprint-2/?view-product=y, accessed on 14 April 2015.
[7]Mahindra Reva, Price List, http://mahindrareva.com/buy/price-list, accessed on 14 April 2015.

- State Investment and Cost-Benefit Analysis

Beyond 2020, the share of two-wheelers is kept constant at 11.9 per cent, while that of cars is kept at 2.7 per cent. The additional passenger volume freed from this freezing is transferred to short-distance and long-distance buses, respectively. In actual terms, this shift implies a marginal increase in passenger volume of 1.35 billion pkm for buses (short distance and long distance). As compared to a BAU scenario this translates into 581 additional buses by 2030. The financial calculations for state sector investments in new buses are done based on the assessment in *The Energy Report –Kerala*.[8] A brief of key assumptions and calculations are shown below:

Total expenses = CAPEX + OPEX
Where, OPEX is fuel cost + operational cost
CAPEX assuming Rs. 16.5 lakh per bus[9]
OPEX (fuel) = (average annual distance travelled per bus/year (82,860km)/fuel efficiency of 4.5km/litre)× fuel cost of Rs. 60/litre[10]
TOTAL OPEX=2×OPEX (fuel)[11]

Revenue realization = average earnings Rs. 33.07/km× average annual run/bus (82,860km)[12]

Based on the above assessment, the CAPEX for a new bus based on current costs is Rs. 16.5 lakh, while annual OPEX (fuel and others) is assessed at Rs. 23.93 lakh. The annual revenue realization based on the above assumptions comes to Rs. 27.40 lakh. This would indicate that even assuming a current level of average earnings per kilometre, the investments in buses can pay for itself, in approximately 5.5 years.

Based on this estimation, the Table 11.1 below summarizes the investment requirement in new buses for the district. CAPEX investments are based on additional bus requirements over each five year interval, while OPEX and revenue realization are based on cumulative values across the years.

TABLE 11.1: STATE INVESTMENTS REQUIREMENTS FOR NEW BUSES IN PALAKKAD

Investment in New Buses and Public Transport (Rs. in Cr)	2015-20	2021-25	2026-30
CAPEX	0	38.8	57.1
OPEX	0	161.0	463.1
Total State Investment	0	199.7	520.2
Revenue Realization	0	199.6	574.3
Net Profit		**-0.13**	**54.0**

The details of actual calculation and narrative description of methodology are given in Annexure 6.

[8]WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.
[9]Kerala State Road Transport Corporation. 2015. "Financials". http://www.keralartc.com/html/financials.html, accessed on 14 April 2015.
[10]Ibid.
[11]Ibid.
[12]Ibid

POLICY MEASURES ON RESOURCE POOLING

Resource pooling (car pools/bus pools/shared taxis/rickshaws) has a very high potential for reducing traffic congestion and energy use. Industrial clusters and corporates can be encouraged to follow resource pooling and shared transport services through shared administrative services. Industrial parks typically house many industrial companies at one location and there is huge scope for integrating transport needs. In addition, these industries should be encouraged to levy parking charges for personal cars for people who do not use pooled services in a serviced route. Understandably, collecting data and putting infrastructure in place would be difficult initially, but once the system is operationalized, it will require very little effort to maintain it.

Another intervention from this policy could be a move to shared rickshaws/shared taxis as fast moving transport modes for short-distance travel within largely urban areas. This strengthening of ‘last mile’ transport systems can be done by reducing entry barriers (reducing vehicle and road taxes, easing licensing norms, etc.).

- Stakeholder Engagement Activities

  The key stakeholders will be industries, industrial associations, government offices, auto rickshaw and transport unions. The key management strategy will be identified as a part of the stakeholder management plan in the district mobility plan.

- State Investment and Cost-Benefit Analysis

  No state investments are envisaged for this strategy. However, there are significant benefits associated with this strategy in terms of better environmental and climate performance.

Policy Measures on Travel Avoidance

Modern communication technologies enable us to avoid frequent travelling; using these to conserve energy inputs would be beneficial. In particular, facilities like videoconferencing (VC) can effectively reduce travel requirements substantially. This could be particularly useful for the government, where a VC facility can be provided at district level for meetings. Another area of intervention could be use of ERP systems like SAP, which would obviate the need for paper files and physical transport of documentation. In a district like Palakkad the scenarios where such conservation can be focused would be in industries, and government and private offices.

Facilities like videoconferencing are made available by the National Informatics Centre, which is the IT service provider for the government of India.[13]

No separate stakeholder management plan or cost benefit analysis is done for these strategies as these are requirement specific.

[13] National Informatics Centre, Services, http://vidcon.nic.in/AboutUs.htm#Services, accessed on 14 April 2015.

COMMERCIAL AND RESIDENTIAL BUILDINGS

Policy Objectives

- Move towards sustainable architecture/green buildings
- Policies to encourage use of locally available building materials
- Policies to encourage retrofitting of existing buildings in the commercial sector

Policy Targets

- 10 per cent energy reduction in the residential sector through sustainable architectural practices and retrofitting
- All new commercial buildings to meet green building guidelines
- 50 per cent of existing commercial buildings to be retrofitted to new efficiency standards by 2030

Buildings perhaps have the second largest potential to save costs and reduce energy. The energy uses in buildings are mainly on account of electricity. However, in terms of the total energy invested, all forms of energy are used in a building lifecycle: transport fuels, industrial heat and electricity. In Kerala, the real estate sector is growing at a very high rate.

However, it has to be realized that this level of activity should also be sustainable. There is an increasing shortage of construction materials. The prices of construction materials are also escalating very high, because of decline in availability and increasing transportation cost. In addition, a high labour cost also adds substantially to the final built cost. In this context, a course correction in the housing and real estate sector could be very crucial.

Move towards sustainable architecture/ green buildings:

The most effective move for this sector can be increased adoption of sustainable architectural practices that use locally available materials, as far as possible, for individual houses. These practices have tremendous potential to reduce the energy invested in buildings and also to reduce the energy requirement of a built structure. On the other end of the spectrum are green buildings, which use integrated planning and modern materials to maximize resource use and minimize energy requirements of the built enclosure. These could be very effective for commercial buildings.

Interestingly, both these alternatives are mentioned in the Housing Policy and the Green Building Policy of the state. In the given context, the way forward is to start working towards implementing the objectives that are listed in these policies. Commercial and institutional buildings have the maximum potential to effect this change. Even though the existing green building policy draft talks about the promotion of green buildings, no guidelines have been issued by the government. So the most immediate action is the drafting of specific guidelines under these green building policies. These guidelines can contain best practices and techniques for construction of green buildings and a minimum performance standard so that the life cycle energy consumption can be brought down.

A policy stipulation on green building regulation that mandates long-term targets for large real estate companies could be a very effective step. All large real estate companies can be mandated to comply with floor-area based percentage target of meeting green buildings/sustainable buildings in all buildings under construction. For example, a real estate firm that constructs 100,000ft^2 of floor area in the first year and could be mandated to have 2 per cent (2,000ft^2) as target for green building/ sustainable building with the facility to carry over this target for three years. The advantage of this top-down target setting is that the cost of such buildings will be borne by the eventual owners, who would be persuaded by the real estate companies to opt for these buildings. In addition, compulsory environmental and building certification norms for commercial buildings (starting in 2020) would help bring compliance from the supply side. This would necessitate setting up of separate building standards that not only include features of green buildings, but also the features of sustainable architecture, which holds a great promise for Kerala.

For the housing sector, sensitization of alternative building practices, like use of locally available materials, has to be done with the help of organizations like COSTFORD, Nirmithi Kendra, etc. This sensitization has to be on a large scale and can be supported by the government through separate budgetary allocation. This programme aimed at targeted groups could also include site visits to actual built structures. Subsequently, the government can incentivize such construction practices by allowing a reduction in housing tax, local body taxes, electricity and water connection charges, etc. The stakeholders should ensure that continuous auditing is being carried out on the buildings to check whether all necessary guidelines are complied by the builder.

- Stakeholder Engagement Activities:

  The key stakeholders for this strategy are EMC as the knowledge partner, PWD (buildings), municipal corporations, large panchayats and builders as implementation partners along with commercial and domestic consumers. The first step includes the drafting of the green building guidelines, and labelling and minimum performance standards. This can be done by the joint effort of EMC and PWD. Once the guidelines are prepared, a detailed awareness campaign will have to be conducted by EMC with the support of municipal corporations for builders and the citizen. The guidelines drafted can mandate all new commercial buildings under construction in the district after 2020 to be compliant with Energy Conservation Building Codes (ECBC), and this mandate can be ensured by the Municipal Corporation while giving approvals for commercial buildings. On the other end, EMC will also have to take measures to encourage domestic buildings to adopt sustainable architectural practices.

- State Investment and Cost-Benefit Analysis

  The main investment in these strategies would be related to dissemination of building guidelines and awareness campaign, and audit activities associated with the strategy. Except for government buildings, the cost associated with building construction will come from private sector. The key benefit will be significant savings in energy demand by 2030, which indirectly gives monetary benefits to domestic and commercial consumers. Another benefit of this strategy will be to avoided CO_2 emissions due to the increased use of locally available materials. Another specific benefit will be the employment potential as there will be an increased demand for technical experts for green building/sustainable architecture.

Improving Energy Efficiency of Existing Buildings

There is very high scope for improving the energy efficiency of existing buildings with emphasis on retrofits and cost effective modifications through targeted renovations, to comply with green building norms. Although, the potential of energy savings (electricity savings) are very site specific, passive improvements in building lighting and cooling applications have the potential to reduce electricity consumption from 10 per cent to 30 per cent. A district-level building energy auditor can be appointed to assess and evaluate retrofitting possibilities, budgetary requirements and energy savings. Partial state support for initial studies on retrofitting and energy audits can help commercial entities to undergo audits. Once the scope of the savings is identified, the investments may come from the beneficiaries as they are self-paying. The state can support this initiative by auditing government buildings and institutions for retrofits.

- Stakeholder Engagement Activities

  The key stakeholders involved in this strategy are EMC, PWD (buildings), energy auditors, and commercial and domestic consumers. So the primary step to initiate this strategy could be to conduct a thorough energy audit of all existing buildings. This can be initiated by EMC by selecting a district level building and energy audit consultancy to carry out the audit of existing buildings and identify retrofitting possibilities. In the initial phase, this can be started with the high energy consuming buildings. EMC will have to conduct massive knowledge enhancement sessions and awareness campaigns to stakeholders in the residential and commercial sectors on the specific benefits of retrofitting. The energy audit consultancy will be responsible for giving short term cost effective targets to these buildings. EMC along with energy audit consultancy can ensure the implementation of retrofits by re-audits and setting new targets at regular intervals. Steps should also be taken to cover targeted buildings in a phased manner.

- State Investment and Cost-Benefit Analysis:

  Existing government buildings: These buildings are spread across various categories like shops/offices, schools/colleges, worksheds/

factories, hospitals/dispensaries, hotels, places of worship etc.

For each of these categories, standard floor area availability is assumed in line with the assumptions stated in rooftop PV potential assessment. Depending on the type of institution, the share of state owned buildings in each category is either assigned a value – 5 per cent or 10 per cent. Assuming single storied structures, the total floor area available in public sector buildings for retrofit is estimated. To assess the costs of retrofits in terms of floor area, the NRDC study[14] on retrofitting of Godrej Bhavan Building in South Mumbai was referred. According to empirical data available, the total retrofit investments including investments in energy efficient equipment (lighting, refrigeration, fans, etc.), accessory fittings (improved louvers, glass films, etc.) and water harvesting was about Rs. 2,473/m^2 of floor area. The savings reported in the study suggested a reduction of about 33kWh/m^2.[15]

Assuming a retrofitting cost of Rs. 2,500/m^2, an energy density of 200kWh/m^2 for standard commercial buildings,[16] a saving potential of 33kWh/m^2, commercial electricity tariff of Rs. 10/kWh, and considering 50 per cent of the old building will be retrofitted by 2030, the cumulative savings for state-owned buildings is calculated. Based on the above level of interventions, the state-level investment requirements for state-owned buildings are as shown in Table 11.2 below.

TABLE 11.2

STATE INVESTMENT REQUIREMENTS FOR ENERGY EFFICIENT RETROFITS IN PUBLIC SECTOR IN PALAKKAD DISTRICT

Cost of energy efficient retrofitting and water harvesting in public sector buildings (Rs. in Cr)	2015-20	2021-25	2026-30
CAPEX	-	169.58	339.16
Savings	-	67.15	179.07
Net Outflow	**-**	**102.43**	**160.08**

The details of actual calculation and narrative description of methodology are given in Annexure 6.

However, it should be noted that much of the investment in energy efficient equipment (lights, fans) will be covered under existing central/ state subsidy or incentive schemes, and the net investment may be much lower than Rs. 2,500/m^2. Other costs to the state will be related to the appointment of an energy audit consultancy, and audit charges and costs incurred for the awareness campaigns.

ENERGY AND POWER

Policy Objectives

- Higher penetration of efficient/super-efficient appliances
- Integrating all available renewable energy sources
- Stabilized use of wood for cooking in households

[14] NRDC. 2013. *Saving Money and Energy: Case Study of the Energy-Efficiency Retrofit of the Godrej Bhavan Building in Mumbai*. Natural Resources Defense Council and Administrative Staff College of India.http://www.nrdc.org/international/india/files/energy-retrofit-godrej-bhavan-CS.pdf, accessed on 14 April 2015.
[15] Ibid.
[16] TERI. n.d. *High Performance Commercial Buildings in India: Initial Project Findings*. The Energy and Resource Institute.http://high-performancebuildings.org/pdf/HighPerformanceCommercial%20Buildings_Brochure.pdf, accessed on 14 April 2015.

Policy Targets

- 100 per cent penetration of super-efficient fans and lighting by 2030, 60 per cent penetration of super-efficient TV's, AC's and refrigerators by 2030 in the domestic sector
- Stabilized use of wood after 2020 for domestic cooking
- 30 per cent penetration of solar water heater in the domestic sector
- Higher penetration of super-efficient appliances, mainly lighting and refrigeration in the commercial sector
- Solar PV target – 1,085MW rooftop PV and 400MW grid-tied PV by 2030
- Wind energy target – 200MW by 2030
- Small hydro target – 16.5MW by 2030

The main strategy for the energy and power sector is a shift towards super-efficient appliances and integrating all potential renewable energy sources. Energy Management Centre, Kerala has been actively campaigning and spreading awareness about energy conservation and uses of energy efficiency. Furthermore, the district also has high potential of renewable sources especially solar PV and wind, which can be exploited for meeting the district electricity demand.

Some of the policy measures proposed here are reiterations or an extension of existing state/national policies.

Policy Measures for Supporting Super-efficient Equipment [SEA]

A move towards super-efficient appliances has already been mooted at the central level with the Bureau of Energy Efficiency (BEE) announcing the Super-Efficient Equipment Programme (SEEP). While the availability of super-efficient appliances (SEAs) is limited, if we consider the rate of penetration of CFLs in the last decade, high level of penetration of SEAs would be possible by 2030. In this context, the state will have to work closely with the Bureau of Energy Efficiency (BEE) to understand the progress in SEA identification and labelling programme across different appliances and possible time-frame for their availability at the retail level.

Adoption of this programme at the state level could be the first step, followed by a regulation mandating SEEP penetration in new commercial buildings. Considering the difficulties in ensuring compliance on super-efficient appliance (SEA) use, the best way to effect the change could be to make SEAs available in the state. This can be followed by large-scale dissemination and awareness campaigns that could help in gradual acceptance of SEAs. Subsequent measures could be taxing non-efficient products, to reduce the price disparity between SEA and non-SEA products.

The industrial policy of the state already supports development of industries focusing on eco-friendly products and value added products. This policy can be promoted in a larger scale in the district itself, which could help in bringing down the costs of these appliances. For such a step, it is necessary to increase the attractiveness of the companies to set up their manufacturing units in the district.

- Stakeholder Engagement Activities

  The key stakeholders of this strategy are EMC, the Department of Finance of the Government of Kerala, external survey agency and the Department of Industries of the state. As an initial step, EMC should take measures for fast pace adoption of the SEEP programme in the district by ensuring the availability of SEAs in the market and through massive awareness campaigns. The state government will devise subsidy schemes along with an understanding with equipment providers. The Department of Industries will have to create an industrial attractiveness for SEA equipment manufacturers to set up manufacturing units in the district. EMC should ensure that all non-efficient equipments are phased out by a targeted time frame through door-to-door surveys at regular intervals.

- State Investment Cost-Benefit Analysis

  The major cost incurred to the state would be for awareness campaigns and subsidy schemes provided to the consumers.

  The key benefits of the strategy are reduced energy consumption, which indirectly gives monetary benefits to the domestic and commercial consumers.

SPO Targets and Net Metering for Supporting Development of Rooftop Solar PV

This provision is already mooted in the draft solar policy of the state. The next obvious step would be to mandate targets as early as possible. The main strategy for formulating substitution intervention in the commercial sector could centre around solar power generation at the distribution level. Commercial establishments like malls, large office buildings, hospitals, hotels may have ample space which can be made available for solar rooftop PV generation. The Kerala Solar Energy Policy (Draft) 2013 also indicates large-scale deployment of rooftop PV and heat collector systems for large establishments.

Considering the seasonal variation in solar power generation, providing appropriate incentives (FIT) or implementing net metering may help in achieving a year target of 10 per cent of the energy demand of large establishments through solar. This target can be increased by 1 per cent every year up to 2030 to achieve a yearly target of 20.

However, the main challenge for commercial solar PV is the issue related to right of way and tenant rights as many commercial building's rooftops are common property or owned by builders and not actual electricity users. New business models will be needed to overcome these challenges and it may require significant alterations in electricity regulations and tenancy rules.

Although there is a provision for net-metering systems, it is learnt that actual implementation of net metering is facing regulatory and administrative hurdles. Without urgent resolution of these issues, the policy mandates on SPOs or domestic sector subsidy may not be effective. The best way forward is to notify the solar policy and resolve administrative and regulatory hurdles to net metering.

- Stakeholder Engagement Activities

  The key stakeholders involved in this strategy are ANERT and KSERC, KSEBL. ANERT can devise plans to incentivize domestic and commercial sector to set up rooftop PV plants using net metering schemes. KSERC can mandate and ensure that all concerned commercial and industrial establishments abide by the solar purchase obligation. The role of KSEBL will be to provide all necessary administrative and technical support.

- State Investment and Cost-Benefit Analysis

  The major cost incurred to the state would be of implementation and monitoring. The main benefits will be better energy security, and better environmental and climate performance.

Support for Large Scale Wind and Solar Power

Renewable resources are very site specific. In this sense they should be given preferential allotment of land/sea (or a first right of refusal) that is deemed to be resource rich. Considering the high grid-tied potential in the district, the first and foremost priority will be to set targets for development of grid-tied RE capacity (wind, solar and small hydro). Once the targets are set, the next step can be a study to identify potential areas for development of large scale solar PV or wind parks. The study can assess the preliminary level feasibility of the identified locations by assessing land availability, grid access and evacuation potential, and other infrastructure needs.

Taking in to consideration the large investments in the grid-tied capacity, the focus could be on inviting private sector players to set up these RE parks. In this context, the state will have to revise the existing policy to make it more amenable to private sector participation modes like tendering, reverse bidding, etc. To support this policy, the state will have to notify suitable regulations that will allow the utility to undertake power procurement and set necessary guidelines for power purchase agreements.

- Stakeholder Engagement Activities

  The main stakeholders for this strategy are ANERT, KSEBL and KSERC. It will be important for ANERT to ensure buy-in for the proposed actions from KSEBL and KSERC. Achieving consensus in target-setting for RE capacity development can help establish initial buy-in of these two institutions to developing RE parks.

- State Investment and Cost-Benefit Analysis

  The major cost incurred to the state would be for implementation and monitoring. The main benefits will be better energy security, better environmental and climate performance.

Development of Small Hydro

Even though the district has potential sites for small hydro development, there has been very limited implementation in the past. To achieve the implementation target by 2030, the best way could be to allow more private sector participation for development of small hydro plants. To enable this, it is necessary to have a better risk sharing mechanism by the government providing a single window clearance mechanism for the investors. The respective municipalities can also devise a better public opinion mechanism before the projects are allocated to avoid the risk of public opposition to the investor at a later stage.

- Stakeholder Engagement Activities

  The major stakeholders for this strategy are ANERT, EMC, KSEBL, State Department of Environment and Forests. ANERT and EMC can initiate the steps to implement small hydro in the sites already identified in the study. These stakeholders can devise steps to allow more private investment into these areas. The Department of Environment and Forests along with the respective municipalities must ensure that the site proposed for small hydro is suitable for development and can get all required clearances.

- State Investment and Cost-Benefit Analysis:

  The major cost incurred to the state would be for implementation and monitoring. The main benefits will be better energy security, better environmental and climate performance.

Stabilized Use of Wood for Cooking in Households

To decrease the dependence on LPG for cooking it is very important to encourage a move towards using wood and biogas for cooking. To encourage households in the district to use firewood, two measures are necessary. First, ensuring a constant supply of firewood in households; second, large-scale distribution of smokeless chulhas at subsidized rates. For ensuring supply of firewood, it is necessary to initiate a community based group (similar to Kudumbashree). This group will be under the guidance of the local self government, and their main responsibilities can include collection of wood fallings and potential firewood pieces from households and other areas assigned to them, process/chop it according to the requirements in cook stoves and distributing it to all the houses within the assigned area.

- Stakeholder Engagement Activities

The key stakeholders identified for this strategy are local self government department, ANERT and IRTC. Local self government can initiate steps to create a group of people who works dedicatedly for collection, processing and distribution of firewood in a specific defined area. The complete responsibility for timely collection and distribution of required amount of firewood in the houses of the district is with this group managed by local self government. ANERT and IRTC can design strategies for large-scale distribution of efficient and smokeless chulhas.

- State Investment and Cost-Benefit Analysis

  The major benefit of this strategy is to avoid life cycle cost of LPG, as firewood use will mostly be localized. Other benefits of the strategy are reduced dependence on LPG gas.

Increased Penetration of Solar Water Heater in Domestic Households

In order to decrease dependence on electricity for non-cooking water heating requirements, it is important to encourage the penetration of solar water heaters in domestic households. A targeted approach to achieve 30 per cent of water heating by solar water heaters may help in improving the end use efficiency as well as peak loads by replacing electrical geysers.

- Stakeholder Engagement Activities:

  The key stakeholders identified for this strategy are ANERT, equipment suppliers and domestic households. ANERT can conduct awareness campaigns targeting the domestic consumers to encourage the use of solar water heaters, especially the new domestic households which are coming up in the district. ANERT along with equipment suppliers can devise subsidy/incentive schemes for the domestic consumers willing to switch to solar water heating system.

- State Investment and Cost-Benefit Analysis

  The major cost incurred to the state would be for any subsidy schemes provided to the consumers.

  The key benefit of the strategy is reduced energy consumption, which indirectly gives monetary benefits to the domestic consumers.

INDUSTRY

Policy Objectives

- Adoption of energy management protocols
- Government support in encouraging adoption of BAT and BPT for all upcoming projects
- Promote and implement energy efficiency in SME's

Policy Targets

- Energy reduction through passive interventions by reducing waste energy, energy recovery, equipment level efficiency improvement (efficient lighting, efficient motors), and limited process intervention.
- Energy savings of 10-20 per cent across electricity and heat use for the identified 10 industry clusters or sub-sectors.
- All new manufacturing capacities, particularly in the four key sectors –agro and food processing, textiles, metals and alloys, and engineering and industrial goods –coming on line after 2022 will be mandated to have the Best Available Technology (BAT) as on today.
- Up to 20 per cent switch to solar process heating in select sectors (textiles and agro which use low grade heat) by 2030.

Adoption of Energy Management Protocols for the Industries

The main strategy considered is the adoption of an energy management protocol for each sub-sector within the industry. The energy management protocols essentially delineate the energy use (specific Energy Consumption Norms) guidelines for operational industries and new upcoming industries, and set energy saving targets (in electricity and heat use) across each industry clusters or sub-sector in addition to encouraging the industries to conduct regular audits and modifications to achieve the benchmark target.

Such a protocol could also contain separate guidelines and performance benchmarking for new industries. This would require involvement of the government to support assessment and procurement of the technology. Under this protocol, a separate technology assessment committee (like a consortium of government agencies, technology experts and auditors) can be constituted to ensure that the upcoming projects adopt BAT and BPT available, especially in focus sectors like agro- and food-based industries. This technology assessment consortium will be responsible for approving an upcoming project.

In this context, one of the key evaluation and approval criteria can be the specific energy consumption (SEC) of the new industry. Validated data on SECs from design firms can be evaluated against the industry target benchmark and the existing policy support (soft financing) available can be linked with whether the new industry adopts a specific energy consumption target within a certain percentage of the industry benchmark.

Implementing this would require substantial resources for capacity building, monitoring and dispute resolution, but these resources can be harnessed through joint manpower and financial pooling of industry bodies, EMC, Department of Industries and state industries development corporation. Another way to implement this could be create designated sector based ESCOs that provide guidelines on implementation.

A separate package can be developed to promote and implement energy efficiency in SME's. A provision should be made to convey relevant information and proven practices in each industrial sector. This should ensure that all the SME clusters carry out regular energy audits and the SME's can be made aware of the performance benchmarking and the measures to conserve energy.

- Stakeholder Engagement Activities

  The key stakeholders involved in this strategy are district industries centre, EMC, industry associations, energy auditors and the industries. EMC along with DIC will have to identify the energy intensive industries in the district among large/medium and SME's. These industries can be then segregated into well-defined sub-sectors. Through assessment of existing industries and based on standards, EMC will have to set specific energy consumption benchmarks for the new and existing industries. EMC will conduct sector-wise awareness programmes on the energy efficiency options. To ensure that the industries comply with the specific energy consumption benchmarks, EMC and energy audit consultancies will have to conduct regular audits and set specific targets to the industries.

- State Investment and Cost-Benefit Analysis

  The main costs involved in this strategy would be related to the appointment of an energy audit consultancy, and audit charges and costs incurred for the awareness campaigns.

  The key benefit will be significant savings in energy demand by 2030. This indirectly translates into reduced fuel costs. Another major indirect benefit of implementing energy efficiency measures are increased productivity and reduced operational costs. This may translate into huge economic benefits for the industries. In most cases, the energy savings pay for the investment. Moreover, several of these proposed measures are also eligible to receive direct financial subsidies from state-level agencies, making the returns more attractive. In cases where significant incremental investments are needed, they have to be provided for either through multi-lateral funding arrangements, particularly for small and medium enterprises (SMEs).

Promoting Solar Process Heating in selected sector:

The state can encourage industry clusters requiring low-grade process heat to switch to solar process heating for catering to their heat demands. The main sectors which can switch to solar process heating are agro- and food-based industries, textile industries, rubber-based industries, paper and pulp.

- Stakeholder Engagement Activities

  The key stakeholders involved in this strategy are Department of Industries, DIC, ANERT, industry clusters, solar process heating technology providers, industry clusters. The DIC will have to first identify the industry sub-sectors, including small-scale industries, which use low-process heat. DIC along with ANERT district unit will conduct a detailed awareness sessions in these identified industries about the benefits of shifting to solar process heating, and information about the payback period of accepting any new technology and cost reduction resulting from lowered energy use. State industries can get into partnership with solar technology providers to facilitate subsidies to the solar process heat system.

- State Investment and Cost-Benefit Analysis

  The main costs involved in these strategies would be related to awareness sessions associated with the strategy. The cost due to subsidy can be taken from the special fund created for the industries.

  The key benefit will be significant savings in energy demand by 2030, which indirectly gives monetary benefits to the industry. Another benefit will be avoidance of CO_2 emissions.

AGRICULTURE

Policy objectives

- Adopting micro irrigation techniques
- Accelerated switching to energy efficient pumps/solar water pumps

Policy Targets

- Complete phase out of diesel pumps by 2020
- 25 per cent reduction in energy use by adoption of micro-irrigation in 50 per cent of the irrigated land by 2030
- 35 per cent reduction in energy use for irrigation pumps with 100 per cent shift in energy efficient pumps/solar water pumps by 2030
- 60 per cent reduction in energy use by ensuring 60 per cent penetration of solar water pumps by 2030

Adopting Micro-irrigation Techniques

The agricultural policy of Kerala already includes promotion of micro-irrigation as one of the strategies for agricultural development. The agricultural pattern of Palakkad is different from other districts mainly because the main crops in the district are seasonal. The main rainy season in the district is south-west monsoon, lasting from June to September, when 75 per cent of the annual rainfall in the district takes place. But in recent times there is a lack of availability and timely rainfall, and droughts in the district have adversely affected the agricultural output of the district. In the face of immense water shortage, declining water table and drought in Palakkad, micro-irrigation techniques could potentially save water use up to 70 per cent. It is a common practice to irrigate mixed crops and the cropped area is flooded beyond the optimum specification with little regard for water conservation. Therefore, micro-irrigation could be one of the centre-piece of conservationist approach in Palakkad. Under the existing norms, a total subsidy of 65 per cent to general farmers and 75 per cent of the cost of the system to small and marginal farmers, up to a maximum beneficiary area of 5Ha is provided by the government of India and the government of Kerala through special assistance schemes.

- Stakeholder Engagement Activities:

  The key stakeholders involved in this strategy are the principal agricultural office of the district, regional agricultural research station, Department of Agriculture of the state, agricultural unions and farmers of the district. The initial steps include the principal agricultural office of the district identifying the type of crops and areas cultivating those crops, which can be converted into micro-irrigation areas. Principal agricultural office along with regional agricultural research station as knowledge partners will have to conduct knowledge enhancement sessions and workshops to the farmers regarding the benefits of adopting micro-irrigation techniques

- State Investment and Cost-Benefit Analysis

  The key benefits include optimum usage of water for irrigation and energy savings. The cost incurred to the state will be mostly for the subsidy schemes provided by the government. The government of Kerala provides a subsidy of 10 per cent for a maximum beneficiary area of 5Ha. The average cost of a micro-irrigation set up is Rs. 32,000/Ha. Considering the penetration target of 50 per cent of the irrigated land for micro-irrigation, the total subsidy to be provided by the government works out to be Rs. 58.43 Cr in 2030. Based on assumptions made in Chapter 9, a 25 per cent reduction in energy use is assumed from micro-irrigation. Based on this, the cumulative savings in electricity are calculated across each five year intervals. Assuming net savings to the state of Rs. 3.3/kWh (average cost of supply of utility of Rs. 4.5/kWh – average agricultural tariff of Rs. 1.2/kWh,[17] the cumulative cost savings is calculated up to 2030. Table 11.3 below calculates the investment and the savings.

[17]KSERC. 2013. *Annual Revenue Requirements (ARR)*, Expected Revenue from Charges (ERC) and Tariff order for KSEB – 2013-14. Kerala State Electricity Regulatory Commission, Thiruvananthapuram, Kerala.

TABLE 11.3: STATE INVESTMENT REQUIREMENTS FOR MICRO-IRRIGATION IN PALAKKAD

Investment in Micro-irrigation (Rs. in Cr)	2015-20	2021-25	2026-30
CAPEX	11.69	29.22	58.43
Savings	8.5	24.7	43.3
Net Outflow	**3.20**	**4.53**	**15.12**

The details of actual calculation and narrative description of methodology are given in Annexure 6.

Accelerated Switching to Energy Efficient Pumps/Solar Water Pumps

In addition, from an energy perspective, move towards efficient pump sets and solar water pumping has to be supported through subsidies to the farmer. The Agricultural Policy of Kerala also mentions improving energy access through renewable energy and talks about incentives for farmers practicing energy smart agriculture and for replacement of inefficient equipment. In the past, many state utilities have in fact made an economic case out of providing direct subsidy (up to 90 per cent) for a switch to efficient pumps. This was done as the energy savings on the already subsidized electricity more than paid for itself by allowing the utility to increase its revenue from non-subsidized categories.

In this context, solar water pumps can play a very major role in the agriculture sector of Kerala. Considering the decentralized functioning of the administration and relative financial autonomy of local government, a well-designed solar PV pumping policy can make a large difference.

- Stakeholder Engagement Activities

  The key stakeholders involved in the strategy are EMC, ANERT, principal agricultural office of the district, pump suppliers and farmers. As the first step, it will be important to assess the optimal level of subsidy that can be given by considering the agricultural tariffs and the cost of supply of the utility. Once an appropriate level is identified, the state may allocate the budget for subsidy disbursal under energy conservation fund. In the second stage, EMC will have to identify the inefficient electric pumps and co-ordinate with the principal agricultural office of the district to replace it with new efficient pumps or co-ordinate with ANERT to replace these pumpsets to solar water pumps. ANERT with the ground water department of the district will have to identify the irrigated areas where ground water table is appropriate for the operation of solar water pumps. The state department of agriculture will have to devise subsidy schemes for these pumpsets.

- State Investment and Cost-Benefit Analysis

  No costs are envisaged for this strategy. Central subsidy is already available for solar water pumps. The government of Kerala has recently announced its intention to distribute 1,800 solar water pumps directly to farmers across the state. The current scheme is based on central subsidy and does not provide any state subsidy. However, in cases where agricultural electricity use is subsidized, it may make economic sense for the state to actually provide additional subsidy support to the farmers. It would be advisable for the government to explore this option.

PUBLIC UTILITIES

Policy objectives

- Reducing water wastage in transmission
- Switch to solar street lighting

Policy Targets

- 15 per cent reduction in energy use by reducing water transmission losses; identifying panchayats which are entirely covered with its own surface water and bore-wells
- 25 per cent reduction in energy use in street lighting by 2030
- 50 per cent penetration of solar street lighting by 2030

Reducing Water Transmission Losses through Better Operational Management and Maintenance

Many studies have consistently pointed out the huge saving potential in this sector. Based on identified strategies, an immediate policy measure could be to reduce transmission loss (currently at about 25 per cent) to 5 per cent. It will be increasingly difficult to sustain these levels of losses as piped water supplies increase and an early intervention can have long-term benefits.

- Stakeholder Engagement Activities

  The key stakeholders involved in this strategy are district ground water department and district wing of the KWA. KWA will identify the areas of water transmission losses and conduct continuous maintenance of these pipelines.

- State Investment and Cost-Benefit Analysis

  Cost to the state includes maintenance charges
  Benefits include reduced water losses and energy savings

Switching to Solar Street Lighting

Another major strategy is to increase the efficiency levels of the street lighting installed. Old and inefficient lights must be replaced with new energy efficient fittings. It can also be made mandatory that all new street lights to be installed can be solar street lights wherever possible.

- Stakeholder Engagement Activities

The key stakeholder involved in this strategy is PWD. The main duty of the PWD district department will be to ensure that all inefficient street lights are replaced by efficient street lights or solar street lights.

- State Investment and Cost-Benefit Analysis

Based on the assessment done in *The Energy Report – Kerala*, a brief summary of the cost benefit analysis is presented below.

Assuming a standard solar street light cost of Rs. 12,000[18] and a 50 per cent capital subsidy, the total cost per street light would be Rs. 6,000. Assuming a replacement ratio of two to one (two solar street lights of low spans with one conventional street light of larger span), a standard street light energy intensity (70W High Pressure Sodium Vapour) of 254kWh/year[19] and an electricity tariff rate of Rs. 5/kWh, the total state investment requirements in street lighting for the district is shown in the table below. The added benefit of solar street light would be nearly zero maintenance cost. Table 11.4 below estimates the actual state investments and net savings for the state.

TABLE 11.4: STATE INVESTMENT REQUIREMENTS FOR EFFICIENT STREET LIGHTING IN PALAKKAD

State Investments in Street Lighting (Rs. in Cr)	2015-20	2021-25	2026-30
CAPEX	18.66	38.37	96.45
Savings	7.38	18.5	42
Net Outflow	**11.3**	**19.9**	**54.5**

The details of actual calculation and narrative description of methodology are given in Annexure 6.

[18]MNRE. 2011. *Development of Agra Solar City: Final Master Plan*. Ministry of New and Renewable Energy, Government of India, and ICLEI South Asia, New Delhi, India. http://mnre.gov.in/file-manager/UserFiles/agra_solar_city_master_plan.pdf, accessed on 16 April 2015.
[19]WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

CHAPTER 12

RENEWABLE ENERGY PLAN FOR PALLAKAD: IMPLEMENTATION ROADMAP

The last chapter clearly elucidates the policy approach, stakeholder mapping and cost-benefit analysis of key interventions. However, from an implementation perspective, it is also necessary to clearly juxtapose actions, their priorities, responsibilities and assess the cost to benefit perspective to make it possible for policymakers to assess desirability and potential of a particular action. The following tabulated format attempts to provide a complete snapshot of actions, activities, timelines, responsibilities and cost-benefits.

It is to be noted that many of the implementation measures of intervention strategies include activities like formation of a new agency/ organization, specific studies, meetings, workshops, dissemination, monitoring etc. Considering the ad hoc nature of these activities, the cost associated with these is not included. In this context, the focus of the investment and cost-benefit analysis is on direct state investments, whose cost-benefit figures have already been estimated in the last chapter.

The following narrative captures the sector-wise implementation roadmap.

Implementation Roadmap – Transport Sector

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Appointing a District Transport Planning Agency (DTPA)	The main role of the District Transport Planning Agency will be: Taking ownership of transport policy implementation and providing administrative and budgetary support for identified schemes through KSECF or the Department of Transport Directly conducting transport studies or contract appropriate transport studies to independent consultants Pro bono consulting or direct support through an empanelled consultant to government and private agencies to develop a transport energy management plan for large entities Coordinating with other government departments and private agencies to facilitate implementation of progressive policy measures and their monitoring and verification Disseminating information on transport policy, policy schemes, transport technologies and energy conservation through mass media	
Transport Sector Freight shift from road to railway: Increasing rail freight share to 50 per cent from the current 26 per cent by 2030	Commissioning a study to understand freight requirements of industrial units and assess commercial barriers for a shift to railways *Note: DTPA to interact with industries to investigate key barriers (technical and commercial) for switching industry freight from road to rail*	
	Commission a study to assess the capability of the railways to undertake additional freight at a competitive rate *Note: DTPA to interact with the railway to investigate key barriers (technical, infrastructural and commercial) for managing 200 per cent freight volume*	
	Facilitate a dialogue between the railway and industry associations to decide on technical and commercial terms of freight transport *Note: DTPA will have to act as a mediator and bring the railway and the industries on board for making a freight deal.*	
	Approaching the central government (Ministry of Railways) to seek support for developing additional infrastructure to support additional freight traffic	
	A multi-stakeholder workshop to discuss policy objectives and mandate for freight modal shift to rail *Note: DTPA to clearly present government perspective on the desirability and necessity of freight shift from road to rail. The main intent of this workshop will be to disseminate information about the strategic benefits from the strategy*	
	Monitor freight share and assess monetary and energy savings over time	

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-2 years	Implementing agency: Department of Transport, Government of Kerala Stakeholders: NATPAC, EMC Kerala, District Collector	Costs related to institutional establishment and salaries	
	0-2 years	Implementing agency: DTPA Stakeholders: Industries, Department of Transport, Indian Railways	**Investment/Costs:** **No investment (CAPEX or OPEX) is envisaged:** Costs of studies, workshops, institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Lower fossil fuel use, lower running costs, lower cost of production for industries, better environmental and climate footprint
	0-2 years	Implementing agency: DTPA Stakeholders: Indian Railways		
	0-2 years	Implementing agency: DTPA, government of Kerala Stakeholders: Ministry of Railways		
	0-2 years	Implementing agency: DTPA Stakeholders: Indian Railways, industry associations, transporters		
	2-5 years	Implementing agency: DTPA Stakeholders: Indian Railways, industry associations, transporters, CSOs		
	5-15 years	Implementing agency: DTPA Stakeholders: Indian Railways, industry associations		

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Transport Sector: Implementing Stringent Fuel Efficiency norms to target 30-40 per cent reduction in energy intensity of large buses, trucks and small commercial vehicles, and use of hybrid vehicle technologies in other categories	Seek support from the Central Road Research Institute, New Delhi to chalk out a plan for reducing energy intensity of heavy vehicles *Note: DTPA can approach CRRI regarding preparing a comprehensive plan for reducing energy intensity of heavy vehicles citing recent research report by CRRI claiming possibility 40 per cent energy intensity reduction by 2030*	
	Appoint a transport technology consultant to identify promising hybrid technologies and set up fuel efficiency standard for some vehicle categories	
	Appoint transport consultants to study traffic delays and suggest smart measures at checkposts at Walayar and other inter-state entry points	
	Prepare a draft policy intent document clearly indicating the potential actions envisaged for improving transport sector energy efficiency	
	Conducting a seminar to discuss the policy objectives and proposed actions related to standards and labelling and adoption of hybrid technologies	
	Support transporters with driver training through direct/indirect support *Note: DTPA can provide partial support for driving institutes who provide driver training packages to truckers and bus drivers*	
	In coordination with the central government, enact necessary regulatory provisions to mandate labelling, monitoring and verification measures and hybrid technology standards *Note: DTPA to work with CRRI and the Department of Road Transport to enact monitoring, labelling and verification norms for vehicles in line with similar measures in advanced countries. Based on the report of the transport technology consultant, DTPA to notify policy regulations for hybrid technologies.*	
	Build capacity for coordinating and monitoring agencies through support from the central government	
	Monitor vehicle sales, monitor energy use data	

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-2 years	Implementing agency: DTPA Stakeholders: Central Road Research Institute, New Delhi	**Investment/Costs:** No investment (CAPEX or OPEX) is envisaged: Costs of studies, workshops, institutions and activities (inspection and monitoring)	**Revenues/savings/benefits:** No direct or indirect revenues or savings. Main benefits will include lower fossil fuel use, lower running costs, better environmental and climate footprint
	0-2 years	Implementing agency: DTPA Stakeholders: Transport technology consultant, vehicle manufacturers		
	0-2 years	Implementing agency: DTPA Stakeholders: Transport consultant		
	2-5 year	Implementing agency: DTPA Stakeholders: CRRI, RTO, Traffic Department		
	2-5 years	Implementing agency: DTPA Stakeholders: CRRI, RTO, Traffic Department, transporters, vehicle manufacturers, general public, state transport corporation		
	0-10 years	Implementing agency: Driving Institutes, DTPA Stakeholders: Transporters		
	2-5 years	Implementing agency: DTPA Stakeholders: Transporters, CRRI, Department of Transport, RTO		
	2-5 years	Implementing agency: DTPA Stakeholders: Transporters, Department of Transport, RTO		
	5-15 years	Implementing agency: RTO Stakeholders: DTPA, transporters, Department of Transport		

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Transport Sector: Electric Vehicles: 50 per cent penetration of electric two wheelers, 20 per cent for cars and three-wheelers and 15 per cent for mini buses	A comprehensive assessment of EV technologies, their market potential, and performance record through an independent consultant. *Note: DTPA to prepare a comprehensive ToR which will include market assessment, technology availability detailed specifications, drive control, years of operation, actual running costs, service and spares delivery network, actual user reviews for all available Indian two=wheeler, three-wheeler and electric car models. A separate benchmarking study will also be a part of the study to compare the technology performance of Indian models with globally leading EV models, particularly from the USA, Germany and China.*	
	Conducting awareness campaigns on electric vehicles and their benefits.	
	Notification of limited subsidy of 15 per cent to first 100 EV's (two-wheelers) in the district *Note: The key intent of the limited subsidy is to spread the ownership of EVs in the local populace. The given level of concentration of EVs will not only help advertise the EV through word of mouth but would also encourage EV manufacturers to develop a dealer and service network and possibly a manufacturing plant.*	
	Discussing new industry investments with EV manufacturers in Kerala *Note: DTPA along with the Department of Industries can approach and solicit investments from select EV manufacturers to invest in new manufacturing capacities and service network in the district.*	
	Notification of limited subsidy of 5 per cent to first 25 EV's (4-wheelers) in the district	
	Formulating an industrial policy to support EV manufacturing in Kerala	
	Oversee and encourage development of EV manufacturing and supply chain and servicing ecosystem	

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-2 years	Implementing agency: Transport Technology Consultant Stakeholders: DTPA, EV manufacturers	**Investment/Costs:** Subsidy outlay for 2-wheelers (15 per cent capital subsidy on first 100 electric 2-wheelers in the district): Rs. 6.9 lakh Subsidy outlay for 4-wheelers (5 per cent capital subsidy on first 25 electric four wheelers in the district): Rs. 6.94 lakh In addition, costs of studies, workshops, institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings: Lower fossil fuel use, lower running costs, better environmental and climate footprint
	0-2 years	Implementing agency: EV Manufacturers, DTPA Stakeholders: Transporters, Public, Electricity Officials		
	0-2 years	Implementing agency: DTPA Stakeholders: Transporters, Public, Electricity Officials, EV manufacturers		
	0-2 years	Implementing agency: DTPA Stakeholders: EV manufacturers, Department of Industries, Electricity Officials		
	2-5 years	Implementing agency: DTPA Stakeholders: Transporters, Public, Electricity Officials, EV manufacturers		
	2-5 years	Implementing agency: DTPA Stakeholders: Department of Transport, Department of Industries, EV manufacturers		
	5-10 years	Implementing agency: DTPA Stakeholders: Department of Transport, Department of Industries, EV manufacturers		

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Transport Sector: Effecting passenger transport inter-modal shift: Freezing the share of 2-wheelers and cars at 2020 level.	Creating a district mobility plan that assess the following: A survey on the bus fleet in the district and possibilities of modal share shift from motorcycles and cars to buses across different routes. Identification of key transport routes where the shift would be effective (whether short routes or long routes). Assess augmentation needs of public transport systems to meet transport requirements. Assessing new transport architecture (small capacity high frequency transport against high capacity low frequency transport, point to point routing or a ring route, etc.). Assessing strategies to curtail indiscriminate growth of personal vehicle use by direct/indirect measures like high entry taxes, congestion charges on personal vehicles in a phased manner. *Note: The state may take a leading role in meeting increased public transport sector needs. The cost benefit of investing are covered subsequently.*	
	Implementing strategies to curtail indiscriminate growth of personal vehicle use by direct/indirect measures like high entry taxes, congestion charges on personal vehicles in a phased manner.	
	Investing in new transport capacity: Procure new buses for high traffic routes Phasing out old efficient buses with new low-capacity high-frequency mini buses wherever feasible.	
Transport Sector Resource pooling: Supporting car pool, bus pool and shared taxis	Survey of industrial establishments/offices for feasibility of car-pooling and survey of areas and routes for shared rickshaw services.	
	Creating awareness among identified clusters for switching to pooled services	
	Time based targets for identified commercial/industrial establishments in a phased manner	
	Identification of high-density, high-frequency routes in urban areas.	
	Encouraging small shared modes of transport to run these routes.	

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-2 years	Implementing agency: DTPA Stakeholders: Transporters, public, RTO	**Investment/Costs:** CAPEX: Rs. 16.5 lakh/bus OPEX Rs. 23.93 lakh/bus/year Total CAPEX Rs. 38.8 Cr (2021-25) and Rs. 57.1 (2026-30) OPEX Rs. 161 Cr (2021-25) and Rs. 463.1 Cr (2026-30) (See Chapter 10) In addition, costs of studies, workshops, institutions and activities (inspection and monitoring)	**Revenues/savings/benefits:** Revenue: Rs. 27.40 lakh/bus/year Total Revenues of Rs. 199.6 Cr in 2021-25 and Rs. 574.3 Cr in 2026-30 (See Chapter 10) In addition, lower fossil fuel use, less traffic, better transport options, better environmental and climate footprint
	2-5 Years	Implementing agency: DTPA Stakeholders: Transporters, public, RTO		
	5-15 years	Implementing agency: State Transport Corporation Stakeholders: DTPA, transporters, public, RTO		
	0-2 years	Implementing agency: DTPA Stakeholders: RTO, traffic department, transporters, public	**Investment/Costs:** No investment (CAPEX or OPEX) is envisaged: Costs of studies, workshops, institutions and activities (inspection and monitoring)	**Revenues/savings/benefits:** No direct or indirect revenues or savings. Less traffic, better transport options, better environmental and climate footprint
	0-2 years	Implementing agency: DTPA Stakeholders: RTO, traffic department, transporters, public		
	0-2 years	Implementing agency: DTPA Stakeholders: RTO, traffic department, transporters, public		
	0-2 years	Implementing agency: DTPA Stakeholders: RTO, traffic department, transporters, public		
	2-5 years	Implementing agency: DTPA Stakeholders: RTO, traffic department, transporters, public		

Implementation Roadmap – Buildings

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Buildings: Move towards green buildings and sustainable architecture	Constituting a technical committee to implement green buildings/sustainable architecture at the district level.	
	Draft green building guidelines, labelling and minimum performance standards for buildings.	
	Devise programme that encourages individuals or businesses to implement green building/sustainable architecture for their properties through incentives such as reduction in building tax, local body taxes, electricity and water connection charges, etc	
	Conduct a comprehensive awareness campaign for commercial as well as residential sector on the benefits of green buildings/sustainable architecture	
	Develop measures to mandate all new commercial buildings to be compliant with ECBC by 2020	
	Integrate standard approval processes with the buildings regulations to ensure that administrative approvals are linked with compliance to buildings regulations	
	Facilitating technical assistance to individuals/ businesses who follow green building code guidelines	
	With the help of agencies like COSTFORD, develop a program for architects and building contractors to integrate GRIHA rating systems in designs of Independent houses	
	Develop measures to encourage domestic buildings to switch to sustainable architecture techniques: eased norms for approval, concession in property taxes,	
	Measure progress of implementation, recommended actions and strategies and necessary modifications.	

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-2 years	Implementation Partner: PWD (buildings), Municipal Corporations Knowledge Partner: EMC Other stakeholders: Commercial sector and Domestic sector	**Investment / Costs:** **No investment (CAPEX or OPEX) is envisaged** Costs of studies, workshops, institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Energy security, revenue generation from export of power, better environmental and climate footprint
		Implementing agency: PWD (buildings)		
	2-3 years	Implementing agency: PWD (buildings), Municipal Corporations Stakeholders: Commercial sector and Domestic sector		
		Implementing agency: EMC Stakeholders: Commercial sector and Domestic sector		
		Implementing agency: Green building regulatory board Stakeholders: PWD (buildings), Municipal Corporations, commercial sector		
		Implementing agency: PWD (buildings), Municipal Corporations		
		Implementing agency: EMC Stakeholders: Domestic sector		
	3-15 years	Implementing agency: PWD (buildings)		
		Implementing agency: PWD (buildings), municipal corporations		
		Implementing agency: PWD (buildings), municipal corporations		

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Buildings Retrofit of existing buildings	Constitute a district level building and energy audit consultancy to carry out energy audits of the existing commercial buildings and establish minimum performance standards for the existing buildings in kWh/ sqm	
	Allocate budget for providing part support to building and energy audits for select commercial customers including government buildings	
	Segregate commercial establishments according to their energy consumption and initiate the policy measure in phased manner by starting with high energy consuming establishments	
	Conduct audits on the identified establishments and identify retrofitting potential of these buildings and prioritize retrofit strategies on the basis of their strategic priority or commercial feasibility	
	Set short term targets to these buildings based on cost effective retrofits and renovation	
	Conduct re-audit of these buildings to measure and monitor the progress based on the stipulated targets	
	Set new and tightened targets to further decrease the energy consumption and ensure that buildings achieve the minimum performance standards	

Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
0-3 years	Implementing agency: PWD (buildings), EMC Stakeholders: Energy auditing agencies	**Investment / Costs:** Investments for retrofits: Rs. 2500/ m^2 Total CAPEX Rs. 169.58 Cr (2021-25) and Rs. 339.16 (2026-30) OPEX Rs. 161 Cr (2021-25) and Rs. 463.1 Cr (2026-30) Apart from the above, direct cost, energy audits, knowledge enhancement programs subsidies, institutions and activities (inspection and monitoring) will also be incurred. (refer Chapter 10)	**Revenues/ savings/ benefits:** Effective savings Rs. 330/m^2/Year Total Savings of Rs. 67.15 Cr in 2021-25 and Rs. 179.7 Cr In 2026-30 (Refer Chapter 10) Other benefits include energy security, revenue generation from export of power, better environmental and climate footprint
	Implementing agency: EMC		
	Implementing agency: EMC Stakeholders: PWD (buildings), municipal corporations Commercial establishments		
3-8 years	Implementing agency: Energy audit agency Stakeholders: PWD (buildings), commercial sector		
	Implementing agency: Energy audit agency Stakeholders: PWD (buildings), commercial sector		
8-15 years	Implementing agency: Energy audit agency Stakeholders: PWD (buildings), commercial sector		
	Implementing agency: Energy audit agency Stakeholders: PWD (buildings), commercial sector		

Implementation Roadmap – Energy and Power

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Energy And Power Measures for Supporting Super Efficient Equipments	Conduct a survey to explore the existing pattern of appliance used in households and available in market in the district	
	Work closely with BEE to understand progress on SEA labeling the possible timelines for SEA availability in India.	
	Formulate a strategy to facilitate the ready availability of Super efficient appliances in the market	
	Create a strong information system and conduct massive awareness programs among domestic and commercial consumers through different media for available SEA models their energy saving potential and payback period	
	Initiate measures to phase out non-efficient equipments from the market by imposing direct/indirect measures	
	Formulate measures to establish partnership with appliance manufacturers/Suppliers to devise subsidy schemes for SEA's	
	Creation of internet database to disseminate the information on the empanelled list of appliance providers, technical specifications, models available and the subsidy schemes for different SEA	
	Monitor the progress of phasing out of inefficient appliances and subsequently ensure the planned penetration of SEA.	
	Create an environment to attract SEA equipment manufacturers to set up manufacturing plants in the district	
	Provide necessary infrastructure requirements for the manufacturing plants	
Energy and Power Measures for supporting Decentralized Renewable Energy	Early notification of the Solar Policy	
	Study on barriers to implementing net metering and resolving technical, administrative and regulatory issues	
	Conduct a study on viable business models that can work on shared investment using common infrastructure (ESCO model or rooftop rental model). The study should also assess the regulatory measures required to support these business models. development of necessary regulatory Mandate and ensure that all concerned commercial and industrial establishments abide by the solar purchase obligations	
	Implement identified regulations to facilitate business models for commercial PV investments and mandate SPOs	
	Mandate and ensure that all concerned commercial and industrial establishments abide by the solar purchase obligations	

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-5 years	Implementing agency: EMC	**Investment / Costs:** **No investment (CAPEX or OPEX) is envisaged** Costs of studies, subsidies (as notified), institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Energy security, revenue generation from export of power, better environmental and climate footprint
	2-8 years	Implementing agency: EMC Stakeholders: External survey agency		
		Implementing agency: EMC Stakeholders: Domestic and commercial consumers		
		Implementing agency: EMC		
		Implementing agency: State Finance department, GoK Stakeholders: EMC, Appliance manufacturer/ Supplier		
		Implementing agency: EMC		
	8-15 years	Implementing agency: EMC Stakeholders: External survey agency		
		Implementing agency: State Industries department Stakeholders: DIC, EMC		
		Implementing agency: DIC		
	0-2 years	Implementing agency: ANERT Stakeholders: KSEBL, KSERC, Consumer Associations, Solar PV suppliers, empanelled consultants	**Investment / Costs:** **No investment (CAPEX or OPEX) is envisaged.** Costs of studies, subsidies (as notified), institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Savings in fossil fuel use, lower production costs for Industries, better environmental and climate footprint
	2-15 years	Implementing agency: ANERT		
		Implementing agency: ANERT, KSERC		

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Energy and Power Measures for supporting large scale Renewable Energy	Formulate a renewable energy plan document based on the assessed RE potential to set targets for development of grid-tied solar and wind power	
	Identify potential for large solar and wind parks based on the RE resource and conduct a pre-feasibility study for the identified locations. Some of the areas of focus of the pre feasibility study could be: Assessing Row (right of way) and land acquisition issues, Assessing preliminary grid evacuation assessment, and identifying other infrastructure support requirements (roads, water, etc).	
	Notify revised policies aimed at inviting private sector participation for developing wind and grid—tied solar projects in the district	
	Notify necessary regulations to allow the utility to seek power procurement from these parks	
	Facilitate private sector participation in large wind and solar PV development through suitable regulatory incentives and land allocation measures and single window clearance.	
	Implement RE parks in a phased manner	
Power and Energy Stabilized use of wood for cooking	Constitute a community based group for collection, processing and distribution of firewood	
	Create a plan for large scale distribution of smokeless chulhas in the households	
	Create an awareness plan among households about the duties of these groups and encourage the households to use firewood for cooking	
	Monitor the progress of stabilized use of wood in the district.	

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-2 years	Implementing agency: KSEBL, ANERT, Department of Energy	**Investment / Costs:** **No investment (CAPEX or OPEX) is envisaged:** Costs of studies, institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Energy security, revenue generation from export of power, better environmental and climate footprint
		Implementing agency: ANERT, Independent Consultant		
		Implementing agency: ANERT		
		Implementing agency: KSERC		
	5-15 years	Implementing agency: KSEBL, ANERT		
		Implementing agency: KSEBL, ANERT		
	0-3 years	Implementing agency: Local Self Government	**Investment / Costs:** No investment (CAPEX or OPEX) is envisaged. Costs of institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Savings in LPG use, economic savings for households, better environmental and climate footprint
		Implementing agency: ANERT/IRTC		
	3-15 years	Implementing agency: Local Self Government Stakeholders: Community based group, households		
		Implementing agency: Local Self Government		

Implementation Roadmap – Industry

Sector and Policy Measure	Activities & Stakeholder Management Plan	
Industry Sector Energy Management Protocol	Constitute an industrial energy audit group for the district to formulate separate energy intensity (Specific Energy Consumption) benchmarks for existing and new industries Constitute a technology assessment committee for providing technical assessment of all new upcoming projects.	
	Create an information database detailing the best available technologies and best process technologies for each type of industries. This can be revised every ten years to reflect the changes in Industry technologies	
	Create an internet based information system for on the energy efficiency benchmarks for each type of industries and details about the empanelled energy audit agencies	
	Formulate measures to make energy audit compulsory in all industries within a stipulated time	
	Conduct knowledge enhancement programs on industrial energy efficiency and conservation options, information transfer to industries on the best practices and techniques to reduce energy intensity	
	Identify the potential areas of reduction and set efficiency targets for each industry to achieve the set benchmark targets in a phased manner.	
	Formulate measures to encourage all the new upcoming industries in the district to adopt best available technology and best process technologies	
	Ensure that the upcoming projects adopt the best available technology and best process technology currently available in the market	
	Conduct re-audits to ensure that industries are complying by the protocol.	
	Set progressively more stringent targets to the industries	
	Continuous monitoring to ensure that specific targets are achieved	
Industry Sector Promoting solar process heating	Identify industries which use low process heat including SME's	
	Conduct awareness programs to these clusters on the benefits of shifting to solar process heating	
	Formulate measures to establish partnership with technology providers to devise subsidy schemes for solar process heating	
	Information dissemination on the subsidy schemes and incentives and the empanelled list of technology suppliers	
	Formulate measures to ensure that identified industries are shifting to solar process heating in a phased manner	

	Timeline	Ownership	Investments/ Costs to State	Revenues/ Savings/ Benefits
	0-2 years	Implementing agency: EMC, DIC Stakeholders: Energy audit agencies, Industry experts, Technology assessment committee	**Investment / Costs: No investment (CAPEX or OPEX) is envisaged** Costs of studies, subsidies (as notified), institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Savings in fossil fuel use, Savings in Electricity, lower production costs for Industries, better environmental and climate footprint
		Implementing agency: EMC/DIC		
	2-5 years	Implementing agency: EMC and DIC		
		Implementing agency: EMC Stakeholders: DIC, Industries		
		Implementing agency: EMC, Industry experts Stakeholders: DIC Industries, Technology assessment committee		
	5-15 years	Implementing agency: EMC, DIC Stakeholders, Industries, Technology assessment committee		
		Implementing agency: Energy audit agencies Stakeholders: DIC, Industries, EMC		
		Implementing agency: EMC, Energy audit agencies Stakeholders: DIC, Industries		
		Implementing agency: Energy audit agencies Stakeholders: DIC, Industries, EMC		
	0-2 years	Implementing agency: DIC Stakeholders: Industries	**Investment / Costs: No investment (CAPEX or OPEX) is envisaged.** Costs of studies, subsidies (as notified), institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Savings in fossil fuel use, lower production costs for Industries, better environmental and climate footprint
		Implementing agency: ANERT Stakeholders: DIC Industries		
	2-4 years	Implementing agency: State Industries Department, ANERT Stakeholders: Equipment supplier		
	4-15 years	Implementing agency: State Industries Department Stakeholders: Identified industries		
		Implementing agency: DIC		

Implementation Roadmap – Agriculture

Sector and Policy Measure	Activities & Stakeholder Management Plan
Agriculture Sector Adopting micro irrigation techniques	Identify irrigated areas and crops where micro-irrigation can be adopted
	Conduct awareness campaign among farmers about the benefits of micro-irrigation techniques and micro-irrigation technologies
	Formulate a plan for the phased adoption of micro-irrigation in the district
	Promote micro-irrigation by implementing the incentives provided by the government
	Monitor the progress of implementation of micro-irrigation
Agriculture Sector Switching to energy efficient pumps/solar water pumps	Study on subsidy design for efficient irrigation pump sets. The study will have to assess the cost of supply and the revenue realization from agriculture sector and compare it with the cost of savings to assess the quantum of subsidy for efficient pumpsets/solar water pumps.
	Formulation of an internal subsidy and monitoring structure through existing government institutions
	Devising policy for large scale replacement of diesel pumps with solar PV pumps through best case studies (Rajasthan Solar water pumping policy)
	Formulate measures to establish partnership with equipment manufactures to provide subsidized efficient motors/ solar water pumpsets
	Identify irrigated areas having appropriate ground water table for installing solar water pumps
	Phased replacement of old pumpsets with efficient pumps/ solar pumps
	Monitor the progress of phased replacement of old inefficient pump sets.

Implementation Roadmap – Public Utilities

Sector and Policy Measure	Activities & Stakeholder Management Plan
Public Utilities Reduce water wastage in transmission	Conduct an independent study on the ground water resources available in the district
	Identify the areas which can self sustain with the available ground water resources
	Formulate steps to utilize the all ground water in the available area thus reducing the need for long water transmission lines.
	Conduct an inspection to identify areas of water transmission losses
	Carry out immediate actions to rectify the transmission losses
	Ensure continuous maintenance of water transmission pipelines at regular time intervals
Public Utilities Switch to solar street lighting	Identify the areas were new installations of street lights are being done
	Mandate that new street light installation will be solar street lighting
	Replace old inefficient street lights with either solar or efficient lights.

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-3 years	Implementing agency- District Principal Agricultural Office	**Investment / Costs:** Investment for subsidy is 3200/ Ha of land adopting micro-irrigation practices **Total Investement:** Rs. 11.69 Cr (2015-20), Rs. 29.22 Cr (2021-25) and Rs. 58.43 Cr (2026-30) Other costs include costs of studies, subsidies (as notified), institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** Savings in electricity use, at the rate of Rs. 3.3/Kwh **Total savings:** Rs. 8.5 Cr (2015-20), Rs. 24.7 Cr (2021-25) and Rs. 43.3 Cr (2026-30) Other benefits include better environmental and climate footprint
		Implementing agency- Regional Agricultural Research Station Stakeholders- Agricultural Unions, Farmers		
		Implementing agency- District Principal Agricultural Office		
	3-15 years	Implementing agency- State Agricultural Department		
		Implementing agency- District Principal Agricultural Office Stakeholders-Farmers		
	0-2 years	Implementing agency- District Principal Agricultural Office, District ground water department	**Investment / Costs:** **No investment (CAPEX or OPEX) is envisaged** Costs of studies, subsidies (as notified), institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Savings in electricity use, higher revenue realization for electricity utility, better environmental and climate footprint
		Implementing agency- EMC/ANERT		
		Implementing agency- State Agricultural Department Stakeholders-Equipment Supplier		
		Implementing agency- ANERT/ District Principal Agricultural Office		
	3-10 years	Implementing agency- District Principal Agricultural Office Stakeholders-Equipment Supplier, Farmers		
		Implementing agency- District Principal Agricultural Office		

	Timeline	Ownership	Investments/Costs to State	Revenues/ Savings/ Benefits
	0-3 years	**Implementing agency**: PWD	**Investment / Costs:** **No investment (CAPEX or OPEX) is envisaged.** Costs of studies, institutions and activities (inspection and monitoring)	**Revenues/ savings/ benefits:** No direct or indirect revenues or savings. Water saving, increased revenue collection for water authorities, better environmental and climate footprint
	0-5 years			
	5-10 years			
	0-2 years	**Implementing agency**-PWD	**Investment/ Costs:** **CAPEX:** Rs. 12000/Streetlight Total investments: Rs. 18.66 Cr (2015-20), Rs. 38.37 Cr (2021-25) and Rs. 96.45 Cr (2026-30)	**Revenues/ savings/ benefits:** **Savings:** Rs. 1270/Year **Total savings:** Rs. 7.38 Cr (2015-20), Rs. 18.5 Cr (2021-25) and Rs. 42 Cr (2026-30) Other benefits include lower maintenance costs, better environmental and climate footprint
	2-15 years			

CHAPTER 13
CONCLUSION

The study findings indicate that technically, at the district level, 47.7 per cent of the energy demand can be met from renewable energy sources by 2030. The study is structured into four parts.

The study estimates renewable energy supply potential for wind power, solar energy, sustainable bioenergy and small hydro power. GIS-based assessment is done for grid-tied wind and solar, and a narrative-based assessment is done for decentralized solar (rooftop PV, solar water heating, solar pumping and solar process heating) and bioenergy. Assessment of small hydro potential is based on the assessment of feasible untapped potential that can be harnessed by 2030. The results of the assessment indicate a 2030 RE supply potential of 4.34 billion units of electricity and 1.47 Peta Joules of heat.

In the assessment of demand side, one of the key technical finding is the demand curtailment potential. Aggressive demand side interventions in energy conservation, energy efficiency and carrier substitution have the potential to reduce energy demand by about 36 per cent over a non-intervention scenario. The key sectors of energy curtailment intervention for the district are transport, industry and domestic.

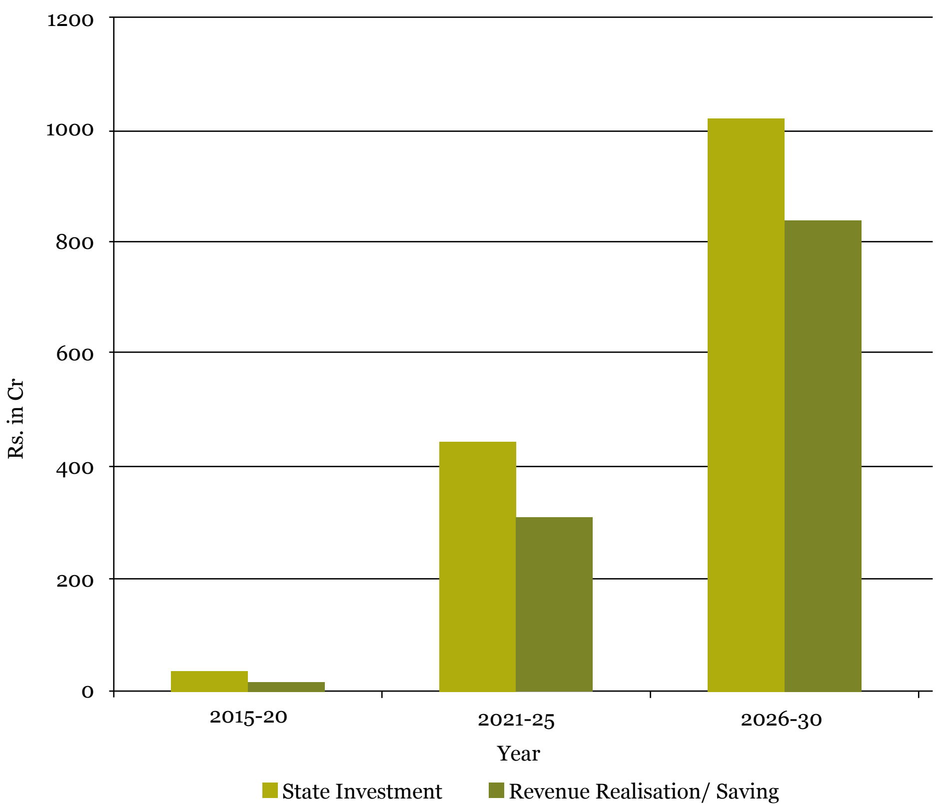
Based on the assessment of supply and demand scenarios, it is assessed that 47.7 per cent of the total demand and 100 per cent of the electricity demand can be met by renewable sources. Complete phase out of fossil fuels is not deemed possible mainly because of unavailability of substitutes for transport fuels and specific industrial heating fuels like pet coke by 2030. Although wood-based combustion potential is large, it can only displace coal. Furthermore, only a part of LPG requirement in the domestic/commercial sector is deemed to be replaceable because of limited availability of biogas resources. As the focus of the study is on implementation, a detailed policy analysis and implementation roadmap is also presented. The four key areas of focus are: policy approach, stakeholder engagement, cost-benefit analysis and implementation roadmap. While policy approach focuses on strategies and intervention activities required from the state, the stakeholder management strategy identifies key stakeholders and focuses on soliciting stakeholder buy-in through awareness creation, encouraging dialogue and enhancing government-stakeholder interaction. The focus of the cost estimation is on infrastructure and large capital investments. The benefit analysis considers direct economic benefit (revenue realization or economic savings) and indirect benefits accruing to the state.

Based on the assessment, the state sector investment requirements for facilitating the transition to a 50 per cent RE scenario (including 100 per cent electricity from RE sources) appears to be practical for the district considering the significant possibilities of investment returns through accrued savings and revenue realization. Table 13.1 and Figure 13.1 below summarize the total district-level capital investments (CAPEX + OPEX) and savings/revenues for the interventions.

TABLE 13.1: TOTAL DISTRICT-LEVEL INVESTMENT REQUIREMENTS

STATE INVESTMENT- CAPEX & OPEX (Rs. in Cr)	2015-20	2021-25	2025-30
Total Investment in New Buses and Public Transport	0	199.74	520.19
State Investments for Micro-irrigation	16.69	38.22	67.43
State Investments in Street Lighting	18.66	38.37	96.45
State Investment in Building Retrofitting	0	169.58	339.16
TOTAL INVESTMENT	**35.35**	**445.91**	**1,023.23**
REVENUE REALIZATION/SAVINGS			
Revenue Realization from New Buses	0	199.61	574.28
Savings to the State from Micro-irrigation	8.5	24.7	43.3
Savings to the State from Street Lighting	7.38	18.5	42
Savings from Building Retrofitting	0	67.15	179.07
NET OUTFLOW/INFLOW(-)	**19.5**	**135.95**	**184.6**

FIGURE 13.1: DISTRICT-LEVEL INVESTMENT REQUIREMENTS



Interestingly, in many of the proposed intervention strategies where state sector investment is proposed, the benefit to cost ratio is positive. Investments in public transport seem to have high benefit to cost ratios. In some interventions, although the monetary benefits may not be apparent, these interventions are assessed to have long-term strategic benefits.

In addition to a detailed focus on the policy approach, stakeholder mapping and investment assessment of key interventions, an implementation roadmap is also presented to clearly juxtapose actions, their priorities, responsibilities to make it possible for policymakers to assess desirability and the potential of a particular action.

Although the study clearly spells out the potential for action and maps out a step by step implementation plan, actual on-ground implementation will require careful pre-planning of activities and a revision in the standard implementation framework. In this context, four key areas that can help the state to move from planning to on-ground implementation are

- **Preliminary stakeholder identification and management:** It is strongly recommended that the state government formalizes use of stakeholder mapping and stakeholder management plans before implementing any major policy measure. A well-defined stakeholder management plan will help specify the ownership level and responsibility of each stakeholder as well as measure the strength of potential opposition. This would help policymakers and implementing agencies to develop innovative approaches that build in specific adaptation and mitigation approaches at the design stage.

- **Encouraging strategic investments in financial planning:** In some strategic areas, state sector investment motives can be based on strategic and welfare priorities rather than short-term financial viability. In many cases, especially in new areas of technology and materials, a small public sector investment support could have the potential to clear entry barriers and open new sectors to private investments. In this context, the financial planners will have to be open to new investments that may result in long-term strategic benefit and sustainable growth.

- **Defining responsibility for action and ownership:** The most important prerequisite for successful implementation is the need for ownership. Real on-ground implementation can only happen if there is a clear motivation to see end result and ownership of action may be as important as the development of policy and regulation. It would be important for the state to not only clearly earmark responsibilities, but also empower the implementation agencies and end users to put strategies and policies into action.

- **Ensuring task completion and measurement of results:** The last and the most important aspect of implementation will be effective completion. Well-supported and well-meaning measures may fail without a comprehensive post-implementation strategy. It will be important for the state to see that not just outputs but anticipated outcomes are also achieved.

However, the most important prerequisites for initiating the transition to a 50 per cent RE paradigm would be political will and a sense of shared vision between the government and the other stakeholders. It is hoped that the study findings help facilitate this transition to the new paradigm.

ANNEXURE

ANNEXURE 1
SECTOR OVERVIEW AND POLICIES

Annexure 1 summarizes the current status, upcoming projects and the respective policies for electricity, commercial, industrial, agricultural and transport sectors in Palakkad. The Integrated District Development Plan, Palakkad was used as a reference to obtain the required information.[1]

ELECTRICITY SECTOR

Palakkad became India's first fully electrified district in 2010. However, a major share (above 90 per cent) of electricity requirements of the district are met by generating sources from neighbouring districts. There is huge potential for renewable energy deployment in the district to meet its energy needs. The present installed capacity of grid electricity in Palakkad is 2 per cent of Kerala's total electricity generation capacity. The current generation capacity of the district is about 23MW, with about 5MW of small hydro capacity (Malampuzza and Meenavallom small hydro plants), one 2MW solar PV plant in Kuzhalmandam in Palakkad (the first in Kerala)[2] and two wind power projects (one at Kanjikode, with an installed capacity of 2.025MW, and another at Agali (IPP) with an installed capacity of 13.8MW). The focus of the state government has been on developing renewable energy generation and upgrading energy conservation and energy efficiency measures to reduce the demand-supply gap. Integrated District Development Plan, Palakkad, proposes large-scale solar deployment by constructing PV modules on dams, irrigation canals on PPP model. ANERT has installed solar heat and lighting systems at Agali and Shoyalur gram panchayats, which benefit about 349 households in the area.

Policies, Legislations and Regulations

Some of the key policies with regard to the electricity sector are discussed below.

- R-APDRP Scheme

  These schemes cover improvement and upgradation of power supply by constructing 193.17km of 11kV lines; installation of 274 additional transformers are under progress.

- Energy Efficiency Projects

  Energy Conservation Bachat Lamp Yojana was implemented with the coordination of the Energy Management Centre, Kerala, and KSEBL. Till date, 1,068,714 incandescent lamps are replaced with CFL lamps under this scheme, which saves 196,643 units per day. A pilot project was carried out in Palakkad to improve energy efficiency of street lights, automation of switching on and off of street lights and recording the consumption of energy. This project is being replicated in the entire district.

---

[1] District Planning Committee. 2013. *Integrated District Development Plan Palakkad, Volume 1: Perspective Plan*. Department of Town and Country Planning, Kerala.
[2] Ibid.

- Kerala Solar Energy Policy, 2013

The policy intends to achieve an installed capacity of 500MW for Kerala by 2017 and 2,500MW by 2030. This target is to be met by installing off-grid roof-top modules, off-site generation at locations like canal, reservoirs, wastelands, etc. The policy intends to make it mandatory for all industrial buildings, government and private hospitals, hotels, resorts, municipal buildings, educational institutions and tourist centres where hot water is used for process heat applications, to install solar modules. Solar Purchase Obligation (SPO) will be mandated for commercial consumers with more than 20kVA connected load, LT industrial with more than 50 kVA connected load and for all HT & EHT consumers in a phased manner. All HT & EHT consumers shall have to procure 0.25 per cent of their consumed energy through SPO till March 2015 with 10 per cent increase every year. From April 2015 onwards, the same shall be applicable for commercial consumers and LT industrial as per the criteria mentioned above. The same will also be applicable for high-consuming domestic consumers, i.e., more than 500 units per month at a later stage.

- Kerala State Energy Conservation Fund, 2014

The state's designated agency to implement the Energy Conservation Act, 2001 is the Energy Management Centre (EMC). EMC has encouraged energy auditing of government and private office buildings by financing 50 per cent of the auditing fees, which is done for identification of cost-effective energy savings and relative measures. In 2014-15, the outlay of funds allocated is Rs. 105 lakh for the purpose of identification and implementation of energy conservation activities.[3] For government offices and other public sector buildings, the Performance Contracting Scheme has been introduced under KSECF for identifying, construction, implementation and maintenance of buildings complying with energy efficiency norms. Performance contracting allows private energy service companies to design, construct, implement and maintain the buildings offering performance guarantees in terms of cost reductions for saving energy consumed. A similar scheme has been launched for energy-efficiency projects where the government will provide grant up to 50 per cent of the costs of the project.[4]

In addition, KSECF allocates funds in coordination with local financial institutions and manufacturers to promote energy-efficient refrigerators and ACs for the domestic sector. The scheme is only applicable for four- and five- star rated refrigerators and ACs. KSECF will select a financial institution and provide a list of manufacturers from where the consumers need to choose. The scheme provides zero interest loans to consumers to buy energy-efficient equipment for domestic consumption. The budget allocated under this scheme is reviewed annually by the State Finance Department.

---

[3]Hindu.2013. "ANERT to Set Up 2-MW Solar Farm in Palakkad". The Hindu (21 November). http://www.thehindu.com/todays-paper/tp-national/tp-kerala/anert-to-set-up-2mw-solar-farm-in-palakkad/article5374300.ece, accessed on 15 April 2015.

[4]Limaye, Dilip R., Natarajan, Bhaskar, Kumar, B. Anil, Lal, Swati and Pradeep Tharakan. 2009. Kerala State Energy Conservation Fund (KSECF) Financing Schemes: Final Report. International Resources Group, KSECF and USAID. http://www.keralaenergy.gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20CONSERVATION%20FUND%20%28KSECF%29%20FINANCING%20SCHEMES.pdf, accessed on 16 April 2015.

- Kerala State Electricity Regulatory Commission (Renewable Purchase Obligation and its Compliance) Regulations, 2010

  As per the regulation, every obligated entity shall purchase not less than 3 per cent of its consumption of energy from RE sources from 2010 under the Renewable Purchase Obligation (RPO),with an annual increase of 10 per cent over the base value of 3 per cent per year up to a maximum RPO limit of 10 per cent.

- Kerala State Budget Allocation for Energy Sector 2014-15[5]

  A total of Rs. 215.26 crore has been allocated for the development of hydro-electric projects implemented by KSEBL. Further, Rs. 10 crore is set apart for setting up of solar power projects to generate 60MW of energy. For gas-based power projects, Rs. 2 crore has been allocated. Rs. 5 crore has been provided to enhance the capacity of wind power projects to 100 MW and for thermal power projects. Energy conservation activities in the state will be provided an allocation of Rs. 1.05 crore. In addition, Rs. 26 crore is provided for electrification of rural BPL households under RGGVY scheme. The state government has allocated Rs. 10 crore for completion of ongoing activities.

COMMERCIAL SECTOR

Energy consumed by the commercial sector in Palakkad is low in proportion to the energy consumed by other sectors. The local authorities and the state government plan to boost tourism, health and education sectors in the district.

The development mission for tourism focuses on measures like green and sustainable tourism, and development of new tourist infrastructure. Public-private partnership is recommended for development of tourist destinations. The health sector planning of the district focuses on sustaining traditional practices of medicine like Ayurveda. The local self governments also have ambitious plans to upgrade facilities at all the medical centres, to provide basic medical tests and improve healthcare facilities in remote areas of the district. At present, there are nine government hospitals, 75 primary health centres, 7 dispensaries and 19 community health centres and one T.B. centre in the government sector. There are 73 private hospitals having around 2,200 beds.

IT sector development in the district has not flourished so far; the district has one software technology park at Kanjikode. However, Palakkad was selected for propagating Akshaya projects in the state. The project involves setting up registered centres in rural areas, where all transactions related to the government are executed. These centres also form the platform for e-learning, e-governing and improving ICT (Information and Communication Technology) infrastructure in the state.

With increasing demand for cost-effective construction, the rural housing sector is in dire need of upgradation of building technology.

[5] GoK. 2014. Kerala Budget 2014-15. Chapter V –Energy. Department of Finance, Government of Kerala. http://www.finance.kerala.gov.in/index.php?option=com_docman&task=doc_download&gid=6378&Itemid=57, accessed on 27 April 2015.

The district development authorities have proposed implementing construction in a phased manner in five phases starting at Malampuzha and Palakkad blocks and ending at Chittur and Attappady blocks. Infrastructure facilities around the industrial development zones are also proposed through the construction of multi-storied buildings for efficient land utilization. The project may be implemented by local authorities/ PPP.

Integrated District Development Plan, Palakkad, proposes the construction of a medical college, court complex, district jail, civil stations at Mannarkkad, Pattambi and Kollegode, and district planning secretariat. Tool room testing centre at Malampuzha, state-of-the-art training facility for research, development and training in tooling, CAD/ CAM, is expected to be commissioned by 2015. MSME testing lab is to be provided with high precision testing equipment, calibration, etc., which is being jointly implemented by the state government and the district panchayat; it is expected to be commissioned by 2017. There is high demand for skilled labour in the district. A finishing school is proposed for providing training facilities to the unemployed youths in the district. District authorities plan to establish the school in the Palakkad block with an outlay of Rs. 2 to 5 crore, to be financed by NRI's/nationalized banks. The Department of Fisheries, Kerala, proposes to set up a research facility at Malampuzha to conduct studies to improve fishery in the district; the cost of the project is estimated to be Rs. 50 lakh.

Policies, Legislations and Regulations

- Kerala State Budget Allocation for Commercial Sector, 2014-15

  An amount of Rs. 10 crore has been provided for the development of Periyar Tiger Reserve and Parambikulam Tiger Reserve based on ICT with the assistance of the central government. A detailed project report for the setting up of an IIT in Palakkad has been submitted to the central government. An amount of Rs. 148.79 crore has been provided during 2014/15 for the development of infrastructure for various projects of KINFRA, which include non-conventional energy park at Palakkad

INDUSTRIAL SECTOR

Palakkad ranks second in industrial categorization of districts of Kerala. Its proximity to Cochin and Coimbatore (TN) makes it a favourable destination for investment. Traditional industries like handloom and coir have become obsolete; authorities are channelling investments in these industries to upgrade the available technologies.

In the Integrated District Development Plan,[6] the following project proposals were identified for the optimum utilization of agro- and food-based resources available in the district.

Rice Products: On the basis of availability of raw materials in the district, rice-based units can be set up at an average cost of Rs. 1 crore for

[6]District Planning Committee. 2013. *Integrated District Development Plan Palakkad, Volume 1: Perspective Plan*. Department of Town and Country Planning, Kerala.

products such as flour, flakes, puffed and instant foods. The units shall be established by 2015, by entrepreneurs who are experienced in this area. The power requirement for the units is estimated to be around 10 to 15HP per unit. The District Industries Centre will provide assistance under different government schemes for these units.

Coconut Products: The project envisages utilization of coconut-based raw materials to convert them into products such as virgin oil, packaged tender coconut water and milk cream. Such raw materials are mainly found in Chittur, Mannarkkad and Alathur blocks; the units average set up costs sum up to Rs. 1 crore. The power requirement for the units is estimated to be around 15 to 20HP. Technological support is provided by the Coconut Development Board, Kochi and the Agricultural University, Minutia. The Kerala Finance Corporation and other nationalized banks will provide financial assistance for the project.

Dairy Products: Milk production in the district is 1,569 lakh litres per year. The milk processing units can produce butter, milk, ghee, butter milk, curd, powder and paneer on a large scale, with technology upgradation and assistance of local departments. Chittur, Malampuzha, Attappady and Alathur blocks have the scope for these units with an outlay of Rs. 1 crore.

Fruit-based Products: The project envisages development of fruit-based products such as mango pulp, squash, jam, pickles, jack fruit chips, jackfruit jam and banana chips. Mango is an important crop of the district, with majority of it coming from Muthalamada Panchayat in Chittur – hence the mango city of Kerala. The project outlay for developing processing units is Rs. 2 crore to be financed by local authorities and private agencies through the PPP model. The power requirement for the proposed units will be 75HP. Jack fruit processing units have been given an outlay of Rs. 75 lakh for setting up three SME units.

Other proposed projects include a coir cluster incorporating 20 coir units at Muthalamada and Palakkad blocks. This is another traditional industry which is bound for mechanization; land and resource estimation for the project are at the conceptualization stage. The power requirement for this proposal is estimated to be 80HP. Coir geo-textiles are processed from husk, which is available aplenty in the state. They are used for seepage prevention drain, investor fitter solution and other projects. The units are proposed to be set up in Mannarkkad and Chittur blocks at an investment of Rs. 50 lakh per unit to be shared by Coirfed and district development agencies. The power requirement for the proposed units is estimated to be 100HP.

District authorities have also proposed setting up of five units of plastic based industries. The project cost is estimated to be Rs. 25 lakh per unit. The power requirement for setting up these units is 10 to 15HP. There is good demand for glass etching. It is proposed to promote glass etching by setting up units at Ottapalam, Mannarkkad, Palakkad, Alathur and Chittur blocks. The cost of each proposed unit is estimated to be Rs. 10 to 25 lakh.

The Ministry of Textiles, Government of India has proposed setting up of handloom clusters under the Integrated Handloom Development Scheme (IHDS). A proposal to set up handicrafts cluster at Vadakkenchery with an investment of Rs. 30 lakh is to be implemented by the District Industries Centre. The Department of Industries, Government of Kerala acquired about 532 acres of land in Pudussery village in Kanjikode for New Industrial Development Area (NIDA). About 120 acres of this land was allotted to KSEBL for a 220kV substation and a wind farm, the remaining land was allotted to prospective industrialists like MARICO, KAMCO and a number of small-scale industries. Considering the fact that the district's economy is dependent on agriculture, the local administration has proposed setting up of seven cold storage chambers in the district with an approximate cost of Rs. 50 lakh per unit. This reduces post-harvest wastage, thus providing better returns for the harvest. The Ministry of Food Processing Industries plans to assist the programme with 25 per cent grant for the plant and machinery.

Equipment manufacturing is another industry that the district authorities are considering for investment by setting up 30 units at Shoranur, Palakkad, Nemmara, Elavancherry and Vadakkancherry blocks, which would produce wide range of equipment to be used in healthcare, agriculture, cutlery, etc. The required cost is estimated to be between Rs. 10 to 15 lakh per unit, which would be financed by nationalized banks and DIC. The power requirement for this proposal is about 20HP.

Kanjikode industrial area has been designated for future development of the district with many promising upcoming projects, including the railway coach factory, which has been allocated land and Rs. 6,000 crore investment in two phases. The BHEL unit, whose second phase is in progress, and where LHB coaches, aluminium and stainless steel goods will be manufactured, is said to bring in an investment of Rs. 400 crore. The Kerala State Industrial Development Corporation (KSIDC) has acquired land for setting up a Light Engineering Park at Walayar, where 35 units will be established for light engineering, having an investment of Rs. 10.5 crore. The Kerala Industrial Infrastructure Development Agency (KINFRA) has acquired 350 acres of land for setting up a textile park in the district. This park will include high quality testing laboratories, design centres, trade and display centres and raw material storage depots. The proposed park is set up for modernizing the traditional textile industry in Palakkad.

The industrialization of the district is proposed in a planned manner by setting up mini industrial estates around the proposed projects through a PPP mode, to provide an integrated development plan. The proposed estates are said to cost Rs. 75 lakh. The activities will require 5 years for completion with power requirement of 50KVA.

Under the state government's 'Industrial Perspective Plan[7] for 2030', a

[7] GoK. 2013. Kerala Perspective Plan (Vision)-2030. Chapter 9 – *Industry*. State Planning Board, Government of Kerala.p. 337.

Kochi-Palakkad National Investment and Manufacturing Zone (NIMZ) worth Rs. 53,825 crore is proposed. The NIMZ is expected to expand across Ernakulam, Thrissur, Malappuram, and Palakkad districts encompassing 20 identified nodes.

Policies, Legislations and Regulations

- Marginal Money Loan Scheme

  All new registered small-scale industries, specifically excluded by the government, shall be eligible for assistance under this scheme. The scheme is to assist entrepreneurs in setting up new industries by providing loans upto Rs. 2.5 lakh or 20 per cent of the project cost, whichever is less, with a 6 per cent interest rate as a seed capital.

- State Investment Subsidy Scheme

  This scheme is towards providing subsidy to small-scale units, which undertake expansion and modernization. Investment subsidy at 10 per cent of the fixed capital investment is available to industries up to a limit of Rs. 5 lakh. For thrust sector industries such as rubber-based, electronics, food processing, light engineering, drugs and pharma, leather products, garments and units based on clay and silica, the subsidy is up to 15 per cent up to a limit of Rs. 15 lakh.

- Kerala Technology Start-up Policy 2014

  This policy is to provide an investment friendly environment in the state for technology start-ups. The incentives provided under this policy are return of VAT/CST, limited to a turnover of Rs. 50 lakh for the first three years after incubation. An investment of subsidy of 20 per cent of CAPEX other than land and building shall be provided to the incubators that enter into an MoU with the state. The subsidy is limited to a maximum of Rs. 5 crore.

- Kerala State Budget Allocation for Industrial Sector, 2014-15

  The Department of Industries implements various programmes by giving more attention on revival and development of village and small-scale industries. Village and small-scale industries have a significant role in the economic development of Kerala. In 2014-15, an amount of Rs. 639.40 crore has been provided which includes Rs. 23.44 crore as One Time Additional Central Assistance, for implementing various schemes focusing on the activities of traditional small-scale industries, handicrafts, industrial parks, industrial investment promotion activities, etc.

  Green Financing Scheme will be introduced to promote green and clean initiatives in the industry with a cost of Rs. 100 crore. An initial allocation of Rs. 10 crore is made to provide financing for clean and green enterprises. The government proposes to implement an 'Innovative Enterprises Promotion Programme in Handloom' to preserve traditional heritage and attracting new entrepreneurs to set up handloom units. For this purpose, an amount of Rs. 1.5 crore has been provided, out of which Rs. 50 lakh is earmarked for providing margin money to set up such units. An amount of Rs. 148.79 crore has been provided in 2014-15 for the development of infrastructure for various projects of KINFRA. Non-Conventional Energy Park at Palakkad is one of the projects under this list.

AGRICULTURAL SECTOR

Palakkad is blessed with plenty of resources for irrigation. Rice cultivation in the district is the highest in Kerala. However, rising labour costs and lack of skilled labour is reducing the overall productivity of the district. The cultivated area has decreased in the past few years and is a worrying trend for the state's food security. The government has proposed and implemented many schemes to increase crop productivity.

In terms of energy use, the agricultural sector consumes 9 per cent of the total electricity consumed in the district. The government has introduced various schemes to improve the efficiency of irrigation equipment to save energy inputs into agriculture. The district development authorities plan to introduce lift irrigation schemes to be commissioned in three years, to be sourced from the Bharathapuzha River. Five such projects have been identified at Kulukkallur, Thrithala, Vilayoor and Agali. The scheme is said have a combined cost Rs. 604 lakh to irrigate an area up to 795Ha in these panchayats. Lift irrigation schemes are highly power consuming; the higher the elevation, the higher the energy required to lift water.

Fisheries: Palakkad has 8,696.11Ha of land covered with inland water bodies. The district is endowed with perennial rivers. Ponds contribute about 15 per cent of the area of water bodies. The district has the highest number of private ponds per panchayat with an average 9.98Ha/panchayat, as compared to other neighbouring districts. The district has wide variety of fish, with over 80 species found in the natural water bodies. Being an inland district, the focus is on fish farming and aquaculture. The district development authorities have proposed establishment of ornamental fish production units with cost outlay of Rs. 3 lakh per unit; eight such units are proposed for implementation. There are five wholesale fish markets for fresh fish in the district. The government proposes to improve infrastructure and sanitation of these markets with an estimated outlay of Rs. 50 lakh.

Policies, Legislations and Regulations

- Coconut Development Programme

The programme aims to integrate development of holdings for maximizing income from unit area through better agricultural practices and farming systems. The productivity level of coconut is low in Kerala as compared to other neighbouring states. The programme proposes better pest management and related irrigation practices to increase coconut productivity in the region.

- Micro Irrigation Scheme

  Micro irrigation schemes were started by the central government in 2012 to promote better water and energy management practices in this sector. This is especially being taken up in plantation farming. Sprinkler irrigation is being widely used in vegetable and floriculture. This system also reduces infusion of weeds and helps in application of fertilizers and chemicals along with the water.

- Agricultural Development Policy 2013

  The policy attempts to improve the overall productivity of farming in Kerala. The focus of the policy is on improving technology in farming and resource management. It emphasizes on conserving the water and land resources available in the state. Customized farm mechanization has been encouraged to use crop and area specific machines for better soil conservation. Financial incentives for replacement of inefficient equipment for better performance and reduced energy input.

  A separate energy-smart policy have been included in the document, which refers to sustainable agricultural practices, improving energy access through renewable energy, replacing mechanical tillage with biological tillage and incentives for farmers practicing energy-smart agriculture.

- Kerala State Budget Allocation for Agricultural & Allied Sectors, 2014-15

  The Agricultural Research Centre in Pattambi has been selected for being converted into a centre for excellence with a budget of Rs. 3.5 crore. As a part of the integrated services delivery, agriculture malls will be set up with central assistance in specific locations in the state, for which an amount of Rs. 5 crore has been provided. An amount of Rs. 73.25 crore is set apart for conservation of soil and water bodies in the state. In order to achieve self-sufficiency in milk production, an increased outlay of 47 per cent is earmarked for dairy development.

TRANSPORT SECTOR

Palakkad is connected to other parts of the state and India through roads and railway. The nearest airport is Coimbatore International Airport, which is about 52km away. The nearest port is in Cochin, which is 110km away. The total length of roads in the district is 2,172.78km. Palakkad has only 8 per cent of the total registered vehicles in the state. However, the total number of vehicles registered in the district in the past few years has been growing steadily. This is a sign of increasing economic activity in the district as the transport sector is the key to industrial and agricultural growth. There are two major railway stations in Palakkad. Palakkad Railway Junction at Olavakkode, where the office of the Divisional Railway Manager (Palakkad) is located. Pollachi, Dindigul and Madurai are connected to Palakkad town railway station by the metre-gauge line. The Shornur railway junction is the biggest in Kerala, this junction is of historical importance because of the “Shornur- Cochin Harbour Section”, which was a metre-gauge line in the early 1900’s where all the cargo was transported from Cochin port to Shornur.[8]

The on-going projects in the transport sector include 12 bridges and 20 roads under renewal in the district. Proposals for widening of NH 47 in Coimbatore–Thrissur route and NH 213 to solve traffic problems in the industrial towns are being framed. Construction of bus stands at Koduvayur and Pudussery, shifting all existing bus stands to Yakkara and Olavakkode, are projects for the second phase.

Policies, Legislations and Regulations

- Kerala State Transport Policy

  This policy is aimed to improve the condition of roads and highways across the state. Increase public awareness about traffic sense and right of way to avoid accidents. Public transport in the state is set for a major revamp to increase its share of passenger traffic from 33 per cent in 2011 to 80 per cent by 2025. The government plans to improve services of KSRTC in rural areas and improve the passenger information system in the state. Introduction of mini-buses in low density areas for better access and connectivity is also proposed. The aim of the policies is to reduce usage of personal vehicles and increase the use of public transport in the state.

- Kerala State Budget Allocation for Transport Sector, 2014-15

  An amount of Rs. 17.32 crore has been earmarked for the renovation of bus depots, workshops, construction of new bus stations, modern garages, etc. To complete the computerization and implementation of 'e-governance' in KSRTC, an amount of Rs. 10.30 crore has been provided. A regulator-cum-bridge across Thrithala–Kangappuzha River, parallel to Kuttippuram Bridge, will be constructed to connect Palakkad and Malappuram districts at a cost of Rs. 1 crore.

[8] The Hindu. 2004. “Waiting for the Train of Hope”. *The Hindu* (June 24). http://www.thehindu.com/mp/2004/06/24/stories/2004062401020100.htm, accessed on 20 April 2015.

ANNEXURE 2

OVERVIEW AND METHODOLOGY OF RENEWABLE ENERGY POTENTIAL

Annexure 2 gives an overview of methodology for assessing renewable energy potential and covers reference assumptions and detailed calculations for assessing the final RE potential. The narrative covers the RE potential assessment of grid-tied solar PV, rooftop solar PV, wind power potential and bioenergy.

ASSESSMENT OF METHODOLOGY: GIS-BASED GRID-TIED SOLAR AND WIND POTENTIAL

The common challenge expressed when discussing centralized grid-tied renewable energy in Kerala is the lack of availability of land for new projects. It is generally believed that the possibilities of large-scale projects of any kind (even a concentrated thermal power project) are small, considering the scarcity of land. While Kerala has one of the highest population densities, this does not translate into a clear preclusion of land availability. Furthermore, existing RE potential estimates (for wind) assume a certain percentage availability of land for estimating the potential value, which may also not be the right approach.

Why GIS?

Considering the ambiguities and differences in the assumptions, it is increasingly obvious that a paper-based exercise for large grid-tied RE potential assessment cannot and will not give a reliable and robust estimate of renewable resource potential. The first step before any real assessment exercise can take place is to understand the assumptions and their underlying rationale. For renewable resources and technology, this assumption-set can only be accurately validated with on-site measurements and detailed land surveys. The scope of the project visualised a GIS-based exercise supported by suitable field and spatial data that not only considers terrain features but also numerical models based on reliable source data for micro-scale assessment. Moreover, such a GIS-based exercise will add tremendous value to the planning process as it will enhance visualization and aid data analysis for varying spatial selections. For the present project, all GIS-based analysis are been done on the ArcMap 10 platform.

GIS Datasets and Sources

Wind Resource Data: Modelled wind resource data is sourced from AWS Truepower, USA, a leading resource-assessment firm. Based on the scope of supply, AWS supplied raster and vector datasets of wind-power density and Weibull c and k parameters, respectively. The GIS format data was supplied for three hub heights (80m, 100m and 120m) and had a resolution of 200m × 200m.

Solar Resource Data: The solar resource data is sourced from the National Renewable Energy Laboratory (NREL) dataset with a resolution of 10km × 10km.

Land Use Data: NRSC-ISRO 2010-11 LULC data is used for the analysis, because it is the latest data available (2010-11) and has very high resolution (52.8m) as compared to global datasets. Another important reason for choosing NRSC-ISRO data was that it is government approved and validated by experts attuned to Indian land-use patterns. Table An2.1 provides description and specification of the other datasets used.

TABLE AN2.1: DESCRIPTION OF DATASETS USED

No.	Database	Dataset	Base data	Date
1	Shuttle Radar Topography Mission (SRTM) Version 2	90m × 90m	NASA satellite	2009
2	Protected Area	World Database on Protected Areas	UNEP	Not known
3	Geographic Features (rivers, water bodies)	VMAP 0	National Imagery and Mapping Agency	Not known
4	Administrative Boundaries	GADM database of Global Administrative Areas v2	Unknown	2012
5	Infrastructure (roads, railroads, cities, settlements, urban areas)	VMAP 0	National Imagery and Mapping Agency	2000

Assessment Of Methodology: GIS-Based Grid-Tied Solar PV Potential

The approach for grid-tied solar PV potential assessment is worked out based on the net available area suitable for grid-tied solar projects after excluding the social, technical and geographical constraint layers. This net area identified for solar PV technology, assuming average land utilization factor applicable for technologies, i.e., 50MW/km^2 for solar PV.

Based on detailed literature review done in the previous study undertaken by WWF-India and WISE[1], the assumptions for GIS-based solar potential assessment are summarized in the Table An2.2.

TABLE AN2.2: ASSUMPTIONS CONSIDERED FOR ASSESSMENT OF SOLAR PV POTENTIAL FOR PALAKKAD

Parameter	Value	Remarks/sources
Average Land Requirement (PV)	50MW/km^2	Based on WWF-India and WISE[2]
Minimum GHI (PV)	1,600kWh/m^2	Based on field interactions
Maximum Slope (PV)	5 per cent	Based on industry norms

[1] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.
[2] Ibid.

Parameter	Value	Remarks/sources
Minimum Contiguous Land	5 acres (0.02 km²)	Assuming minimum scale of 1MW
Land Availability	Wasteland Only Scenario and Grassland Only scenario	

Off-grid assessment methodologies are covered in the later sections of the annexure.

- Potential Assessment for Grid-Tied Solar PV

  Figure An2.1 below shows the base resource layers of LULC, GHI and terrain slope of Palakkad, which are used for potential assessment analysis. It illustrates the methodology graphically, while Figures An2.2 to An2.4 show the base layers considered for GIS assessment.

FIGURE AN2.1: METHODOLOGY OF GRID-TIED SOLAR RESOURCE ASSESSMENT

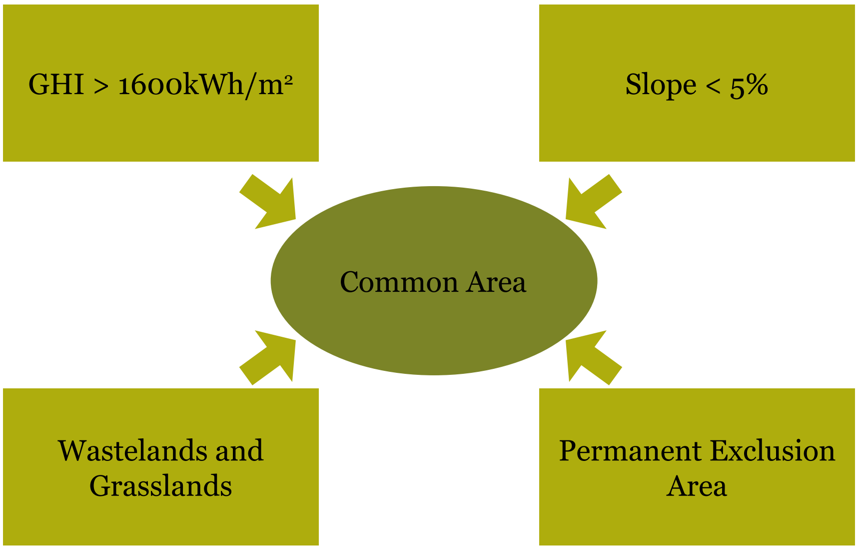


FIGURE AN2.2: LULC MAP OF PALAKKAD

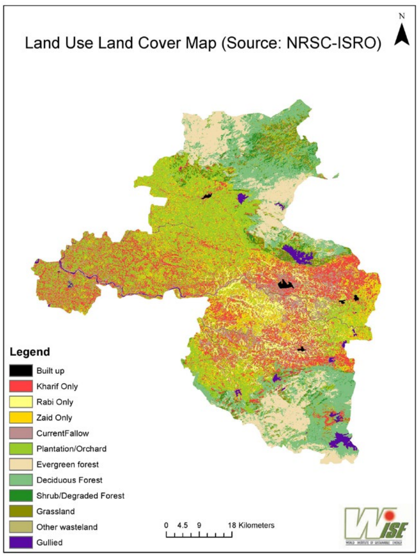


FIGURE AN2.3: GIS-BASED RESOURCE LAYERS FOR SOLAR PV POTENTIAL ANALYSIS

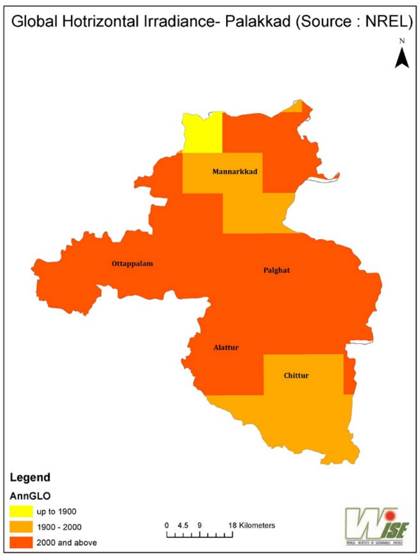
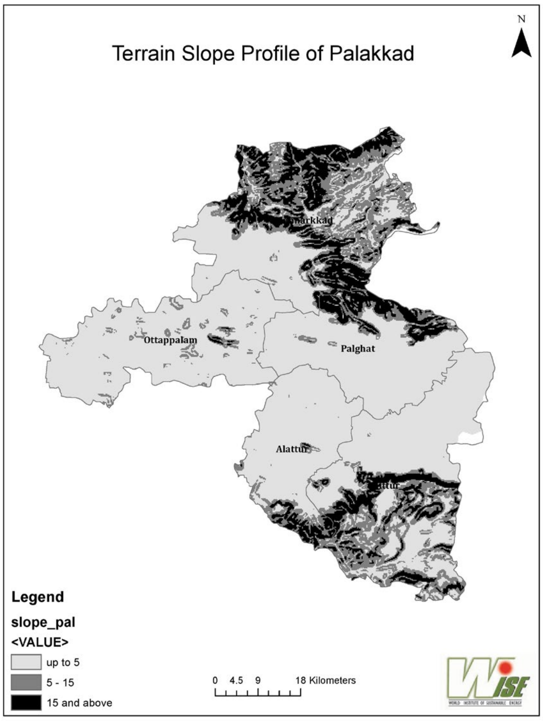


FIGURE AN2.4: SLOPE PROFILE OF PALAKKAD



Based on the methodology proposed, the three data layers were re-categorized using the following criteria: land use, wasteland and slope, <5 percent and GHI >1600kWh/m². These layers were then overlapped and all common areas were removed from the final considerations along with some permanent exclusion (land unavailable for development). In addition, areas with contiguous land area of less than five acres (0.02km²), representing a minimum of 1MW solar PV plant capacity was excluded. The remaining area was assumed as area available for solar PV development and was multiplied by the solar PV density function of 50 MW/km² to arrive at wasteland-based solar PV potential of Palakkad. A similar analysis was done separately for assessing grassland-based potential.

Assessment of Methodology: GIS-based Grid-tied Wind Potential

The wind power assessment of Palakkad was done using the following assumptions. About 300MW capacity of wind power is identified for the district. Table An2.3 below summarizes the assumptions made for estimating the wind-power potential of the district.

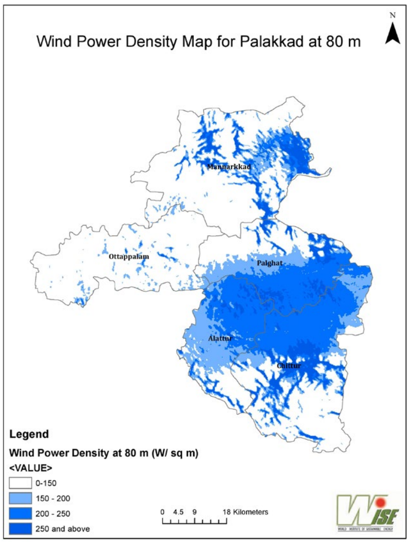
TABLE AN2.3: ASSUMPTIONS FOR ESTIMATING WIND POWER POTENTIAL

Assumed Parameter	Exclusion Value	Source/Remarks
Density	<150W/m²	To maximize the potential land area at 80m, 100m, and 120m
Land Requirement	7MW/km²	Conservative, assuming 5D × 7D criteria
Land Elevation	>1500m	In line with similar studies

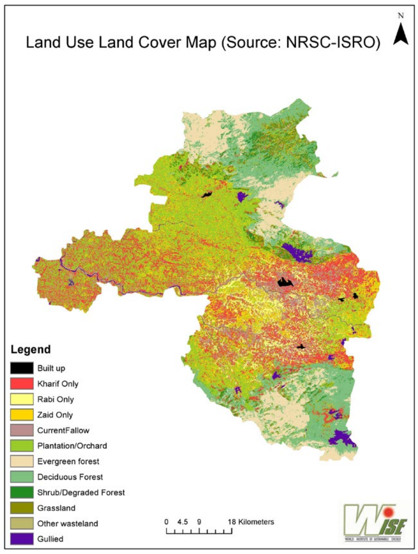
Assumed Parameter	Exclusion Value	Source/Remarks
Slope	>15%	in line with similar studies
Land Availability Percentage in Potential Region	100% Availability	Non-irrigated farmland (kharif +rabi +current fallow)+ Non-farmland (wasteland + grassland)

Figure An2.5 (A-E) below show the base data layers in wind power potential assessment: wind power density map, LULC, slope and elevation.

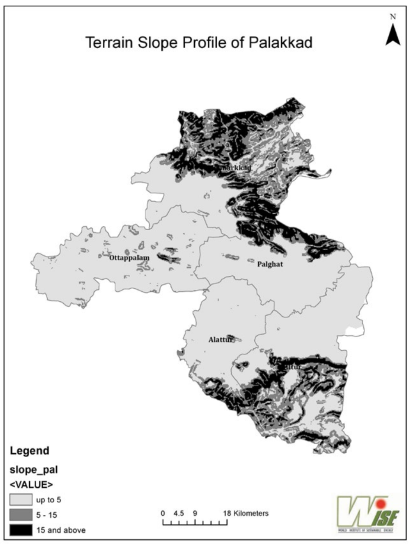
FIGURE AN2.5: GIS-BASED RESOURCE LAYERS FOR WIND POWER POTENTIAL



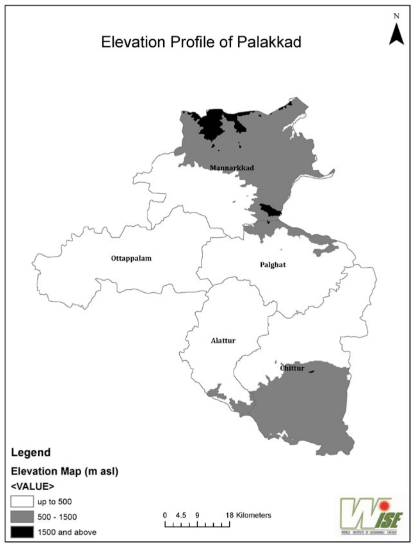
(A) Wind Power Density Map



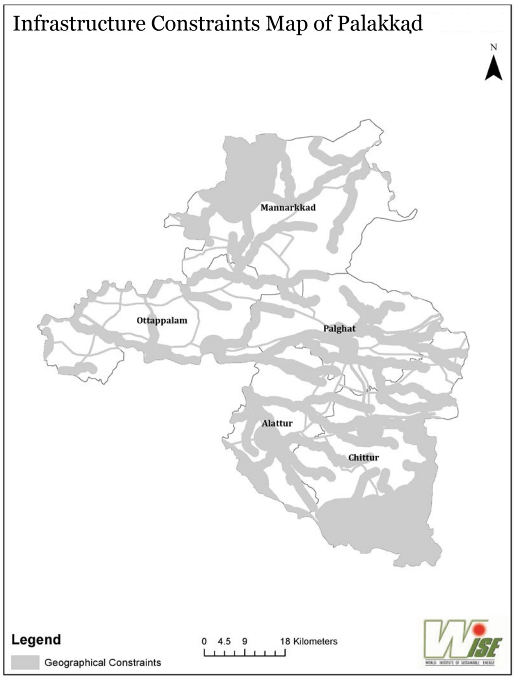
(B) Land-Use Land-Cover Map



(C) Terrain Slope of Palakkad



(D) Elevation Profile of Palakkad

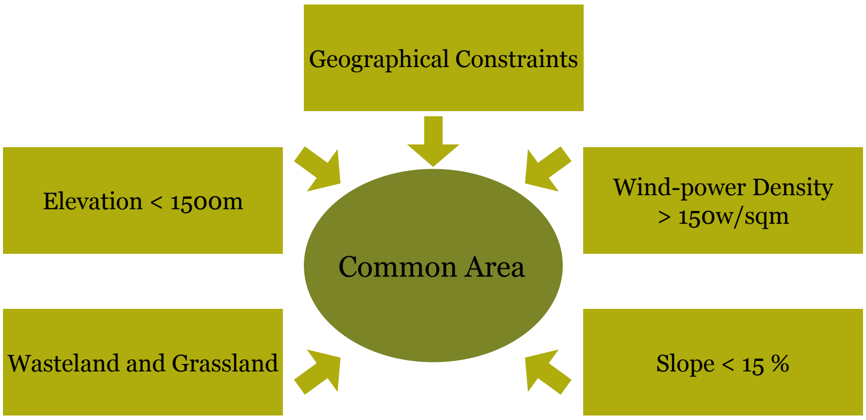


(E) Infrastructure Constraints Map of Palakkad

Based on the methodology, four data layers, namely wind-power density, LULC layer, terrain slope and terrain elevation, were re-categorized.

Figure An2.6 below shows a diagrammatic summary of the operation.

FIGURE AN2.6: GRAPHICAL REPRESENTATION OF METHODOLOGY FOR WIND POTENTIAL AT 80M



The common area for the categorized layers was then overlaid with permanent exclusions (land not available for development), and all common areas were removed from the final consideration. The remaining were assumed as available for wind power development and were multiplied by the turbine density factor of 7MW/km² to arrive at the farmland potential of Palakkad. Resource categorization of potential areas is done on the basis of wind power density to differentiate quality of wind resources.

ASSESSMENT OF METHODOLOGY: ROOFTOP SOLAR PV POTENTIAL

Considering the prevalence of two monsoon seasons in Kerala spread across 6-7 months, the general notion held by outsiders is that solar PV in Kerala would not be viable. However, taking into account the assumptions made in the Kerala study,[3] the outcomes suggest an average GHI of 5.51kWh/m^2/day (or annual value of 2,011.15kWh/m^2/year) and a Direct Normal Irradiance (DNI) daily average value of 4.55kWh/m^2/day (or annual value of 1,660.75kWh/m^2/year). As a general principle, any site with GHI of more than 1,500kWh/m^2/year is suitable for SPV technology. This resource assessment is an indication that Palakkad is suitable for solar PV generation. However, the resource values do not support suitability of solar thermal power generation because the average DNI is significantly less than the threshold value of 1,800kWh/m^2/year required for developing such projects. Considering the same, potential of large-scale solar CSP has not been considered for Palakkad.

Rooftop PV

The first step in assessing district-based potential of solar rooftop PV was to assess the number of rooftops available in the district. Two categories were identified for the purpose: individual households and institutional/commercial establishments. For assessing on-site implementation feasibility, spot surveys of identified households with rooftop systems were carried out for rural and urban households in Kerala in the earlier study.[4] Before conducting the spot survey, the general notion was that there would be scarcity of shade-free rooftops mainly due to proximity of plantation crops and coconut trees in the house compound. However, it was found that most of the houses in the district and practically half of the houses in villages were double-storied pucca houses with flat roofs having clear shadow free areas. Based on these surveys, it was assessed that on an average 50 per cent of the rural households were partially or fully shaded (20 per cent were fully shaded and 30 per cent partially shaded), while the remaining 50 per cent households had completely shade-free rooftops. For urban households, it was assessed that 30 per cent were partially or fully shaded (10 per cent were fully shaded and 20 percent partially shaded), while 70 per cent of the households had clear shade-free roof area. This assessment means that practically 80 per cent of the households in rural areas and 90 per cent of those in urban areas can be used for solar PV power packs.

Based on the house roof material categorized in census 2011, households with thatched roofs and polythene covered roofs were not considered suitable for solar PV installation. Out of the remaining categories, roofs with tiles and slates were considered suitable for installation of only 1kWp solar PV power packs as many of the houses with this kind of roof were found to have 1kWp system using additional special kind of structures. Concrete roofs were considered suitable for 3kWp solar PV power packs, which need around 45m^2 of roof area. For partially shaded roofs, inclusion of 20 per cent additional capacity of solar module was proposed to get the desired output of 1kWp or 3kWp. Based on these

[3] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.
[4] Ibid.

assumptions, the potential for off-grid solar power packs in households are estimated in Table An2.4 below.

TABLE AN2.4: DECENTRALIZED ROOFTOP PV POWER POTENTIAL IN PALAKKAD HOUSEHOLDS

Roofs	Rural			Urban			
		Nos	kW		Nos	kW	Total
Thatched/ Plastic	100% shaded	24,210	0	100% shaded	3,924	0	
Title/ Asbestos roofs (1kWp/ roof)	20% shaded	66,162	0	10% shaded	8,127	0	
	30% partially shaded	99,243	119,092	20% partially shaded	16,254	19,505	
	50% shade free	165,406	165,406	70% shade free	56,890	56,890	
Concrete Roofs (3kWp/ roof)	20% shaded	24,432	0	10% shaded	6697	0	
	30% partially shaded	36,648	131,933	20% partially shaded	13,393	48,216	
	50% shade free	61,080	183,240	70% shade free	46,877	140,631	
Total MW			**599.67**			**265.24**	**865**

Decentralized solar PV power potential for institutional/commercial establishments was estimated based on the data available from the Census of India 2011. Table An2.5 below shows the assumptions and the final potential figure assuming a requirement of 15m²/kWp.

TABLE AN2.5: DECENTRALIZED ROOFTOP PV POWER POTENTIAL IN INSTITUTIONAL/ COMMERCIAL ESTABLISHMENTS

Categories of Institutional/ Commercial Establishments in Kerala	Shop/ office (Nos)	School/ College etc. (Nos)	Hotel, Lodge, Guest Houses etc. (Nos)	Hospital/ Dispensary etc. (Nos)	Factory/ Workshop/ Workshed etc. (Nos)	Places of Worship	Total
Total number of commercial institutional buildings with concrete roofs	68,016	6,073	3,303	2,441	12,867	12,654	105,354
Percentage of shadow free area availability assumed	50	80	50	70	40	80	
Number of households roofs available	34,008	4,858	1,652	1,709	5,147	10,123	57,497
Area available m² assumed	30	1500	450	750	1500	450	
Capacity kW	68,016	485,840	49,545	85,435	514,680	303,696	150,7212
Capacity MW	**68**	**486**	**50**	**85**	**515**	**304**	**1,507**

ASSESSMENT OF METHODOLOGY: POTENTIAL FOR SUSTAINABLE BIOENERGY

This section includes all the assumptions and methodologies followed for assessing biomass resource potential. The three technologies assessed are gasification, combustion (electricity and heat) and biogas.

The bioenergy assessment assumes use of limited residues for a variety of end-use energy generation technologies. To avoid resource conflict, it is assumed that areca nut husk, coconut fronds, tapioca stalks, cashew nut shell, rice husks and rice straw are used exclusively for biomass gasification-based electricity generation. Forest wood and rubber wood are considered exclusively for combustion. The organic component of MSW, and animal wastes are considered as feedstock for biogas generation. The inorganic component of MSW is considered for biomass combustion electricity generation.

Methodology for Assessment of Biomass Gasification Potential of Agro-residues

Gasification is a technology of great relevance, especially in the de-centralized or rural scale power generation scenario. The overall conversion efficiency is generally considered to be about 20 per cent in case of gasifiers.[5] Both raw as well as processed forms of biomass material could be utilized as feedstock for this technology. The crops considered for gasification are rice husk and straw, coconut fronds, areca nut husk, cashew nut shell and tapioca stalks.

Based on past production data, the production of each of these primary crops is projected up to 2030 using past trend and expected future agriculture production. The projected production is then multiplied by the crop to residue ratio[6] to assess the residue generation potential. To factor in alternative uses of residues, 10 per cent availability is considered for rice residues and 30 per cent for all other residues. The collection efficiencies are considered to increase from 15 per cent in 2015 to 50 per cent by 2030. Equation 1 below summarizes the expression for assessment of biomass gasification potential.

Residue Available (in tonnes/y) = Production of crop× Crop Residue Ratio× Availability (10% for rice residues and 30% for others)× Collection efficiency (15% in 2015 to 50% in 2030)

(Equation 1)

The assumptions for estimating crop residues are summarized below.

Paddy: Rice straw in Kerala is usually either left over farms to be mulched or is burnt so that the soil can be prepared for the next crop cycle. The predominance of small and fragmented land parcels, lack of mechanization and high labour costs make collection of rice straws difficult and as a result, the collection of straw is negligible. However, this availability can increase in case of better prices and increased farm mechanization. The projected values have been calculated assuming no

[5] Anonymous.n.d. "What do you Mean by Gasification?". http://projects.nri.org/biomass/conference_papers/gasification_process.pdf, accessed on 23 April 2015.
[6] CGPL. 2009. Biomass Resource Atlas of India, Residue Generation per kg of Crop". Combustion Gasification & Propulsion Laboratory, Banglalore. http://lab.cgpl.iisc.ernet.in/Atlas/Downloads/CropImages_with_residuedetails.pdf, accessed on 20 April 2015.

change in area under paddy cultivation in Palakkad over the next four decades.

Coconut: It is anticipated that the area under coconut farming will continue to decline with the neighbouring states like Tamil Nadu and Andhra Pradesh becoming highly competitive over the years in terms of increasing their area under coconut cultivation, as well as by developing markets for products from processing industries. Coconut cultivation area statistics suggest a steady decline from 2008-09. It is assumed that the cultivated area will decline at 0.65 per cent yearly by 2030.

Areca Nut: Areca nut, the seed taken out from Areca palm, is a major ingredient in the tobacco industry in the country. It is also used widely in religious and cultural ceremonies. Veterinary medicine is another area where arecanut finds wide applications. Areca nut husk on the other hand doesn't find a significant alternate use and could be utilized for the generation of power. It is not anticipated that the area under areca nut cultivation will be expanded in future. The area under areca nut plantation is considered to decline at a rate of 1.66 per cent per year (rate of decline for the past five years).

Tapioca: Price volatility in markets, unpredictable monsoons and a shift to rubber plantations have contributed to reduction in its cultivated area. However, if market prices were to increase, cultivation will rise accordingly. Hence a constant area is assumed for the crop.

Cashew Nut: Inadequate facilities for processing raw cashew nut and volatile market prices have contributed to declining cultivation. Year on year decline of 2.5 per cent in area under cashew nut cultivation is assumed for the projection period.

Based on the above assessment, the available residues of all the crops considered for gasification are shown in the Table An2.6 below.

TABLE AN2.6: RESIDUE AVAILABLE FOR GASIFICATION

Residue Available (tonnes/y)	2015	2020	2025	2030
Rice Husk	654.47	1,090.78	1,527.09	2,181.55
Rice Straw	4,908.49	8,180.81	11,453.14	16,361.63
Arecanut Husk	309.18	473.92	610.22	801.75
Cashew Nut Shell	23.246	34.137	42.109	53.003
Tapioca Stalks	2,306.51	3,844.18	5,381.85	7,688.36
Coconut Fronds	9,949.60	16,054.52	21,760.46	30,340.80

In the next step, biomass gasification potential is assessed using the following equation.

Biomass gasification potential (kWh) = Residue available (in T/Y)× Calorific value (kcal/kg) × Conversion efficiency of gasification (20%)[7]× *Conversion factor* (1.16×10^{-9} *million kWh/kcal)*

(Equation 2)

[7] Lehra.n.d. "Calorific Value". Lehra Fuel Tech Pvt. Ltd. http://www.lehrafuel.com/briquetts-calorific-value.html, accessed on 20 April 2015.

Table An2.7 below shows the calorific values of crop residues.

TABLE AN2.7: CALORIFIC VALUES OF CROP RESIDUES

Calorific Values (kcal/kg)	
Rice Husk*	3,881.00
Rice Straw*	3,469.00
Areca-nut Husk†	4,275.34
Cashew nut Shell‡	4,890.000
Tapioca Stalks**	3,914.68
Coconut Fronds††	3,988.72

Sources: *Lehra. n.d. "Calorific Value". Lehra Fuel Tech Pvt. Ltd. http://www.lehrafuel.com/briquetts-calorific-value.html, accessed on 20 April 2015.

† Pilon, Guillaume. 2007. "Utilization of Arecanut (Areca catechu) Husk for Gasification". Unpublished Thesis. Department of Bioresource Engineering, McGill University, Montreal. p. 29. http://webpages.mcgill.ca/staff/deptshare/FAES/066-Bioresource/Theses/theses/353GuillaumePilon2007/ 353GuillaumePilon2007.pdf, accessed on 24 April 2015.

‡Mohod, Atul, Jain, Sudhir and Powar, Ashok. 2011. "Cashew Nut Shell Waste: Availability in Small-Scale Cashew Processing Industries and Its Fuel Properties for Gasification". *ISRN Renewable Energy 2011*. http://www.hindawi.com/journals/isrn/2011/346191, accessed on 20 April 2015.

**Wilaipon, Patomsok. 2010. "Density Equation of Cassava-Stalk Briquettes Under Moderate Die-Pressure". *American Journal of Applied Sciences* 7 (5): 698-701. http://thescipub.com/PDF/ajassp.2010.698.701.pdf, accessed on 20 April 2015.

††Raghavan, Krishna. 2010. *Biofuels from Coconut*. FACT. http://fact-foundation.com/sites/default/files/library/documents/17._biofuels_from_coconuts.pdf, accessed on 20 April 2015.

Methodology for Assessment of Biomass Combustion Potential of Inorganic Fraction of MSW

MSW residue projections are done based on the population projections of Palakkad. Present minimum generation of MSW is assumed to be 0.242 kg/head/day.[8] Based on the assessment in *The Energy Report – Kerala*, the MSW generation is assumed to increase at a rate of 1.4 per cent year-on-year t. The collection efficiencies for MSW are assumed to increase from 23 per cent in 2015 to 31 per cent in 2030.[9] The simple expression for assessment of MSW is shown in the following equation.

MSW (tonnes/y) = Per capita MSW (in kg/head/y) × Population × Collection efficiency

(Equation 3)

Based on the assessment in *The Energy Report– Kerala*, the inorganic MSW residue is considered as 30 per cent of the total MSW. The calorific value of inorganic component of MSW is considered as 1,744 kcal/kg.[10] Conversion efficiency is assumed as 21 per cent.[11]

Based on the above assumptions, the expression for assessment of energy generation from inorganic MSW is shown in the equation below.

Total Energy Generated (in MU) = Inorganic Fraction of MSW (in tonnes/y) ×Calorific value (kcal/kg) × Conversion efficiency (21%) × 1000 × Conversion factor (1.16 ×10^{-9} million kWh/Kcal)

(Equation 4)

[8] Kumar, S. and Gaikwad, S.A. 1996. "Municipal Solid Waste Management in Indian Urban Centres: An Approach for Betterment". In K.R. Gupta (ed),*Urban Development Debates in the New Millennium*. p. 2004.Atlantic Publishers & Distributors, New Delhi, India.

[9] Ibid.

[10] Varma, R. Ajaykumar. n.d. "Status of Municipal Solid Waste Generation in Kerala and Their Characteristics". Suchitwa Mission, Government of Kerala.http://www.sanitation.kerala.gov.in/pdf/staeof_solidwaste.pdf, accessed on 24 April 2015.

[11] Envergent.n.d. "The Production of Electricity from Wood and Other Solid Biomass".Table 1.EvergentTech.com. http://www.envergenttech.com/files/envergent_electricity_5406_en_wp_10v1.pdf, accessed on 20 April 2015.

Table An2.8 below shows the methodology for MSW (organic and inorganic) generated.

TABLE AN2.8: ORGANIC AND INORGANIC MSW GENERATED

MSW Generation	Per Capita MSW Generation kg/person/day[12]	Population (Persons)	Collection Efficiency (percentage)[13]	Total MSW (tonnes/y)	Organic Component (tonnes/y)	Inorganic Component (tonnes/y)
Year	A	B	C	D= A×B×C× 365/1000	E= D×70%	F= D×30%
2011	0.242	2,771,944	0.21	51,418	35,992	15,425
2015	0.245	2,810,639	0.23	57,223	40,056	17,167
2020	0.249	2,859,768	0.25	65,183	45,628	19,555
2025	0.252	2,893,765	0.28	73,843	51,690	22,153
2030	0.256	2,924,135	0.31	83,537	58,476	25,061

Assessment of Biogas Potential

Nature has developed highly efficient biochemical processes to break down molecules of which biomass is composed. As biomass is a natural material, many of these biochemical conversion processes can be used to harness energy for a variety of applications.

Anaerobic digestion (AD) is a treatment that decomposes organic waste in the absence of oxygen, producing biogas that can be used to generate electricity and/or heat. It is a natural process, but requires continuous monitoring of the physio-chemical environment within the digester to maintain the rate and activity of the entire process. Although any organic biomass could be used to generate biogas which could in turn be utilized for generation of heat or power, the agricultural residues are usually not preferred as feedstock material for AD technology. The reason for this is the high retention time required in the digester, which makes them highly voluminous and capital intensive in terms of design. The main biomasses considered for biogas are organic component of MSW and animal wastes.

Methodology of Biogas Generation from MSW

It is assumed that 70 per cent of the total MSW is organic. This organic fraction is used as a source for biogas generation using the following equation. It is assumed that 78 per cent[14] volatile solids are present in the organic fraction. Biogas yield assumed is 0.048m^3/kg,[15] calorific value is assumed to be 22MJ/m^3.[16]

---

[12] Kumar, S. and Gaikwad, S.A. 1996. "Municipal Solid Waste Management in Indian Urban Centres: An Approach for Betterment". In K.R. Gupta (ed), *Urban Development Debates in the New Millennium*. p. 2004. Atlantic Publishers & Distributors, New Delhi, India.
[13] NEERI. 1996. *Municipal Solid Waste Management in Indian Urban Centres*. National Environmental Engineering Research Institute, Nagpur, India.
[14] Rao, M.S. and Singh, S.P. 2003. "Bioenergy Conversion Studies of Organic Fraction of MSW: Kinetic Studies and Gas Yield-organic Loading Relationships for Process Optimization". Bioresource Technology 95: 173-185. See p. 183.http://mie.esab.upc.es/ms/informacio/compostatge_digestio_anerobia/digestio_anaerobia/MSW_DA.pdf, accessed on 20 April 2015.
[15] Ibid. Table 5.
[16] Frost, Peter and Gilkinson, Stephen. 2010. *Interim Technical Report: First 18 Month Performance Summary for Anaerobic Digestion of Dairy Cow Slurry at Afbi Hillsborough*. Agri-Food and Bioscience Institute. Hillsborough.http://www.afbini.gov.uk/afbi-ad-18-months-v05.pdf, accessed on 20 April 2015.

The above assumptions are shown as equations 5, 6 and 7 below.

Volatile solids (VS) (tonnes/y) = Organic MSW (in tonnes/y)×78%
(Equation 5)

Biogas yield (m^3) = Biogas yield constant ($0.048m^3/kg$) ×Volatile solids (tonnes/y)
(Equation 6)

Generation potential (in PJ) = Biogas yield (m3)× Calorific value of biogas (assumed as 22×10^{-9} PJ/m^3)
(Equation 7)

Methodology of Biogas Generation from Animal Wastes

Animal waste generation is assessed based on the assumption of 7.5 kg[17] of dung production per animal of the bovine livestock. The available dung is then converted into biogas volume using standard biogas generation yield constant ($0.0088m^3/kg$).[18] The equation for biogas generation potential from animal waste is as shown in equation 8.

Biogas Generation (PJ/Y) = Bovine population (Animal) × Dung generation per animal (7.5Kg/animal/day) × Biogas yield constant ($0.0088m^3/kg$) × Calorific value of biogas (assumed as 22×10^{-9}PJ/m^3)
(Equation 8)

Remarks:

Organic MSW: An additional benefit in this process is the generation of high quality manure, which could be utilized as a resource for soil nourishment. Almost any organic material can be processed with AD, including waste paper and cardboard, grass clippings, leftover food, industrial effluents, sewage and animal waste.

Animal Wastes: As per the Department of Economics and Statistics, Kerala, Palakkad had a total livestock population of 207,678 in 2011. However, due to the distributed nature of availability of this resource, it is usually recommended to set up small-scale family sized biogas plants of 2-4m^3 in size to cater to domestic cooking requirements.

Methodology for Assessment of Biomass Combustion Potential of Rubber Wood and Forest Residues

Combustion is the most direct process of biomass conversion into energy. In general, the conversion efficiency using combustion-based systems for power generation is considered to be 21 per cent for all residues.[19]

---

[17] Ramachandra, T.V. and Kamakshi, G. 2005. *Bioresource Potential of Karnataka [Talukwise Inventory with Management Options]*. Chapter 5: Methodology. Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India. http://www.ces.iisc.ernet.in/energy/paper/TR109/TR109_TVR.pdf, accessed on 23 April 2015.
[18] Ramachandra, T.V. and Kamakshi, G. 2005. *Bioresource Potential of Karnataka [Talukwise Inventory with Management Options]*. Chapter 5: Methodology. Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India. http://www.ces.iisc.ernet.in/energy/paper/TR109/TR109_TVR.pdf, accessed on 23 April 2015.
[19] Envergent.n.d. "The Production of Electricity from Wood and Other Solid Biomass". Table 1.EvergentTech.com. http://www.envergenttech.com/files/envergent_electricity_5406_en_wp_10v1.pdf, accessed on 20 April 2015.

Methodology of Biomass Combustion Potential from Forest Residues

The residues considered under this assessment are saw-milling residues (40 per cent recovery), logging residues (50 per cent recovery) and residue wastes generated from plywood production (50 per cent recovery).

In general, the recovery rates vary considerably depending on local conditions. A 60/40 ratio is often found in the literature, e.g., for every cubic metre of log removed, 0.4m^3 of waste remains in the forest (including the less commercial species). In order to calculate the amount of logging residues an average recovery factor of 60 per cent has been used.[20] After receiving the logs, about 12 per cent is waste in the form of bark. Slabs, edgings and trimmings amount to about 34 per cent, while sawdust constitutes another 12 per cent of the log input. After kiln-drying the wood, further processing may take place resulting in another 8 per cent wastage (of log input) in the form of sawdust and trim end (2 per cent) and planer shavings (6 per cent). For the purpose of calculation, a yield factor of 50 per cent has been used (38 per cent solid wood waste and 12 per cent sawdust).[21]

Plywood making is a large-scale operation and involves the cutting of the logs to the length required and de-barking of the logs. After the preparatory operations–sizing, debarking and cleaning–the logs are sliced, i.e., the logs are rotated in a machine. Recovery rates vary from 45 to 50 per cent with the main variable being the diameter and quality of the log. Of the log input, the main forms of waste are log ends and trims (7 per cent), bark (5 per cent), log cores (10 per cent), green veneer waste (12 per cent), dry veneer waste (8 per cent), trimmings (4 per cent) and rejected plywood (1 per cent). These form the largest amount of waste, while sanding the plywood sheets results in another loss of 5 per cent in the form of sander dust.[22]

Based on the assessment of *The Energy Report– Kerala*, the availability of timber residues was projected, assuming the availability projection to be the same ratio as the ratio of forest area of Palakkad with respect to Kerala. Based on the above assumptions, the estimated timber residue availability is shown in Table An2.9 below.

TABLE AN2.9: FOREST RESIDUES AVAILABLE FOR BIOMASS ENERGY

Annual Available Residues (T/y)	2015	2020	2025	2030
Forest Residues	190,254.56	194,879.85	196,188.66	197,490.47

The expression for estimating the energy generation potential is shown in equation 9 below. The calorific value of forest residues is 4,000 kcal/kg.[23]

[20] FRIM. 1992. “Utilization of Industrial Wood Residues”. Paper presented at the workshop on Logging and Industrial Wood Residues Utilization in Jakarta, Indonesia (24 August).
[21] Koopmans,Auke and Koppejan, Jaap. 1997. “Agriculture and Forest Residue: Generation, Utilization and Availability”. Paper presented at the Regional Consultation on Modern Applications of Biomass Energy, Kuala Lumpur, Malaysia (January 6-10).
[22] FAO. 1990. *Energy Conservation in the Mechanical Forest Industries*. FAO Forestry Paper No. 93, Food and Agriculture Organization, Rome.
[23] Ramachandra, T.V. and Kamakshi, G. 2005. *Bioresource Potential of Karnataka [Talukwise Inventory with Management Options]*. Chapter 5: Methodology. Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India.p. 82.http://www.ces.iisc.ernet.in/energy/paper/TR109/TR109_TVR.pdf, accessed on 23 April 2015.

Generation Potential (in PJ/y) = Residue availability (in tonnes/y) × Calorific value (in kcal/kg) × Conversion efficiency (21%) × 4.184/109

(Equation 9)

Methodology of Biomass Combustion Potential from Rubber Wood

Rubber wood projections are based on availability of rubber wood from plantations and forests. Crop to residue ratio of rubber wood is considered to be 3 tonnes/Ha.[24] Considering alternative uses, only 30 per cent availability is considered while the collection efficiencies are considered to increase from 15 per cent in 2015 to 50 per cent by 2030. Equation 10 shows the expression used for assessment of rubber wood residue availability.

Net Rubber Primary Wood Available (tonnes/y) = Cultivated area (Ha) × Crop residue Ratio[25] × Collection efficiency × Availability (30%)

(Equation 10)

Based on the above assumptions the residue availability is shown in Table An2.10 below.

TABLE AN2.10: ANNUAL RUBBER PRIMARY WOOD RESIDUE AVAILABLE FOR BIOMASS COMBUSTION

Annual Available Residues (T/y)	2015	2020	2025	2030
Rubber Primary Wood	5,209.99	9,198.77	13,642.75	20,646.58

Annual biomass residue availability for rubber wood is assessed using equation 11. Calorific value of rubber wood is considered to be 19.77 MJ/kg.[26]

Generation Potential (in PJ/y) = Residue availability (in tonnes/y) × Calorific value (in kcal/kg) × Conversion efficiency (21%) × 4.184/10^9

(Equation 11)

[24] CGPL. 2009. Biomass Resource Atlas of India, Residue Generation per kg of Crop". Combustion Gasification & Propulsion Laboratory, Banglalore. http://lab.cgpl.iisc.ernet.in/Atlas/Downloads/CropImages_with_residuedetails.pdf, accessed on 20 April 2015.
[25] Ibid.
[26] K. O. Lim, Zainal,Z.A., Quadir, G.A. and M.Z. Abdullah. 2000. "Plant Based Energy Potential and Biomass Utilization in Malaysia". *International Energy Journal* 1 (2): 81, http://www.thaiscience.info/journals/Article/Plant%20based%20energy%20potential%20and%20biomass%20utilisation%20in%20malaysia.pdf, accessed on 24 April 2015.

ANNEXURE 3
FORECASTING OF MAJOR VARIABLES

Annexure 3 cover the details of assumptions and methodology considered for the base projections of parameters like GDDP, population and per capita income.

FORECASTING OF MAJOR VARIABLES

Different regressors are used for performing regressions to forecast the future demand for motor vehicles and appliance penetration. The regressors are gross district domestic product (GSDP), gross district domestic product from agriculture and industry (GDDP [A] +GDDP [I]), population of Palakkad and per capita income. However, the regressors had to be forecasted in order to forecast future demand for motor vehicles. The techniques used in forecasting the regressors are discussed below.

FORECASTING GROSS DISTRICT DOMESTIC PRODUCT (GDDP)

Data for GDDP at 2004-05 prices have been obtained for the years 2004-05 to 2011-12 from Department of Economics and Statistics, Government of Kerala. As per the data, GDDP is found to grow at a compound annual growth rate (CAGR) of 7.56 per cent over the years from 2004-05 to 2011-12. This CAGR became the basis for deriving the figure for Palakkad's GDDP up to 2030-31. The GDDP at 2004-05 prices appears to be Rs. 53,25,149 in 2030-31 as against Rs. 14,34,817 in 2010-11.

FORECASTING GROSS DISTRICT DOMESTIC PRODUCT FROM AGRICULTURE AND INDUSTRY (GDDP[A&I])

Data on gross district domestic product at 2004-05 prices for agriculture and industry have been obtained from the Department of Economics and Statistics, Government of Kerala. Then, year wise GDDP from agriculture for years 2004-05 to 2010-11 has been added to year wise GDDP from the industry for years 2004-05 to 2010-11 to find out year wise GSDP from agriculture and industry (GDDP[A&I]) from 2004-05 to 2010-11.

The annual growth rate for every year from 2005-06 to 2010-11 has been obtained and the average of the annual growth rates was also obtained. The average of annual growth rates came to 4.81 per cent. This growth rate is considered to forecast GDDP (A&I) from 2010-11 to 2030-31. The GDDP (A&I) turns out to be Rs. 843,746 in 2030-31 as compared to Rs. 368,752 in 2011-12.

FORECASTING POPULATION OF PALAKKAD

Data on Palakkad's population from 1961 to 2011 has been collected from the Integrated District Development Plan,[1] Palakkad, Department of Town and Country Planning, March 2013. The population growth rate from 1971-2031 and the percentage decrease in population growth rate from 1981-2031 have been given in the same district plan.

TABLE AN3.1: DECADAL POPULATION GROWTH RATE AND PERCENTAGE DECREASE IN POPULATION GROWTH RATE FROM 1961 TO 2011[2]

Year	Decadal Population	Population Growth Rate (%)	Percentage Decrease in Population Growth Rate
1961	1,369,500	-	-
1971	1,685,347	23.06	-
1981	2,044,399	21.3	-7.63
1991	2,382,235	16.52	-22.43
2001	2,617,482	9.88	-40.24
2011	2,771,944	5.9	-40.24
2021	2,869,696	3.53	-40.24
2031	2,930,247	2.11	-40.24

The population growth rate from 2011 to 2021 has been considered as 3.53 per cent and population growth rate from 2021 to 2031 has been considered as 2.11 per cent. On the basis of the calculation, the population of 2021 turns out to be 2,869,696 and the population of 2031 turns out to be 2,930,247.

In order to find out year-wise population of Palakkad, the CAGR of population growth for every 10 years has been obtained from 2000-01 to 2030-31. The following table depicts CAGR for population growth over the years 2010-11 to 2030-31.

TABLE AN3.2: CAGR FOR POPULATION GROWTH FROM 2010-11 TO 2030-31

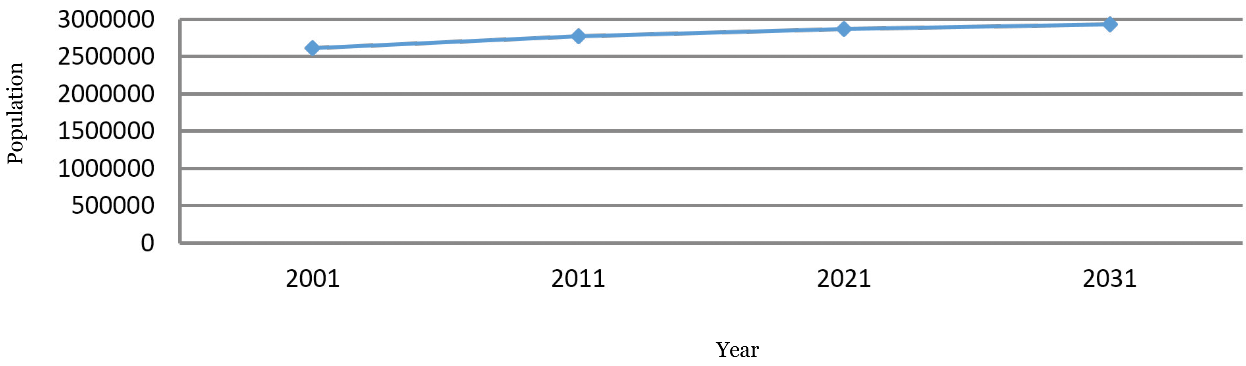
Year	Decadal Population	CAGR (%)
2001	2,617,482	-
2011	2,771,944	0.57
2021	2,869,696	0.34
2031	2,930,247	0.21

Thus, CAGR for population growth in the decade 2001 to 2011 is 0.57 per cent and this CAGR has been used to find out yearly population in the decade 2001 to 2011. The CAGR in the decade 2011 to 2021 is found to be 0.34 per cent and this CAGR has been used to forecast yearly population in the decade 2011 to 2021. In the same manner, 0.21 per cent CAGR for the decade 2021 to 2031 has been applied to find out year-wise population of the respective decade.

Following the above procedure, population of Palakkad for all years between 2011-12 and 2030-31 is obtained. The population in the year 2030-31 appears to be 2,930,247 as compared to population of 2,771,944 in the year 2010-2011. A diagrammatic representation of yearly population of every year from 2000-01 to 2030-31 is depicted below.

[1] District Planning Committee. 2013. *Integrated District Development Plan Palakkad,* Volume 1: Perspective Plan. Department of Town and Country Planning, Kerala.
[2] Ibid.

FIGURE AN3.1: YEARLY POPULATION OF KERALA



FORECASTING PER CAPITA INCOME OF KERALA

Year wise per capita income from 2004-05 to 2030-31 of Palakkad has been obtained by dividing year wise GDDP of Palakkad by population of Palakkad of the respective year. Palakkad's per capita income is appearing to be Rs. 52,059.76 in 2010-11 as compared to Rs. 182,110.23 in 2030-31. However, such a high growth in per capita income may be attributed to the fact that Palakkad's population is reasonably stable while GDDP is growing at the rate 7.56 per cent over the years.

ANNEXURE 4A

METHODOLOGY FOR FINAL ENERGY DEMAND CALCULATION – DOMESTIC SECTOR

Annexure 4A covers the detailed description of derivation of base data for appliance penetration, future projections of appliance penetration and assumptions considered for calculation of the final energy demand for the domestic sector in the BAU scenario.

DERIVATION OF APPLIANCE PENETRATION IN PALAKKAD

Appliance ownership values for households are only available for lighting and television (Census 2001, 2011). Table An4A.1 below shows the lighting and television penetration in Palakkad.

TABLE AN4A.1:

LIGHTING AND TELEVISION PENETRATION IN PALAKKAD (PER 1000 HOUSEHOLDS)

Appliance	Year	
	2001	2011
Tube Lights and Bulbs	684	947
Television	397	721

Source: Census of India – 2001 and 2011

The other appliance ownership levels are derived from the appliance-level ownership of Kerala taken from the NSSO surveys on Household Consumer Expenditure (1999-2000, 2004-05 and 2009-10). Lighting is considered a 'necessity good' and television is considered as a 'luxury good'. Fan, also being a necessity good, the penetration level in the district is calculated based on the ratio corresponding to lighting in Palakkad and Kerala, and linking it with fan penetration level in Kerala. Refrigerator, air conditioner, washing machine, VCD/DVD players, music system, computer, game console, etc., are considered as luxury goods. The ownership levels of these goods are calculated from the respective ownership level in the state linked with the ratio of television penetration in Palakkad and Kerala. Table An4A.2 below indicates the appliance ownership level (for every thousand households) across households in the district.

TABLE AN4A.2:

APPLIANCE OWNERSHIP LEVELS PER 1000 HOUSEHOLDS IN PALAKKAD

Appliance	Year	
	2001	2011
Tube Light and Bulb	684	947
Fan	430	872
Television	397	721
Refrigerator	193	382
Space Conditioning	7	52
Washing Machine	70	172
Others	105	466

The penetration of water heaters is not covered in the NSSO. It is assumed that the penetration of water heaters is equal to that of washing machines. Other categories includes goods like VCD/DVD player, music system, computer, game console, etc.

A simple linear regression model is used to project the future appliance penetration with historic penetration level of each appliance as dependent variable and per capita income (PCI) as the independent variable. Interim annual values of penetration level from 2001-2011 have been interpolated after assuming a constant CAGR between interim years equal to the calculated CAGR of the interval. CAGR for future projections of per capita income are calculated on the basis of future GDDP of the district and population. The detailed regression exercises for appliances are found to be statistically significant. Table An4A.3 below gives the summary of the regression models for all the appliances

TABLE AN4A.3: REGRESSION MODELS FOR ALL APPLIANCES

Appliance	Equation
General Equation - Pij = Cj×PCIi. Where, Pij = Penetration level in year i for appliance j, Cj =Regression coefficient of per capita income for penetration of appliance j across all years, PCIi = per capita income in Year i	
Lighting	Number of households having tubes/ lights/bulbs = .03547×PCI t-statistic (68.404) p-value (0.000) R^2 = 0.99
Fan	Number of households having fans = 9.06075×PCI t-statistic (31.017) p-value (0.000) R^2 = 0.99
Television	Number of households having television = 7.735117×PCI t-statistic (47.131) p-value (0.000) R^2 = 0.99
Refrigerator	Number of households having refrigerator = 4.017346×PCI t-statistic (37.394) p-value (0.000) R^2 = 0.99

Air Conditioner	Number of households having air conditioner = -38844.2075 + 1.2306×PCI t-statistic (-5.148) (7.515) p-value (0.002) (0.000) $R^2 = 0.91$
Washing Machine	Number of households having washing machines = -53537.203 + 2.8539×PCI t-statistic (-3.781) (9.289) p-value (0.009) (0.000) $R^2 = 0.95$
Other Appliances	Number of households having other appliances = -275777.935 + 9.8737×PCI t-statistic (-4.94) (8.154) p-value (0.000) (0.000) $R^2 = 0.92$

Remarks: PCI is found to be statistically significant for all R2 values mentioned above. The equations mentioned above will be used to predict the number of households per thousand households having the respective appliance.

The results of the regression for all appliances are summarized in Table An4A.4.

TABLE AN4A.4: APPLIANCE PENETRATION PER 100 HOUSEHOLDS

Appliance	2015	2020	2025	2030
Lighting	100	100	100	100
Fan	95	100	100	100
TV	81	100	100	100
Refrigerator	42	54	64	77
Air Conditioning	7	11	15	20
Washing Machine	22	31	40	49
Water Heater	22	31	40	49
Others	64	97	100	100

Assumptions

To factor in the actual appliance numbers for fans and lights per household and decide on the saturation level of appliance numbers (saturation of air conditioners), Census 2011 data was referred (*HH-4: Households by ownership status of the census houses, size of the household and number of dwelling rooms*). The weighted average of dwelling size (in terms of number of rooms and number of households) indicates an average room size of 2.86 in the district, while the average household size is 4.4 persons per household.

Based on the above considerations, the following level of household ownership of appliance numbers and their saturation level are assumed.

TABLE AN4A.5:
APPLIANCE OWNERSHIP ASSUMPTIONS PER HOUSEHOLD

Appliance	Ownership level
Light	3 points per household
Fan	3 fans per household but only two fans are considered for the purpose of energy estimation
TV, refrigerator and washing machine	1 each per possessor HH with a saturation of 1 each
Space cooling and water heating	1 each per possessor HH
Others	1 per possessor HH with a saturation of 4

Based on the above assumptions, the change in appliance penetration level is mapped in the Table An4A.6.

TABLE AN4A.6:
APPLIANCE NUMBERS ACROSS PROJECTION PERIOD PER 100 HOUSEHOLDS

Appliance	2015	2020	2025	2030
Lighting	100	100	100	100
Fan	95	100	100	100
TV	81	100	100	100
Refrigerator	42	54	64	77
Air Conditioning	7	11	15	20
Washing Machine	22	31	40	49
Water Heater	22	31	40	49
Others	64	97	126	161

Electricity Estimation: Outputs

For each appliance, there are different versions of appliance technologies and efficiency ratings. In addition, it was also imperative to arrive at possible appliance share between existing and efficient models. In order to factor in the trends in consumer behaviour, as well as the changing appliance efficiency levels, a 2008 study by World Bank on Indian household electricity was referred.[1] The study has made long-term projections (up to 2031) of residential electricity demand based on a bottom-up exercise using individual appliance level ownership and energy intensity values. The energy intensity values are slightly varied in the study to account for changes in appliance sizes (from small-screen TVs to large-screen TVs, small refrigerators to large refrigerators) and moderate level of migration to efficient appliances. A similar transition in energy intensity is assumed for Palakkad. Based on the study, the presumed annual appliance energy consumption across the years is shown in Table An4A.7 below:

TABLE AN4A.7:
ANNUAL UNIT APPLIANCE ENERGY CONSUMPTION (UEC)

Appliance	Annual UEC (kWh)		
	2011	2020	2030
Lighting	35.2	35.1	35
Fans	96.4	92.6	91.8
TV	135	185	203
Refrigerators	568	431	418
Space Cooling	1,083	1,044	1,040

[1] World Bank. 2008. *Residential Consumption of Electricity in India: Documentation of Data and Methodology – India: Strategies for Low Carbon Growth*. The World Bank.http://www.moef.nic.in/downloads/public-information/Residentialpowerconsumption.pdf, accessed on 21 April 2015.

Appliance	Annual UEC (kWh)		
Washing Machine	41	54	64
Water Heater	589	559	554
Others*	35	36	37

Note:*Others include year average of Computers, Microwave and DVD/VCD player

Cooking

The available data on fuel use for cooking for households in Palakkad was found to be inaccurate. Therefore, the data for Palakkad was derived from data of Kerala taken from four NSSO surveys on 'energy sources for cooking and lighting in Indian households' (1999-2000, 2004-2005 and 2009-10, 2010-11). The data available for both urban and rural households indicates that LPG and wood are the major sources of cooking fuels accounting for more than 92 per cent of the fuel type used in household cooking. The remaining share is made up of kerosene, biogas, electricity and other fuels.

The share across the years clearly indicates a gradual shift from wood to LPG. At the same time the share of other fuels is decreasing at a high rate indicating increasing dominance of LPG and wood as preferred fuel types. Table An4A.8 shows the cooking fuel share of the district.

TABLE AN4A.8: COOKING FUEL SHARE OF PALAKKAD

Cooking Fuel	2000	2005	2010	2011
LPG	213	310	410	410
Wood	694	638	534	534
Kerosene	44	6	5	5
Biogas	2	2	2	2
Electricity	1	1	5	5
Others	6	1	1	1

Brief Methodology

The future demand estimation is calculated from the demand estimated in *The Energy Report – Kerala*.[2] Table An4A.9 indicates the projection of fuel share across the years. It is assumed that one household uses only one fuel. The penetration at the district level is estimated by combining the penetration in rural and urban households.

TABLE AN4A.9: COOKING FUEL SHARE PROJECTIONS UP TO 2030

Cooking Fuel	2015	2020	2025	2030
LPG	524	685	808.5	925.5
Wood	456	295	171.5	54.5
Kerosene	3.5	3	2.5	1
Biogas	2	2.5	2.5	2
Electricity	4.5	4.5	4.5	4.5
Others	1	1	1	1

[2]WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

To arrive at the quantitative requirement of cooking fuels at the household level, *TERI's Technology Vision 2030* study was referred.[3] According to the study, per head cooking energy requirement is 620 Kcal/per capita/day. To arrive at the energy requirement per year per household, the per capita figure is multiplied with 365 and the average household size for urban and rural sectors for all the given years.

[3]TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

ANNEXURE 4B
METHODOLOGY FOR FINAL ENERGY DEMAND CALCULATION – COMMERCIAL SECTOR

Annexure 4B covers the detailed description of base data and projections, assumption, actual calculation and narrative description of methodology considered for calculation of the final energy demand for commercial sector in the BAU scenario.

ELECTRICITY DEMAND: INPUTS

Based on KSEBL data, the total electricity consumption of the commercial sector in Palakkad district is shown in the table An4B.1.

TABLE AN4B.1: ELECTRICITY CONSUMPTION OF COMMERCIAL SECTOR FROM 2009-10 TO 2013-14

Electricity Consumption (MU)	2009-10	2010-11	2011-12	2012-13	2013-14
Commercial	117.57	124.625	132.10	137.65	135.08

Source: Primary data collected from KSEBL's circle offices of Palakkad and Shornur.

The data shown in the above table is considered as base for future projections. The number of commercial establishments in Palakkad district as per the electricity consumption statistics in 2010 is 106,197. In this study, commercial consumer includes shops/retails, hospitals, office building, hospitals, etc. For this purpose, the total number of commercial consumers considered for year 2011 will include the above-mentioned establishments.

The growing electricity demand can be explained by the increasing demand for service measured by the value of GDDP of the tertiary sector. In order to predict the future electricity demand in the commercial sector, linear regression of historical electrical consumption on GDDP of the tertiary sector is found to be appropriate. Therefore, the following estimated regression equation is used to assess future electricity consumption of the commercial sector.

Electricity consumption of commercial sector =
74.4065 + 4.05E-05 × GDDP (tertiary)

t statistic	(14.09)	(10.510)
P value	(0.000)	(0.001)

R^2 = .98

In order to estimate the electricity demand of individual sub-sectors within the commercial sector, the BEE study[1] and *The Energy Report– Kerala*[2] was referred which indicated that the percentage breakup of consumption across commercial consumers in Kerala. In *The Energy Report– Kerala* it was assumed that for sub-sectors, malls consumed 2.4 per cent, hospitals

[1] BEE. 2008. "State -wise Electricity Consumption & Conservation Potential in India". Bureau of Energy Efficiency, National Productivity Council, New Delhi, India.
[2] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.

consumed 4 per cent, office buildings consumed 6.4 per cent, IT parks consumed 7.7 per cent, hotels consumed 22.5 per cent and retail consumed 57 per cent of the total commercial electricity demand.

Palakkad, having a slightly different commercial structure due to the absence of IT parks and malls, the share of IT parks is be added to office buildings, and malls to shops and retails. Therefore, the final share of sub-sector assumed in the total commercial electricity demand is shown in the following Table An4B.2.

TABLE AN4B.2: SHARE OF SUB-SECTORS IN THE TOTAL COMMERCIAL ELECTRICITY DEMAND

Commercial	% Share
Shops/Retails	59.4
Hospitals	4
Office Buildings	14.1
Hotels	22.5

This share is assumed to be constant throughout the projection period. In addition, the breakup of various electricity consuming activities like lighting space conditioning has been assumed based on electricity usage norms adopted in the TERI study.[3] Based on the report, it has been assumed that lighting, space conditioning and refrigeration account for 60, 32 and 8 per cent, respectively of the total electricity usage in the commercial sector. The same norms are assumed for hotels, hospitals and shops/retail. For office buildings, the share is assumed at 60 per cent for lighting, 32 per cent for space conditioning and 8 per cent for IT and other applications. For space conditioning, a share of 70 per cent is assumed for fans and 30 per cent for air conditioners.

No changes in any of the shares (%) are considered for the base (BAU) scenario. Furthermore, as the electricity demand is top driven, the breakup of end-use activities in terms of appliances has not been considered in the base (BAU) scenario, but is included in the intervention scenarios covered later.

HEATING DEMAND: INPUTS

The commercial sector uses heat mainly for cooking and water heating. The absence of granular data on commercial sector necessitates its analysis using a top-down methodology. The main fuels used for heat requirements of the commercial sector are LPG and kerosene.

The all India share of LPG and kerosene consumption in commercial sector for the past three years from 2009-10 to 2011-12 are shown in the Table An4B.3 below.

TABLE AN4B.3: SHARE OF LPG AND KEROSENE IN THE COMMERCIAL SECTOR - ALL INDIA

LPG Consumption (000' tons)	2010	%	2011	%	2012	%
Commercial	872	6.8	985	6.9	1045	6.6
Total	**13,122**	**100**	**14,331**	**100**	**15,358**	**100**
Kerosene Consumption (000' tons)						
Commercial	69	0.7	67	0.8	61	0.7
Total	**9,304**	**100**	**8,928**	**100**	**8,229**	**100**

[3] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

Based on statistics of the Ministry of Petroleum and Natural Gas, the total consumption of LPG and kerosene in Kerala for the year 2011-12 was 656,000 tonnes and 155,000 tonnes, respectively. The classification in the statistics referred was provided under the commercial/industrial categories, however, bulk LPG was included as a separate category for the manufacturing sector. Considering this commercial/manufacturing sector was assumed to represent the demand of the commercial sector.

ASSUMPTIONS

It is assumed that the share of LPG and kerosene in the district's commercial sector will be the same as that of national average. The total LPG consumption was calculated based on the total population figures for Kerala and that of Palakkad from Census 2011. The consumption ratio (LPG and kerosene consumption to population) of the district was assumed to be the same as that of the state. The commercial sector consumption of LPG and kerosene was found to be 3,594.56 tonnes and 90.07 tonnes respectively for base year 2011.

For projections of demand, it is assumed that the growth rate will be the same rate as that of hotels.

Based on the ASI survey, the industry sector was clustered into ten major sectors: agro and food processing, textiles, paper and pulp, petrochemicals, chemicals (including fertilizers), rubber products, minerals and materials (including cement and abrasives), metals and alloys, engineering and industrial goods and others. Table An4B.4 captures the categorization.

TABLE AN4B.4: CATEGORIZATION OF INDUSTRY SUB-SECTORS

Categories	Industry
Agriculture and Food	Food Process Industries Manufacture of Beverages Wood Industry
Textiles	Textile Industry
Paper and Pulp	Pulp & Paper Industry
Petrochemicals	Refined Petroleum Products Plastic Products
Chemicals	Chemical Industry
Rubber Products	Rubber Products
Minerals and Materials	Non-metallic Mineral Products (Cement)
Metals and Alloys	Manufacture of Basic Iron & Steel Manufacture of Basic Precious and Other Non-ferrous Metals
Engineering and Mechanical	Casting of Metals Metal Fabrication Electrical Manufacturing Sector Manufacture of Machinery Manufacture of Railway Locomotives and Rolling Stock
Others	Manufacture of Furniture Manufacture of Jewellery Manufacture of Medical Instruments Other Manufacturing n.e.c Publishing of Books/Periodicals/Publishing Activities Others

Based on the above categorization, the electricity and heat demand for the industrial sectors was determined separately.

ANNEXURE 4C
METHODOLOGY FOR FINAL ENERGY DEMAND CALCULATION – INDUSTRIAL SECTOR

Annexure 4C covers the detailed description of base data and projections, assumptions, actual calculation and narrative description of the methodology considered for calculation of final energy demand for industry sector in the BAU scenario.

ELECTRICITY DEMAND: INPUTS

Historical data of electricity consumption by industries for LT category was available from 2009-10 to 2013-14 from KSEBL. However, the available data was not sufficient to correlate with the GDDP (I) growth in Palakkad. Therefore, future projections are calculated from the data available for industrial electricity consumption in Kerala.

LT Electricity Consumption

The historical consumption data shows a constant share of 5-6 per cent with respect to Kerala's industrial LT consumption. Average share of 5.5 per cent is used to derive the future consumption of Palakkad from the electricity consumption details available in the 18th EPS report[1] where the projection of sectoral electricity demand for Kerala is available up to FY 2021/22. From 2022-23 onwards, a linear trend has been fitted to the existing data.

Electricity demand in industry at period t = 5.741x + 51.97

Where, t denotes time and takes values from 1 to 8 [1 = 2023, 2 = 2024 ... 8 = 2030]

The estimated equation has been used to forecast demand for electricity in industry from 2023 to 2030.

HT Electricity Consumption

Historical data of electricity consumption by industries for HT category was available only for the year 2009-10 from KSEBL. This consumption data shows a share of 14 per cent with respect to the consumption of Kerala industrial HT consumption. This share of 14 per cent is kept constant to derive future consumption of Palakkad from the electricity consumption details available in 18th EPS report[2] where the projection of sectoral electricity demand for Kerala is available up to FY 2021/22. From 2022-23 onwards, a linear trend has been fitted to the existing data.

Electricity demand in industry at period t = 19.97x + 373.8

Where, t denotes time and takes values from 1 to 8 [1 = 2023, 2 = 2024 ... 8 = 2030]

---

[1] CEA. 2011. *Report on Eighteenth Electric Power Survey of India*. Central Electricity Authority, New Delhi, India.
[2] Ibid.

The estimated equation has been used to forecast demand for electricity in industry from 2023 to 2030.

ENERGY ESTIMATION: OUTPUT

Forecasted demand for electricity in industry appears to be 965.7 million units in 2030. To break down the total projections across industry sectors, the share of high energy consuming industries in the total HT consumption is used. Instead of using the actual electricity consumption data, the percentage share of HT electricity consumption across sectors was derived and used for allocating consumption share in the base year. Table An4C.1 indicates the actual consumption data and the percentage share across industry sub-sectors.

TABLE AN4C.1

PERCENTAGE SHARE OF ELECTRICITY CONSUMPTION ACROSS INDUSTRY SUB-SECTORS

Industry Energy Share	Percentage Share	Electricity (MU)
Agro and Food Sector	6.51	24.87
Textiles	11.20	42.8
Paper and Pulp	1.10	4.22
Petrochemicals	0.27	1.041
Chemicals	0.48	1.84
Rubber	0.87	3.312
Minerals and Materials	7.49	28.6
Metals and Alloys	51.14	195.4
Engineering and Industrial Goods	14.52	55.49
Others	6.41	24.5
Total	**100**	**382.073**

To assess the future intra-sectoral demand changes, the industrial development plans[3] for the district was studied. The phase of industrialization in Palakkad had been very fast. The upcoming large and medium industrial units such as BEML, Railway Coach Factory, Textile Factory, Light Engineering Park etc., offer good scope for development of MSME units, especially metals and alloys, and engineering and industrial goods. The government also plans to strengthen the agro-and food-based sector and textile and handloom sector.

In view of the industrial development plans in the district, it is assumed that even though the total electricity consumption of the industrial sectors will increase, the absolute increase in consumption level of large industries like chemicals, petrochemicals, paper and pulp, minerals and materials will remain constant after 2015. The development plan for the district indicates that industries such as agro and food, textile, metals and alloys, engineering and industrial goods will expand further in the district. Subsequently, the total increase in electricity will be distributed across these sectors, keeping the sector's share as constant. The total electricity demand remains same, while the intra-sectoral demand changes with a focus on industries having a higher share of the total electricity consumption.

[3] Department of Town and Country Planning. 2013. *Integrated District Development Plan – Palakkad*. Government of Kerala, Kerala.

HEAT REQUIREMENTS: INPUTS

Fuel requirements of industries in Palakkad were not available. The fuel requirement is therefore derived from the fuel requirements in Kerala assessed in *The Energy Report– Kerala*.[4]

In *The Energy Report– Kerala*, data from Annual Survey of Industries was used to assess fuel requirements of the selected sectors. Even though the data on fuel usage across sectors for coal was available in tonnes, for petroleum products and other fuels it was available in terms of value of fuel in Rupees. To arrive at the actual tonnage requirements of petroleum products, data on petroleum product prices on 31 March 2010 was accessed from the Petroleum Statistics released by Ministry of Petroleum and Natural Gas.[5] The main petroleum derived fuel used across the majority of selected industry sectors was furnace oil (FO) and it was taken as a representative fuel for all sectors except petrochemicals. The value of petroleum fuels consumed was divided by the price of FO at the end of FY 2010/11 to arrive at the tonnage of FO requirement for each sector. For the petrochemical sector, the high petrochemical consumption value indicated use of petroleum (Naphtha or Crude) as raw material rather than mainly as a heating fuel. Consequently, the heating demand for petrochemicals was assumed to come from gas and other fuels.

It was further assumed that coke and wood were the best representations of 'other fuels' category. Based on the existing process-requirements of the industry sub-sectors, it was assumed that coke (pet coke) represented 'other fuels' in petrochemicals, chemicals, minerals and materials, and metals and alloys. For all other sub-sectors, it was assumed that 'other fuels' represented wood.

Based on the requirements of industries in Kerala, the fuel requirement for industries in Palakkad was calculated linking it with the share of electricity consumption in the industrial sector in Palakkad with that of Kerala. Table An4C.2 below shows the fuel used across industry sub-sectors.

TABLE AN4C.2: FUELS USED ACROSS INDUSTRY SUB-SECTORS IN PALAKKAD

Industry Fuel Use	POL (FO Kl)	Coal (Tonnes)	Coke (Tonnes)	Wood (Tonnes)
Agro and Food Sector	2,306.704	317.4218	0	9,843.013
Textiles	982.7492	0	0	11,145.39
Paper and Pulp	214.6858	5,486.64	0	1,019.034
Petrochemicals	1,896.379	3,090.053	20.23882	0
Chemicals	31.33641	0	314.4969	0
Rubber	287.681	219.9891	0	236.1906
Minerals and Materials	196.7967	6,405.375	13,549.73	0
Metals and Alloys	4,650.16	6,886.344	446.0473	0
Engineering and Industrial Goods	1,897.1	3,630.119	0	19,432.03
Others	2,112.051	0	0	958.4526

[4] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.
[5] MP&NG. 2012. *Basic Statistics on Indian Petroleum & Natural Gas*. Ministry of Petroleum & Natural Gas, Government of India.http://petroleum.nic.in/petstat.pdf, accessed on 19 May 2015.

ANNEXURE 4D

METHODOLOGY FOR FINAL ENERGY DEMAND CALCULATION – AGRICULTURE SECTOR

Annexure 4D covers the detailed description of base data and projections, assumptions, actual calculation and narrative description of the methodology considered for calculation of the final energy demand for the agricultural sector in the BAU scenario.

ELECTRICITY DEMAND

Based on KSEBL data collected, the electricity consumed for irrigation is shown in the Table An4D.1 below.

TABLE AN4D.1: ELECTRICITY CONSUMPTION IN THE AGRICULTURAL SECTOR FROM 2009-10 TO 2013-14

Electricity Consumption (MU)	2009-10	2010-11	2011-12	2012-13	2013-14
Irrigation	61.79	66.22	70.97	87.59	90.46

Source: Primary data collected from KSEBL's circle offices of Palakkad and Shornur.

The data given in the table above was considered as base data for future consumption projections up to 2030. Palakkad's agricultural sector consumes 30 per cent of Kerala's agricultural consumption, Palakkad being the major agricultural district of Kerala; it can be assumed that the consumption pattern may show a trend similar to the future trend of Kerala. The 18th Electric Power Survey[1] of India indicates Kerala state irrigation power consumption and provides estimates of consumption till 2021-22.

Methodology

As per the EPS survey, the irrigation power consumption of Kerala is 318 MU in 2014-15 and is estimated to be 376 MU by 2021-22. For the purpose of projections, the same yearly growth of Kerala from 2015 to 2022 is considered for Palakkad. From 2022 to 2030, simple linear extrapolation is done.

FUEL

The main fuel demand in the agricultural sector is for pumps and tractors. The following narrative covers the methodology for estimation of fuel demand.

Fuel Demand for Irrigation Pumps

According to district level data 2006-07, Palakkad has about 2,362 diesel pump-sets.[2] Assuming a standard pump size of 5HP with a specific fuel consumption of 169.28 g/bhp-hr (standard 5 hp diesel pump of B.S. Agriculture Industry) and a standard annual operating time of 170 hrs/

[1] CEA. 2011. *Report on Eighteenth Electric Power Survey of India*. Central Electricity Authority, New Delhi, India.
[2] Local Self Government Department. 2006. *District Level Database, Palakkad District* – 2006. Government of Kerala.

year (derived), the total annual diesel requirement in 2006-07 per pump works out to be 187 litres. It is also assumed that diesel pumps will be phased out completely by 2020. It is assumed that diesel pumps are replaced by efficient electric pumps and the electricity consumption of these new pumps are explicitly factored as an additional electricity demand.

Fuel Demand for Tractors

According to the Motor Vehicles Department, Government of Kerala,[3] the total number of registered tractors in Kerala has grown from 3,681 to about 4,713 from 2004 to 2013, registering a CAGR of 3.14 per cent. The same CAGR is used to forecast the total number of registered tractors.

The figure for fleet availability (ratio of on-road to registered vehicles) is assumed to be 70 per cent. Based on the above methodology, the number of on-road tractors are shown in Table An4D.2

TABLE AN4D.2: ON-ROAD TRACTOR POPULATION

Tractors Numbers	2015	2020	2025	2030
Tractors On-road	3,546	3,988	4,430	4,872

Considering the cropping choices in Palakkad, a standard Tractor Size of 18.5 hp/2700 rpm (Shakti MT180D Model of VST Tillers and Tractors Ltd.) with a specific fuel consumption of 230gm/hp-hr is assumed as a representative machine. Assuming 300 hrs (100 days for 3 hrs per day) of on-farm running and 400 hrs of other running including transportation and other uses, the total fuel requirement per tractor per year is estimated at 2,978 kg/per tractor. This is multiplied by the number of tractors to arrive at the total annual fuel consumption of tractors.

[3] The data is taken from different editions of the *Economic Review*, published by State Planning Board, Government of Kerala.

ANNEXURE 4E

METHODOLOGY FOR FINAL ENERGY DEMAND CALCULATION – PUBLIC UTILITIES

Annexure 4E covers the detailed description of base data and projections, assumptions, actual calculation and narrative description of the methodology considered for calculation of the final energy demand for public utilities in the BAU scenario.

ELECTRICITY DEMAND: INPUT

Public utilities mainly cover electricity consumption of utilities and state entities towards street/road lighting, water supply and non-domestic connections.

Methodology

Public Lighting

Future consumption of electricity from street lighting has been derived from the linear projection of the historical data. The trend has been analysed with several options and the finalized equation for projections for public lighting and water works is shown below.

Public Lighting = 1.757x + 20.18

Where x = 1 for 2010, 2 for 2011 …… 21 for 2030.

Water Works

The future electricity consumption from water works is derived by projecting the base year value using the average year on year growth rate considered for water works electricity consumption considered in the 18th EPS report.[1] The average growth rate considered is 3 per cent.

ELECTRICITY DEMAND: OUTPUT

The following Table An4E.1 shows the estimated electricity demand for public utilities up to 2030.

TABLE AN4E.1: ESTIMATED ELECTRICITY DEMAND FOR PUBLIC UTILITIES

Sector Electricity Demand (MU)	2015	2020	2025	2030
Public Lighting	30.72	39.51	48.29	57.08
Public Water Works	6.47	7.50	8.69	10.08

No heating or fuel requirement is separately assessed for this sector.

[1] CEA. 2011. Report on *Eighteenth Electric Power Survey of India*. Central Electricity Authority, New Delhi, India.

ANNEXURE 4F
METHODOLOGY FOR FINAL ENERGY DEMAND CALCULATION – TRANSPORT SECTOR

Annexure 4F covers the detailed description of base data and projections, assumptions, actual calculation and narrative description of the methodology considered for calculation of the final energy demand for the transport sector in the BAU scenario.

TRANSPORT SECTOR

This section tries to assess the total transport volume and the transport energy demand by using a bottom up methodology. The section covers passenger and freight transport separately. Within each branch, the traffic volumes are estimated for different transport modes including road and rail. The units used for estimating transport volumes are Passenger km (pkm) for passenger transport and Tonnes km (tkm) for freight transport. The projections for the BAU traffic volumes for roads covered in this section are derived on the basis of growth in vehicle population.

The assessment of transport technologies is mainly based on empirical data or available studies. The major vehicle categories considered for the assessment are cars, taxi cars, jeeps, auto rickshaws/three-wheelers, two-wheelers, buses (stage carriages), buses (contract carriages), goods vehicles (four-wheelers & above) and goods vehicles (three-wheelers including tempos). Data on category-wise growth of motor vehicles from 2004 to 2012 in Palakkad have been assessed from the "Transport" section of the Economic Review, Kerala State Planning Board.[1] Table An4F.1 below summarizes the vehicle growth in Palakkad district.

TABLE AN4F.1: CATEGORY-WISE TOTAL NUMBER OF MOTOR VEHICLES HAVING VALID REGISTRATION (AS ON 31 MARCH)[2]

Vehicle Description	Goods Vehicles	Buses		Four-Wheelers				Three-Wheelers	Two-Wheelers
	Four-Wheelers & above	Three-Wheelers including Tempos	Stage Carriage	Contract Carriages/ Omni buses	Cars	Taxis	Jeeps	Auto Rickshaws	Scooter/ Motor cycles
2004	11,577	2,628	1,864	3,352	13,456	6,000	3,406	16,297	100,169
2005	12,348	3,015	2,005	3,961	14,744	6,356	3,544	17,890	111,206
2006	14,787	3,946	2,081	5,837	17,383	7,088	3,674	19,869	136,293
2007	16,772	3,885	2,115	8,333	20,211	7,388	3,739	23,908	164,783
2008	17,674	4,863	2,282	8,693	24,290	7,725	3,739	25,692	181,102
2009	18,589	5,421	2,408	8,847	29,993	8,119	3,739	28,464	199,430
2010	19,450	6,031	2,523	8,991	36,727	8,781	3,739	32,950	220,758
2011	21,164	6,836	1,074	9,351	44,871	9,487	3,739	37,901	252,364
2012	22,100	7,536	1,176	9,670	50,648	9,964	3,739	42,361	288,074

[1] The data is taken from nine different editions of the *Economic Review*, published by State Planning Board, Government of Kerala.
[2] Ibid.

The existing road network in the district connects to national, state highways and major district roads, which are maintained by the Kerala Public Works Department and Local Self Government Department. The total length of roads in the district is 2,172.78km.

In order to factor in the new technologies which are near commercialization, a moderate penetration level is assumed for each vehicle type by 2030 in the BAU scenario. This moderate level of penetration is assumed to emphasize that new technology adoption will be primarily based on market drivers and not on specific transport policy actions.

Estimation of Passenger Volumes

Step 1: Based on available data, total number of registered cars has grown from 13,456 in 2004 to about 50,648 in 2012, registering a CAGR of 18.02 per cent. However, as cars are considered to be a superior personal transport option and also have other advantages as compared to motorcycles, it is assumed that car sales are dependant more on the per capita income than on any other market or demographic factors. Based on common perception, regression of registered cars on per capita income is found to be appropriate. Therefore, the following estimated regression equation is used to find out responsiveness of total registered cars to per capita income.

Total registered cars = -33961.1+1.275941×Per capita income
t-statistic (-3.31) (5.54)
p-value (0.02) (0.000)
$R^2 = 0.86$

The independent variable is found to be statistically significant as indicated by the t-values and p-values given within brackets. R^2 is 0.86 which indicates that 86 per cent of variation in registered number of cars is explained by per capita income.

The regression equation is used to predict future total registered cars up to 2030. The forecasted per total number of registered car is 198,401 in 2030 as compared to 50,648 in 2011.

Step 2: Based on literature review[3], the average age of a car is assumed to be 8 years. The total in use vehicles are arrived at by eliminating the total registered cars of more than 8 years old. The results of the derivation for on-road car population are shown in Table An4F.2 below.

Intermediate Output

Based on the above assumptions, the total on road cars is estimated as shown in Table An4F.2 below

TABLE AN4F.2: ESTIMATED ON-ROAD CAR POPULATION

Cars Numbers	2015	2020	2025	2030
Cars On-road	39,597	56,527	67,724	84,119

[3] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

Step 3: Different studies estimate different levels of average mileage for cars. IEA's study[4] assumes total annual mileage of 8,000km constant up to 2035. Other studies by LBNL[5] and Kapoor[6] assume average mileage of cars to be 12,600km and 7,000km, with an increase of 0km and 100km annually, respectively. In addition, interactions with state-based experts indicated that car owners usually also own two-wheelers and usually use cars mainly for family travel or long-distance trip; preferring to commute to office by two-wheelers. Considering the same, the lower of the three values (7,000km) is assumed in the run kilometres.

Step 4: The average estimated occupancy figures vary widely between different studies. IEA[7] assumes 1.89 occupancy declining to 1.64 persons in 2035. Kapoor[8] assumes 1.5 as the occupancy rate, while LBNL[9] assumes 3.5 as the occupancy rate. In line with Kapoor's estimation, occupancy of 1.5 persons per car is assumed throughout the projection period.

Intermediate Output

Based on the above assumptions, the total estimated passenger traffic of cars is given in Table An4F.3 below.

TABLE AN4F.3: ESTIMATED CAR PASSENGER TRAFFIC

Cars Year	2015	2020	2025	2030
Cars (million pkm)	409.8	649.2	1,066.1	1,308.1

Technology Assumptions

For private cars gasoline, diesel, CNG, hybrid gasoline and electric vehicle (EV) technologies are considered.

For BAU scenario, 35 per cent penetration of diesel cars and 65 per cent share of petrol cars are assumed for the base year (2011), based on CRISIL Research. Even though, CRISIL research[10] assumed that the share of diesel will grow to 45 per cent by 2015-16, the base year relative share of petrol and diesel is kept constant throughout the projection period, based on recent media reports that indicate a possible slump of the diesel car market.[11]

Considering a 20 per cent energy intensity reduction potential of hybrid technologies based on TERI's study[12], a steady increase in hybrid technology (both diesel and petrol) from 0 per cent in 2020 to 5 per cent in 2030 is assumed. The penetration of EV is assumed to increase after 2020 to about 5 per cent in 2030.

---

[4] IEA. 2004. *The Sustainable Mobility Project*. International Energy Agency.http://www.oecd.org/sd-roundtable/papersandpublications/39360485.pdf, accessed on 24 April 2015.
[5] Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". In *Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.
[6] Kapoor, Mahesh. 2002. *Vision 2020: Transport*. Report prepared for the Planning Commission, New Delhi, India.
[7] IEA. 2004. The Sustainable Mobility Project. International Energy Agency. http://www.oecd.org/sd-roundtable/papersandpublications/39360485.pdf, accessed on 24 April 2015.
[8] Kapoor, Mahesh. 2002. *Vision 2020: Transport*. Report prepared for the Planning Commission, New Delhi, India.
[9] Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". In *Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.
[10] CRISIL. 2012. *CRISIL-CRB Customized Research Bulletin: Automobiles*. CRISIL Research (September). http://www.crisil.com/pdf/research/CRISIL-Research-cust-bulletin_sept12.pdf, accessed on 24 April 2015.
[11] Poovanna, Sharan and Saha, Samiran. 2013. "Car Makers Run into Diesel Dilemma". *The Indian Express* (19 May). http://www.newindianexpress.com/business/news/Car-makers-run-into-diesel-dilemma/2013/05/19/article1596282.ece, accessed on 24 April 2015.
[12] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

It is assumed that the proposed technology shift will be brought about by market forces without any specific policy intervention. The energy intensity for various technologies for cars is shown in Table An4F.4 below. The energy intensity for full electric version is based on actual performance data of Tesla Motor's Model S 85kWh at 50miles/hr.[13]

Table An4F.4 shows the assumed energy intensities for different car technologies.

TABLE AN4F.4: ENERGY INTENSITIES OF TECHNOLOGIES FOR CARS

Cars	Energy Intensity (EI)	EI Units	EI Reference
Gasoline	0.081	L/km	TERI, 2006*
Diesel	0.074	L/km	TERI, 2006*
Hybrid Gasoline	0.068	L/km	TERI, 2006*
Hybrid Diesel	0.062	L/km	TERI, 2006*
EV	0.15	kWh/km	TESLA Motors†

Source: *TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

The vehicle energy intensity is divided by the average occupancy of the vehicle category to arrive at the value of energy intensity in terms of passenger kilometre.

For the BAU scenario, 5 per cent reduction in energy intensity of dominant ICE technologies and 5 per cent for diesel hybrid and EVs is assumed over the projection period.

TAXI CARS

Estimation of Passenger volumes

Step 1: Based on available data, total registered taxi cars have grown from 6,000 in 2004 to 9,964 in 2012, registering a CAGR of 6.5 per cent. However, as taxi cars are mostly used for commercial purposes, that too mainly in urban areas, it is assumed that their numbers are dependent more on the level of urbanization of the state than on individual income or demographics.

Based on common perception, regression of total registered taxi cars on urban population is found to be appropriate. Therefore, the following estimated regression equation is used to find the responsiveness of total taxi cars to urban population.

Total registered taxi cars = 0.0168×Urban population
t-statistic (195.7)
p-value (0.000)
$R^2 = 0.99$
The independent variable is found to be statistically significant as indicated by the t-values and p-values given within brackets. R2 is 0.99

[13] Musk, Elon and Straubel, J. B. 2012. "Model S Efficiency and Range". TESLA Blog (9 May). http://www.teslamotors.com/blog/model-s-efficiency-and-range, accessed on 24 April 2015.

which indicates that 99 per cent of variation in registered number of cars is explained by urban population

The regression equation is used to predict future taxi car sales up to 2030. The forecasted total registered taxi car sales is 31,807 in 2030 as compared to 9,487 in 2011.

Step 2: Based on TERI's study[14], average life of 8 years is assumed for taxi cars. Assuming a retirement of 8 years, the total in used vehicles is arrived by discarding taxi cars before 8 years.

Intermediate Output

The results of the derivation for on-road taxi car population are given in Table An4F.5 below.

TABLE AN4F.5: ESTIMATED TAXI CAR POPULATION

Taxi Numbers	2015	2020	2025	2030
Taxi Cars On-road	4,775	6,793	9,260	12,758

Step 3: In line with LBNL study,[15] an annual average run of 35,000km is assumed as constant for the entire projection period.

Step 4: Estimation of average occupancy assumed by various studies varies from 3 persons[16] to 3.18 persons[17]. The higher value of 3.18 persons is assumed as average occupancy. It is assumed to be constant over the projection period.

Based on the above assumptions the estimated total passenger volume of taxi cars is given in Table An4F.6 below.

TABLE AN4F.6: ESTIMATED PASSENGER TRAFFIC FOR TAXI CARS

Year	2011	2020	2025	2030
Taxi Car (million pkm)	531.5	756.1	1,030.6	1,420.0

Technology Assumptions

Gasoline, diesel, hybrid diesel and hybrid gasoline technologies are considered for taxi cars. Even though there may be cost savings in CNG-based taxis, the same has not been factored because there may be problems in large scale off take of CNG for taxis unless CNG infrastructure is developed across the state and district. EVs are also not considered in the BAU scenario because of limitations in distance and infrastructure.

For the BAU scenario, 90 per cent penetration of diesel cars and 10 per cent for petrol cars is assumed in the base year (2011). This is done because the predominant buying criterion in diesel vehicle purchase is the level of mileage (annual kilometres run), which is considerably high for taxis.

[14] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.
[15] Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". In *Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.
[16] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.
[17] Kapoor, Mahesh. 2002. *Vision 2020: Transport*. Report prepared for the Planning Commission, New Delhi, India.

Considering a 20 per cent energy intensity reduction potential of hybrid technologies,[18] a steady increase in hybrid technology penetration (both diesel and petrol) from 0 per cent in 2020 to 5 per cent in 2030 is assumed. The ratio between petrol- and diesel-based ICE technologies is assumed to remain constant at 9:1 throughout the projection period.

The energy intensity for various technologies for taxi cars is assumed equal to that of cars as given in Table An4F.7 below.

TABLE AN4F.7: ENERGY INTENSITIES OF TECHNOLOGIES FOR TAXI CARS

Taxi Cars	Energy Intensity (EI)	EI Units	EI Reference
Gasoline	0.081	L/km	TERI, 2006*
Diesel	0.074	L/km	TERI, 2006*
Hybrid Gasoline	0.068	L/km	TERI, 2006*
Hybrid Diesel	0.062	L/km	TERI, 2006*

Source: *TERI. 2006. National Energy Map for India: Technology Vision 2030, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

The vehicle energy intensity is divided by the average occupancy of this vehicle category to arrive at the value of energy intensity in terms of passenger kilometre.

JEEPS

Estimation of Passenger Volumes

Step 1: Historical data indicates that registered jeep population has changed from about 3,406 in 2004 to about 3,739 in 2012 (a CAGR of 1.1 per cent), with zero new additions from 2007 to 2012. Based on stakeholder consultations, it became apparent that jeeps are mostly used in plantation and forest areas, and are used in a limited way for general transportation.

The regression of registered number of jeeps on population is found to be appropriate. Therefore, the following estimated regression equation is used to find out responsiveness of registered number of jeeps to population.

Total registered jeeps = 0.001348×Population
t-statistic (133.4)
p-value (0.000)
$R^2 = 0.99$

The independent variable is found to be statistically significant as indicated by the t-values and p-values given within brackets. R2 is 0.99, which indicates that 99 per cent of variation in registered number of cars is explained by per capita income.

The forecasted total registered number of jeeps is 3,943 in 2030 as compared to 3,739 in 2012.

[18] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

Step 2: To arrive at the on-road population of jeeps, an average life of 10 years is assumed on account of the fact that jeeps usually meet small and medium travel needs of plantations. Table An4F.8 below indicates this trend of the on-road jeep population.

Intermediate Output

Based on the above assumptions, the total on-road jeeps as estimated is given in Table An4F.8 below.

TABLE AN4F.8: ESTIMATED ON-ROAD JEEP POPULATION

Year	2015	2020	2025	2030
Jeeps On-road	246	117	112	87

Step 3: The average annual mileage of a jeep is assumed to be between that of private cars and taxi cars. This assumption is taken based on the fact that while jeeps usually perform commercial functions (plantation related hauls) and also ferry passengers (city to plantation or city to forest areas). This would mean that the average mileage would be more than that of a private car, but would be less than that of commercial taxi, which also performs regular inter-city and inter-state trips. Consequently, an annual average running of 25,000km is assumed for jeeps throughout the projection period.

Step 4: The average occupancy rate of a jeep is also assumed to be between that of a car (1.5 persons) and a taxi (3.18) at 2.34. This occupancy rate is also assumed to be constant throughout the projection period.

Intermediate Output

Based on the above assumptions, the total passenger traffic of jeeps is given in Table An4F.9 below.

TABLE AN4F.9: ESTIMATED PASSENGER TRAFFIC FOR JEEPS

Year	2015	2020	2025	2030
Jeeps (million pkm)	14.4	6.8	6.6	5.1

Technology Assumptions

For jeeps, diesel and hybrid diesel technologies are considered. CNG and EVs are not considered because jeeps usually used in remote areas and fuel availability and fuelling range may be important considerations. For the BAU scenario, 100 per cent penetration of diesel ICE is assumed for the base year (2011). The share of diesel hybrid technology is assumed to increase after 2025 to 5 per cent in 2030.

The energy intensity of jeeps is assumed to be equal to that of large diesel car. Table An4F.10 shows the assumed energy intensity for jeeps.

TABLE AN4F.10: ENERGY INTENSITIES OF TECHNOLOGIES FOR JEEPS

Jeeps	Energy Intensity (EI)	EI Units	EI Reference
Diesel	0.092	L/km	TERI, 2006*
Hybrid Diesel	0.062	L/km	TERI, 2006*

Source: *TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

The vehicle energy intensity is divided by the average occupancy of this vehicle category to arrive at the value of energy intensity in terms of passenger kilometre.

AUTO RICKSHAWS

Estimation of Passenger Volumes

Historical data indicates that registered auto rickshaw population has changed from about 16,297 in 2004 to about 42,361 in 2012 at a CAGR of 12.7 per cent. As rickshaws serve general population, it is assumed that the future population of rickshaws will be largely dependent on population. Regression is done with respect to the total number of registered vehicle and the general population. Regression of the number of registered auto rickshaws is found to be appropriate. Therefore, the following estimated regression equation is used to find out responsiveness of the total number of registered auto rickshaws to the general population.

Total registered cars = -593549 + 0.2277×Population
t-statistic (-13.16) (13.80)
p-value (0.000) (0.000)
$R^2 = 0.97$

The independent variable is found to be statistically significant as indicated by the t-values and p-values given within brackets. R^2 is 0.97 which indicates that 97 per cent of variation in registered number of cars is explained by per capita income.

The regression equation is used to predict future registered number of auto rickshaws up to 2030. The forecasted total registered number of auto rickshaws is 183,228 in 2030.

However, as the number of auto rickshaws are deemed to be dependent on the population, future results indicate a decrease in registered vehicles after the inflexion point when population takes a downward trend. This decrease in the total number of registered vehicles is assumed as the decrease in the number of on-road auto rickshaws that are retired but not replaced.

Step2: Based on stakeholder interaction and available literature for the state, it appears that availability of rickshaws is spread across both rural and urban areas, though the availability of auto rickshaws in urban areas is more. However, it is assumed that auto rickshaw population is a function of population and would tend to vary, based on the population that is to be served. Based on the estimates of population projection for the state (see Annexure 1), it is seen that the absolute growth in population is very low and negative population growth occurs as early as 2020-21. Intuitively, this means that the current on-road rickshaw population would largely remain the same except for some minor variations on account of population.

Assuming a life of 10 years, historical sales of past ten years are summed to arrive at on-road figures for 2011 and 2012. Comparing these numbers with the registered vehicles, on-road auto rickshaws seem to comprise about 65 per cent of the total registered auto rickshaws for 2010-11 and 2011-12, respectively. Based on this ratio, on-road rickshaw population is assumed to be 65 per cent of the registered auto rickshaw population. Based on the above methodology, the projected number of rickshaws is given in Table An4F.11 below.

TABLE AN4F.11: ESTIMATED ON-ROAD AUTO RICKSHAW POPULATION

Year	2015	2020	2025	2030
Auto Rickshaws	30,259	37,532	42,564	47,060

Step 3: An average annual run of 33,500km is assumed based on the LBNL study.[19] No increase in the annual run is assumed.

Step 4: The average passenger carried for stage carriages is taken from the TERI study[20] to be 2.

Intermediate Output

Based on the above estimates, the total estimated passenger traffic of auto rickshaws is given in Table An4F.12 below.

TABLE AN4F.12: ESTIMATED PASSENGER TRAFFIC FOR AUTO RICKSHAWS

Year	2015	2020	2025	2030
Auto Rickshaw (million pkm)	2,027.4	2,514.6	2,851.5	3,153.0

Technology Assumptions

For auto rickshaws, gasoline, CNG, hybrid gasoline, hybrid CNG and all electric technologies are considered. No distinction is made between a two-stroke and four-stroke engine; it being assumed that future environmental regulations will ensure that the total number of four-stroke engine will out numbers that of two-stroke engine.

For the BAU scenario, 100 per cent penetration of gasoline rickshaws is assumed for the base year (2011). Hybrid gasoline, hybrid CNG and electric rickshaws are not assumed as such technologies are expected only after 2030.

The energy intensity (four-stroke engines for ICE technology) for various technologies for auto rickshaws is given in Table An4F.13 below.

TABLE AN4F.13: ENERGY INTENSITIES OF AUTO RICKSHAW TECHNOLOGIES

Auto Rickshaw Technology	Energy Intensity (EI)	EI Units	EI Reference
Gasoline	0.024	litre/km	TERI, 2006*
Hybrid Gasoline	0.0083	litre/km	TERI, 2006*

Source: *TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

[19] Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". In *Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.
[20] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

The vehicle energy intensity is divided by the average occupancy of the vehicle category to arrive at the value of energy intensity in terms of passenger kilometre.

TWO-WHEELERS

Estimation of Passenger Volumes

Two-wheelers are preferred mode of travel for majority of Kerala's population. Based on historical data, total registered two-wheelers have grown from 100,169 in 2004 to 288,074 from in 2012 at a CAGR of 14.1 per cent. Regression of registered two-wheeler sales per capita income is found to be appropriate. Therefore, the following estimated regression equation is used to find out responsiveness of registered two-wheeler to per capita income.

Total Two wheeler = -146834×6.926×Per capita income
t-statistic (-3.217) (6.760)
p-values (0.02) (0.001)
$R^2 = 0.90$

The independent variable is found to be statistically significant as indicated by the t-values and p-values given within brackets. R^2 is 0.90 which indicates that 90 per cent of variation in two-wheeler sales is explained by per capita income. The regression equation is used to predict future total registered two wheelers up to 2030. The forecasted total registered two-wheelers are 1,114,463 in 2030.

Step 2: Assuming an average two-wheeler life of 8 years,[21] the on-road two-wheeler population was deemed by discarding the two-wheelers before 8 years. Based on the above methodology, the total number of on-road two-wheeler population is given in Table An4F.14 below.

TABLE AN4F.14: ESTIMATED ON-ROAD TWO-WHEELER POPULATION

Year	2015	2020	2025	2030
Two-Wheelers On-road	197,377	306,835	367,619	456,614

Step 3: Different studies estimate different annual mileage for motorcycles. LBNL[22] indicates average annual mileage of 6,300, while IEA[23] estimates 10,000km as annual mileage. In line with LBNL study, an annual average run of 6,300km is assumed without any increase.

Step 4: The estimated average occupancy of a two-wheeler also varies across studies (1.7 for IEA[24], 1.2 by Kapoor[25]). An average occupancy rate of 1.5 is assumed throughout the projection period.

Intermediate Output

Based on the above estimates, the passenger kilometre for two-wheelers is given in Table An4F.15 below.

---

[21] Ibid.
[22] Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". In *Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.
[23] IEA. 2004. *The Sustainable Mobility Project*. International Energy Agency. http://www.oecd.org/sd-roundtable/papersandpublications/39360485.pdf, accessed on 24 April 2015.
[24] Ibid.
[25] Kapoor, Mahesh. 2002. *Vision 2020: Transport*. Report prepared for the Planning Commission, New Delhi, India.

TABLE AN4F.15: ESTIMATED TWO-WHEELER PASSENGER TRAFFIC

Year	2015	2020	2025	2030
Two-Wheelers (million pkm)	1,865.2	2,449.6	3,474.0	4,315.0

Technology Assumptions

The technologies considered in two-wheelers are ICE petrol and EV. However, even within the ICE petrol category, there are two technologies: two-stroke ICE and four-stroke ICE. Presently, two-stroke ICE are no longer being manufactured and four-stroke engines being manufactured in a big way. The major advantages of a four-stroke ICE are comparatively high fuel efficiency and lower emissions. Considering the large difference between fuel economics of two-stroke and four-stroke engines, ICE gasoline is divided into ICE two-stroke and ICE four-stroke.

For the BAU scenario, ICE two-stroke share is taken as 10 per cent in the base year and ICE four-stroke is assumed to have a share of 90 per cent. However, it is assumed that two-stroke two-wheelers will be phased out by 2030. EV penetration is assumed to increase to 5 per cent of the total volume by 2030.

For assigning energy intensity value, motorcycles are taken as representative for the two-wheeler category. Table An4F.16 below shows the assumed energy intensity values for two-wheelers technologies.

TABLE AN4F.16: ENERGY INTENSITIES OF TWO-WHEELER TECHNOLOGIES

Two-Wheelers	Energy Intensity (EI)	EI Units	EI Reference
Petrol Two-Stroke	0.019	L/km	TERI, 2006*
Petrol Four-Stroke	0.012	L/km	TERI, 2006*
EV	0.06	MJ/km	IEA ESTAP, 2013†

Sources: *TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

† ESTAP. 2013. "Two and Three Wheeled Vehicles and Quadricycle –Technology Brief". Energy Technology Systems Analysis Programme, International, Energy Agency. 19 January.

The vehicle energy intensity is divided by the average occupancy of this vehicle category to arrive at the value of energy intensity in terms of passenger kilometre.

BUSES

The available data for buses are classified as contract carriages and stage carriages for the district. For capturing the difference in long-distance and short distances buses, it is assumed that 30 per cent of the total buses service long distance routes (with final destination as the only stop) and 70 per cent of the total buses will be used for short distances (with multiple stops).

Short-Distance Buses

- Estimation of Passenger Volumes

Step1: Based on the available data, the number of registered short-distance buses has increased from 3,651 in 2004 to about 8,060 in 2010, registering a CAGR of 14.1 per cent. The figure of on-road fleet availability (ratio of on-road vehicles to registered vehicles) estimated in the study by the Ministry of Road Transport and Highways was about 57 per cent.[26] The same percentage is used to derive the on-road short distance bus availability for the historical years. Regression of the number of on-road buses to population is found to be appropriate. Therefore, the following estimated regression equation is used to find out responsiveness of on-road buses to population.

On road short distance buses = -49005.9 + 0.019365×Population
t-statistic (-3.83) (4.131)
p-values (0.000) (0.000)
$R^2 = 0.71$

The independent variable and the intercept are found to be statistically significant as indicated by the t-values and p-values given within brackets. R2 is 0.71 which indicates that 71 per cent of variation in the number of buses is explained by the population. The regression equation is used to predict future expected number of registered buses up to 2030. The forecasted number of on-road buses is 7,619 in 2030.

Step 2: Based on stakeholder interaction and available literature on the state, it appears that buses are the primary mode of transport in Kerala and almost the entire state, including the remotest village, is served by buses. In that sense, it is assumed that no new routes are to be serviced in Kerala. This would indicate that increase or decrease in on-road bus population can only be on account of increasing population or increasing frequency on existing routes (which again is a function of population). Intuitively this means that the current on-road bus fleet size would largely remain constant except for some minor variations on account of population.

Intermediate Output

The results of the derivation are shown in Table An4F.17.

TABLE AN4F.17: NUMBER OF ESTIMATED ON-ROAD SHORT DISTANCE BUSES

Year	2015	2020	2025	2030
On-road Short Distance Bus	5,421	6,373	7,031	7,619

Step 3: The average annual utilization for stage carriages assumed in various studies on transport indicated a value between 40,000 km[27] and

[26] JPS Associates. 2011. *Study on Volume of Goods and Passenger Traffic on Indian Roads*. JPS Associates and Ministry of Road Transport and Highways (MoRTH), Government of India.
[27] Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". In *Saving Energy – Just Do It!*.In European Council for an Energy Efficient Economy – Summer Study.http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.

46,365km.[28] The values indicated in TERI's study,[29] which assumes a base average annual running of 40,000km in 1995 increasing by 400km every year. In line with TERI's estimate, a value of 46,400km annual average run was assumed for the base year (2011). However, no increase in the kilometre run of these buses over time was assumed as these buses serve fixed routes and it is assumed that there are no new routes to be introduced.

Step 4: In line with TERI's study,[30] the average passenger occupancy is assumed to be 50 throughout the projection period.

Intermediate Output

Based on the above estimates, the total passenger traffic of short-distance buses is given in Table An4F.18 below.

TABLE AN4F.18: ESTIMATED PASSENGER TRAFFIC FOR SHORT-DISTANCE BUSES

Year	2015	2020	2025	2030
Short Distance Buses (million pkm)	9,486.7	11,152.7	12,304.2	13,333.2

Technology Assumptions

For stage carriages diesel, CNG and full electric-based technologies have been considered. Diesel driven Internal Combustion Engine (ICE Diesel) is assumed to have a share of 100 per cent in the base year (2011). The energy intensity values have been mainly derived from existing studies and actual data provided by manufacturers. The following table indicates the values assumed for different technologies. The values assumed for energy intensity for various technologies for short-distance buses are given in Table An4F.19 below.

TABLE AN4F.19: ENERGY INTENSITIES OF TECHNOLOGIES FOR SHORT DISTANCE BUSES

Stage Carriages	Energy Intensity (EI)	EI Units	Reference
Diesel	0.215	L/km	TERI, 2006*
Electricity	1.2	kWh/km	BYD Company Limited†

Sources: *TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

† BYD. n.d. "Electric Bus Feature". BYD Company Limited. http://www.byd.com/ap/ebus.html#spec, accessed on 24 April 2015.

The vehicle energy intensity is divided by the average occupancy of this vehicle category to arrive at the value of energy intensity in terms of passenger kilometre.

Long-Distance Buses

Estimation of Passenger Volumes

Step1: Based on available data, the number of registered long-distance buses has grown from 1,565 in 2004 to about 3,454 in 2010, registering

[28] Bose, R. K. and Chary, V.S."Road Transport in India Cities: Energy Environment Implications". *Energy Exploration and Exploitation* 2(2):154-180.
[29] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.
[30] Ibid.

a CAGR of 14.1 per cent. The figure of on-road fleet availability (ratio of on-road vehicles to registered vehicles) estimated in All India Transport Study was about 57 per cent.[31] The same percentage is used to derive the on-road short distance bus availability for the historical years. Regression of on-road buses to population is found to be appropriate. Therefore, the following estimated regression equation is used to find out responsiveness of on-road buses to population.

Registered number of Long distance buses = -21002.5+0.0083×Population
t-statistic (-3.83) (4.131)
p-values (0.000) (0.000)
$R^2 = 0.71$

The independent variable and the intercept are found to be statistically significant as indicated by the t-values and p-values given within brackets. R^2 is 0.71 which indicates that 71 per cent of variation in registered number of contract carriages is explained by population. The regression equation is used to predict future registered number of contract carriages up to 2030. The forecasted number of registered contract carriages is 3,265 in 2030.

Intermediate Output

Based on the above assumptions, the total estimated on-road long distance buses is given in Table An4F.20 below.

TABLE AN4F.20: ESTIMATED NUMBER OF ON-ROAD LONG DISTANCE BUSES

Year	2015	2020	2025	2030
Long Distances Buses on road	2,323	2,731	3,013	3,265

Step 3: The average annual utilization for stage carriages assumed in various studies on transport indicated a value between 40,000 km[32] and 46,365km.[33] The values indicated in TERI's study,[34] which assumed a base average annual running of 40,000km in 1995 increasing by 400km every year. In line with TERI's estimate, a value of 46400km annual average run was assumed in 2011. However, considering that contract carriages travel long distance, an annual increase in travel distance by 400km is also assumed.

Step 4: In line with TERI's study,[35] the average passenger occupancy is assumed to be 50 throughout the projection period.

Intermediate Output

Based on the above assumptions, the total estimated passenger traffic by contract long-distance buses is given in Table An4F.21 below.

TABLE AN4F.21: ESTIMATED PASSENGER TRAFFIC VOLUME BY LONG-DISTANCE BUSES

Year	2015	2020	2025	2030
Long Distance Buses (billion pkm)	5,389.36	6,335.92	6,990.16	7,574.80

[31] JPS Associates. 2011. *Study on Volume of Goods and Passenger Traffic on Indian Roads*. JPS Associates and Ministry of Road Transport and Highways (MoRTH), Government of India.
[32] Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". In *Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.
[33] Bose, R. K. and Chary, V.S."Road Transport in India Cities: Energy Environment Implications". *Energy Exploration and Exploitation* 2(2):154-180.
[34] TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.
[35] Ibid.

Technology Assumptions

For contract carriages diesel and CNG technologies are considered. No electric versions are considered because they are not presently amenable to long-distance travel. Diesel driven Internal Combustion Engine (ICE Diesel) is assumed to have a share of 100 per cent in the base year (2011).

Table An4F.22 shows the assumed energy intensities of technologies for long-distance buses.

TABLE AN4F.22: ENERGY INTENSITIES OF TECHNOLOGIES FOR LONG-DISTANCE BUSES

Contract Carriages	Energy Intensity (EI)	EI Units	EI Reference
Diesel	0.215	litre/km	TERI, 2006*

Source: *TERI. 2006. National Energy Map for India: Technology Vision 2030, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.

The vehicle energy intensity is divided by the average occupancy of the vehicle category to arrive at the value of energy intensity in terms of passenger kilometre.

For the BAU scenario, a 5 per cent reduction in the energy intensity of diesel is assumed over the entire projection period.

Estimation of Freight Volumes (HCV and LCV)

Step 1: Based on available data, the categorization of goods vehicles is done in terms of two categories: ‘three-wheelers including tempos’ and ‘four-wheelers and above’. For the purpose of the analysis, the three-wheeler and tempo category is considered as LCV and the four-wheeler and above category is assumed as HCV. The total registered number of HCV’s has increased from 11,577 in 2004 to 22,100 in 2012, registering a CAGR of 8.42 per cent. The total registered number of LCV’s has changed from 2,628 in 2004 to 7,536 in 2012, registering a CAGR of 14.1 per cent.

The future population of registered goods vehicle is estimated using the available data. Regression is done with respect to the registered vehicle population and GDDP of agriculture and industry (GDDP A&I).

Regression of registered number of HCVs on GDDP A&I is found to be appropriate. Therefore, the following estimated regression equation is used to find out responsiveness of registered number of HCVs to GSDP from agriculture and industry.

Registered number of HCVs= -10971.9 + 0.0872×GDDP A&I
t-statistic (-5.51) (14.232)
p-values (0.000) (0.000)
$R^2 = 0.97$

The independent variable and the intercept are found to be statistically significant as indicated by the t-values and p-values given within brackets. R^2 is 0.97 which indicates that 97 per cent of variation in registered number of HCVs is explained by GDDP A&I. The regression equation is used to predict future registered number of HCVs up to 2030. The forecasted number of registered HCV's is found to be 70,865 in 2030.

Regression of registered number of LCVs on GDDP A&I is found to be appropriate. Therefore, the following estimated regression equation is used to find out responsiveness of registered number of LCVs to GDDP.

Registered number of LCVs = -8202.31+0.0406×GDDP A&I
t-statistic (-16.69) (26.87)
p-values (0.000) (0.000)
R^2 = 0.99

The independent variable and the intercept are found to be statistically significant as indicated by the t-values and p-values given within brackets. R^2 is 0.99 which indicates that 99 per cent of variations in registered number of LCVs are explained by GDDP from agriculture and industry. The regression equation is used to predict future registered number of LCVs up to 2030. The forecasted number of registered LCVs is found to be 31,624 in 2030.

Step 2: Assuming 10 years of retirement for HCVs, the total in-use vehicles are arrived at by discarding vehicles more than 10 years old. For LCVs, a useful life of 10 years is assumed and a similar process is executed to arrive at the number of in-use LCVs. Table An4F.23 shows the estimated on-road population of HCVs and LCVs.

TABLE AN4F.23: ESTIMATED ON-ROAD HCVS AND LCVS

Vehicle Type	2015	2020	2025	2030
HCVs	12,907	15,456	21,871	27,697
LCVs	5,663	7,143	10,191	12,906

Step 3: Based on TERI's study,[36] the average annual utilization of HCVs remain constant throughout the projection period. For LCVs, the average annual kilometre run data is taken as 27,000km with no increase in route kilometre. This is done because, LCVs mostly ferry consumer goods and agricultural products on fixed routes (usually from bulk markets to end retailers).

Step 4: Based on assessment in TERI's study,[37] an average tonnage of 7.1 tonnes and 1.7 tonnes is assumed for HCV and LCV category, respectively. In line with the study, an increase of 0.1 tonnes carrying capacity per year is assumed for HCVs up to 2030.

Intermediate Output

Based on the above analysis the existing and estimated freight traffic is given in Table An4F.24 below.

[36] Ibid.
[37] Ibid.

TABLE AN4F.24: ESTIMATED FREIGHT TRAFFIC FOR HCVS AND LCVS

Vehicle Type	2015	2020	2025	2030
HCVs (million tkm)	4,252.1	5,091.8	7,205.2	9,124.5
Three Ws and LCVs (million tkm)	259.9	327.9	467.8	592.4
Total Freight (million tkm)	**4,512.0**	**5,419.7**	**7,672.9**	**9,716.9**

Technology Assumptions

The technologies considered in HCVs are ICE Diesel. EVs are not considered because HCVs usually have high mileage, which may need recurrent refuelling of EV technologies that limit the run range per charge.

For the BAU scenario, ICE Diesel is expected to have a share of 100 per cent in base year (2011) and throughout the projection period.

Based on the information, the assumed energy intensities of HCV technologies are as shown in Table An4F.25 below.

TABLE AN4F.25: ENERGY INTENSITIES OF TECHNOLOGIES FOR HCVS

HCVs	Energy Intensity (EI)	EI Units	EI Reference
Diesel	0.2	L/km	LBNL, 2009*

Source: *Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". In *Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.

The vehicle energy intensity is divided by the average tonnage capacity of the vehicle category to arrive at the value of energy intensity in terms of tonnes kilometre.

A 5 per cent reduction in energy intensity of ICE Diesel and 5 per cent for hybrid diesel is assumed over the projection period for HCVs.

The technologies considered for LCVs are ICE Diesel and EV. EVs are considered for LCVs because of the comparatively low running of LCVs.

For the BAU scenario, 100 per cent penetration of ICE diesel is assumed in the base year (2011). EV penetration is assumed to increase from 2 per cent in 2025 to about 5 per cent in 2030.

The energy intensity of ICE diesel is assumed to be 0.117 lit/km. In line with the assumption for HCVs. For EV, the energy intensity data is taken from a study by CARB.[38] Table An4F.26 shows the value of energy intensity considered for different technologies

TABLE AN4F.26: ENERGY INTENSITIES OF TECHNOLOGIES FOR LCVS

LCVs	Energy Intensity (EI)	EI Units	EI Reference
Diesel	0.117	L/km	LBNL, 2009*
EV	1.762	MJ/km	LBNL, 2009*

Source: *Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". *In Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.

[38] Aguirre, Kimberly et al. 2012. *Lifecycle Analysis Comparison of a Battery Electric Vehicle and a Conventional Gasoline Vehicle*.California Air Resources Board, California, USA.http://www.environment.ucla.edu/media/files/BatteryElectricVehicleLCA2012-rh-ptd.pdf, accessed on 24 April 2015.

The vehicle energy intensity is divided by the average tonnage capacity of the vehicle category to arrive at the value of energy intensity in terms of tonnes kilometre.

A 5 per cent reduction in energy intensity of ICE Diesel and EV technologies is assumed over the projection period.

RAIL

Estimation of Passenger Volumes

There are two major railways stations in Palakkad: Palakkad Junction is a broad gauge railway station, located at Olavakkode and Shornur, the biggest railway junction in Kerala. Railways jurisdiction over Palakkad district are, Walayar to Parashannur (95.75km), Shornur to Kulukkallur (15.0km), Palakkad to Palakkad Town (4.09km), and Palakkad Town to Muthamalada (31.63km, metre gauge being converted to broad gauge). Palakkad has total of 146.47km railway route length. Whereas, Kerala has total of 1,257km railway route length as compared to all India route length of about 64,600km. This translates into a share of 11.65 per cent of Kerala's railway route km and 0.2 per cent of India's railway route km. As the passenger volume data is unavailable on the basis of district, passenger volume calculated in *The Energy Report – Kerala*[39] was used as the basis for arriving at the passenger volumes in Palakkad.

In 2011 the rail passenger volume was calculated to be 19.59 billion pkm in Kerala. Considering a share of 11.65 per cent in Palakkad, the base value was estimated to be 2.28 billion pkm

Intermediate Output

As per estimations in *The Energy Report – Kerala*, the rail passenger (in billion pkm) is 20.77, 22.36, 22.40 and 22.51 in 2015, 2020, 2025 and 2030 respectively. The forecasted billion passenger volume is 2.62 billion pkm in 2030.

Based on the above analysis the estimated rail passenger volume is shown in Table An4F.27 below.

TABLE AN4F.27: ESTIMATED RAIL PASSENGER TRAFFIC

Year	2015	2020	2025	2030
Rail Passenger (million pkm)	2,424.4	2,604.9	2,613.7	2,622.4

Estimate of Freight volumes

As the freight volume data is unavailable on district basis, passenger volume calculated in *The Energy Report – Kerala*[40] was used as the basis for arriving at the passenger volumes in Palakkad. A comparative analysis is done between Palakkad's railway route length of 146.47km with that of Kerala and India, as in the earlier estimation of passenger volume.

[39] WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India. 254pp.
[40] Ibid.

In 2011 the rail freight volume was calculated to be 8.76 billion tkm in Kerala.

Intermediate Output:

The same estimates as calculated in *The Energy Report – Kerala*[41] are used to calculate the future freight volume. The forecasted freight volume is 3,688.9 million pkm in 2030 for Palakkad.

Based on the above analysis the estimated rail freight traffic is shown in Table An4F.28 below.

TABLE AN4F.28: ESTIMATED RAIL PASSENGER TRAFFIC

Year	2015	2020	2025	2030
Rail Passenger (million pkm)	1,337.0	1,875.2	2,630.1	3,688.9

Technology Assumptions

It is assumed that Palakkad district has100 per cent electrified rail network.

LBNL study on transport has been referred to assess the energy intensity potential of the two technologies.[42]

Based on the information, the assumed energy intensities are as shown in Table An4F.29 below.

TABLE AN4F.29: ENERGY INTENSITIES OF RAIL MODES

Rail Passenger	Energy Intensity (EI)	EI Units	EI Reference
Electric Traction	0.12	MJ/pkm	LBNL, 2009*

Source: *Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". *In Saving Energy – Just Do It!*. In European

http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.

No decrease in energy intensity is assumed for railway over the projection period for the BAU scenario.

[41] Ibid.
[42] Zhou,Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". *In Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.

ANNEXURE 5A
ENERGY REDUCTION POTENTIAL - DOMESTIC SECTOR

Annexure 5A covers the detailed explanation on energy reduction potential across each appliance in the domestic category.

APPLIANCE ENERGY INTENSITY EVOLUTION STUDY

The study conducted in 2010 indicates that consumers chose to purchase appliances having more than 3-star rating. Considering this consciousness in consumers, it can be expected that consumers may be ready to switch to even more efficient appliances once it is made available in the market. Considering this, it is assumed that a move to super-efficient appliances can be a very successful approach in Palakkad to curb the overall energy intensity of appliances. To factor in the energy efficiency and conservation potential in the domestic sector, a comparative study of each appliance is undertaken.

Lighting

On an average home lighting consumes 25 per cent of the total electricity consumption in a household. For the purposes of illumination switching from conventional incandescent lamps to compact fluorescent lamps (CFL's) or light emitting diodes (LED) bulbs can save enormous amount of energy. Choosing the new technologies to illuminate households can reduce energy use in the house by 50 to 75 per cent.

A CFL uses only one-fifth as much electricity as an incandescent lamp to provide the same level of illumination. A 15W and 20W CFL can replace a 60W and 100 W incandescent bulbs respectively. The 'Bachat Lamp Yojana' aims at large-scale replacement of incandescent bulbs in households by CFLs. Under this scheme, the Bureau of Energy Efficiency (BEE) is coordinating voluntary efforts to provide high quality CFLs to domestic consumers for about Rs. 15 per lamp, at a rate comparable to that of incandescent bulbs. LEDs do not have filament that is heated to create light. These are illuminated by the movement of electrons in a semi-conductor material (diode). Since electricity is directly turned into light, LEDs waste less energy as heat. Energy consumption is lower than CFLs that use mercury vapour to produce light. LEDs have taken over CFLs promoted as the most advanced lighting device, in energy efficiency. A 5W LED can replace a 15W CFL. LEDs score over incandescent bulbs and CFLs in life span as well. An LED bulb lasts three to five years; an average CFL bulb lasts about 250 days and an incandescent bulb, 41 days. Long life makes it a fit-and-forget fixture, saving cost of maintenance and replacement. The biggest challenge LED bulbs faces today is high cost. It is 80 times as expensive as an incandescent bulb and 10 times a CFL bulb. At present, there is no subsidy for LEDs. The LED industry pays 28 per cent import duty and

12 per cent VAT. The manufacturers are looking to the government for subsidies to promote LEDs.[1]

Considering all these facts, it is assumed that a reduction potential of 30 per cent can be achieved by CFL's and a 50 per cent reduction potential can be achieved by LED bulbs. Further it is assumed that, through proper policy push there will be a 100 per cent penetration of CFL/LED light by 2030.

Fans

Fans are mostly ignored in most households, but this appliance has the potential to consume more energy, more than that of lights. Fans runs for an average of 12 hours in most households and in a district like Palakkad, it can be expected that fans are required all the year round. A conventional type ceiling fan consumes around 75W of electricity. Few years back BEE started rating ceiling fans with star labels. A typically 5-star labelled ceiling fan consumes around 55W. This shows a 30 per cent energy saving potential.

BEE has also started its Super-Efficient Equipment Program (SEEP) and intends to initiate the programme with ceiling fans and has already completed the techno-economic feasibility analysis on improving the energy efficiency performance of ceiling fans.[2] Table An5A.1 below indicates the energy intensity comparison between 5-star rated fans and super-efficient fans

TABLE AN5A.1: ENERGY INTENSITY COMPARISON BETWEEN 5-STAR RATED FANS AND SUPER-EFFICIENT FANS[3]

Appliance	Unit	5 star	SEA	Percentage decrease in UEC
Ceiling Fan	W	51	35	32

The Energy Management Centre, Kerala conducted a comparative study to evaluate the energy saving opportunities in a ceiling fan by using both electronic as well as conventional (resistance type) regulators. This study proved that power consumption is reduced by 61 per cent at the minimum speed while using an electronic type regulator. At the same time, the power consumption is reduced by 43 per cent under similar conditions with a conventional (resistance type) regulator. An average saving of 27 per cent can be achieved under reduced speed, if the fan is used along with an electronic type regulator against a conventional type regulator. Though the initial cost of an electronic regulator is high, the higher savings will pay back the investor in less than 10 months.[4]

Considering all these facts, it is assumed that an average reduction potential of 35 per cent can be achieved by 5-star labelled fans and a 50 per cent reduction by super-efficient fans. Further it is assumed that, through proper policy push there will be 100 per cent penetration of star-labelled/super-efficient fans by 2030.

Television

Televisions draw the most power among the entertainment appliances used in households. Old CRT type televisions are the most non-efficient

[1] CSE.n.d. "Lighting". Centre for Science and Environment. http://cseindia.org/content/lighting, accessed on 24 April 2015.
[2] IPEEC. 2014. "Can India Save Energy with Super-Efficient Fans?".International Partnership for Energy Efficiency Cooperation. 7 April. http://www.ipeec.org/blog/view/id/796.html, accessed on 27 April 2015.
[3] Chunekar, Aditya, Kadav, Kiran, Singh, Daljit and Girish Sant.. 2011. *Potential Savings from Selected Super-Efficient Electric Appliances in India: A Discussion Paper*. Prayas Energy Group, Pune, India.
[4] EMC. 2007. *Reduce Speed of Your Ceiling Fan Save Energy up to 60% - Technical Fact Sheet/ Ceiling Fan-Speed Control*. Energy Management Centre, Kerala. http://www.keralaenergy.gov.in/pdf/fan%20regulator.pdf, accessed on 27 April 2015.

TV category. Therefore, for considerable energy saving it is necessary that CRT televisions should be scrapped and consumers must switch over to using efficient technologies like LCD, LED and OLED. But even for this, larger the TV size, the more power consumed. A 60" LCD TV would consume at least four times energy than a 22" LCD TV. Choosing a smaller TV generally means choosing a more efficient TV. Nowadays even HD (high definition) ready TV's are available and cable TV operators are facilitating HD quality reception. These provide a good viewing experience, but consume very high amount of energy. HD TVs have more pixels per square inch of screen area and therefore tends to consume more energy than SD (standard density) TV.

Table An.2 below indicates the energy intensity comparison of 5-star rated televisions and super-efficient televisions.

TABLE AN5A.2: ENERGY INTENSITY COMPARISON OF 5-STAR RATED TELEVISIONS AND SUPER-EFFICIENT TELEVISIONS[5]

Appliance	Unit	5 star	SEA	Percentage Decrease UEC
Television	W	62	36	41

Most modern TVs go to a standby mode while the power button is used. This may tend to consume 1W of electricity. This energy can be saved by switching off the TV completely from the main switch when not in use.

Considering all these facts, it is assumed that a reduction potential of 41 per cent can be achieved. Further it is assumed that, through proper policy push there will be a 60 per cent penetration of super-efficient TVs by 2030.

Refrigerator

It is very important to choose the right size of refrigerator according to the storing and cooling needs. If the refrigerator is too small, you may be overworking it, resulting in reduction of efficiency. And, if the refrigerator is oversized, it may lead to unnecessary power consumption. Before buying a refrigerator, it is important to check the star rating of the appliance. Based on the study by BEE study[6] and the study by Prayas on SEA's,[7] the table below compares the energy consumption of 5-star labelled standard 260 litre refrigerator and super-efficient refrigerators.

TABLE AN5A.3: ENERGY INTENSITY COMPARISON OF 5-STAR RATED REFRIGERATOR AND SUPER-EFFICIENT REFRIGERATOR[8]

Appliance	Unit	5 star	SEA	Percentage decrease UEC
Refrigerator	kWh/Y	411	128	69

Considering this, it is assumed that a reduction potential of 69 per cent can be achieved, by adopting super-efficient frost free refrigerators. Further it is assumed that, through proper policy push there will be a 60 per cent penetration of super-efficient refrigerators by 2030.

Air Conditioners

Room air conditioners available in the market generally have cooling capacities that range from 0.7 to 2 tons. The required cooling capacity for a room air conditioner mainly depends on the size of the room being

[5] Chunekar, Aditya, Kadav, Kiran, Singh, Daljit and Girish Sant. 2011. *Potential Savings from Selected Super-Efficient Electric Appliances in India: A Discussion Paper*. Prayas Energy Group, Pune, India.
[6] BEE. 2010. "Energy Efficiency Guide - Buying and Maintaining an Energy-Efficient Home Refrigerator". Bureau of Energy Efficiency. New Delhi, India. http://www.beeindia.in/schemes/documents/ecbc/eco3/SnL/Guide%20on%20Energy-Efficient%20Home%20Refrigerator.pdf, accessed on 27 April 2015.
[7] Chunekar, Aditya, Kadav, Kiran, Singh, Daljit and Girish Sant. 2011. *Potential Savings from Selected Super-Efficient Electric Appliances in India: A Discussion Paper*. Prayas Energy Group, Pune, India.
[8] Chunekar, Aditya, Kadav, Kiran, Singh, Daljit and Girish Sant. 2011. *Potential Savings from Selected Super-Efficient Electric Appliances in India: A Discussion Paper*. Prayas Energy Group, Pune, India.

cooled, apart from several other factors. An air conditioner that is too small may not do a good job of cooling a room at the desired temperature range. An oversized unit costs more and may cool the room quickly but it may lead to poor humidity removal due to excessive on-off cycling. Table An5A.4 below indicates the energy efficiency ratio of 5-star rated air conditioners and super-efficient air conditioners.

TABLE AN5A.4: ENERGY INTENSITY COMPARISON OF 5-STAR RATED AIR CONDITIONERS AND SUPER-EFFICIENT AIR CONDITIONERS

Appliance	Unit	5 star	SEA	Percentage decrease UEC
Air Conditioner	EER	3.1	4.86	36

For each temperature above 22°C, air conditioners can save 3-5 per cent of electricity.[9] Therefore, the optimum temperature for operating an air conditioner is 25/26°C to save maximum power consumption. Considering all these facts, it is assumed that a reduction potential of 36 per cent can be achieved, by adopting super-efficient air conditioners. Further it is assumed that, through proper policy push there will be a 60 per cent penetration of these air conditioners by 2030.

Other Appliances

For all other appliances, a reduction potential of 30 per cent is considered, assuming a penetration level of 60 per cent by 2050.

[9] BEE. 2010. “Energy Efficiency Guide - Buying and Maintaining an Energy-Efficient Room Air Conditioner”. Bureau of Energy Efficiency. New Delhi, India. http://www.beeindia.in/schemes/documents/ecbc/eco3/SnL/Guide%20on%20Energy-Efficient%20Room%20Air%20Conditioner.pdf, accessed on 27 April 2015.

ANNEXURE 5B
ENERGY REDUCTION POTENTIAL - INDUSTRY SECTOR

Annexure 5B covers the detailed assessment of the base energy conservation potential across the industry sub-sectors

INDUSTRIAL SECTOR ENERGY DEMAND CURTAILMENT

The reduction potential targets indicated in this assessment can mainly be achieved through passive interventions by reducing waste energy, energy recovery, equipment level efficiency improvement (efficient lighting, efficient motors), and limited process intervention. Major process improvements, which are capital intensive, have not been considered in this assessment. The following narrative tries to identify the saving potential of the identified sectors.

Agro and Food Processing

The agro-food industry comprises an integrated complex production chain which ranges from the agriculture processing to the mature food and beverage sector. Energy is the absolute prerequisite for the processes required for food freshness and safety. Thermal processing and dehydration are the most commonly used techniques for food preservation, and require significant amount of energy. Process heating uses approximately 29 per cent of total energy in the food industry, while process cooling and refrigeration demands about consume about 16 per cent of total energy inputs.[1]

As per the studies carried out in similar type of industries in the cluster units, it is estimated that about 30 per cent of total power consumption of a rice mill can be reduced by proper motor maintenance and operation. The replacement of iron and MS buckets with plastic buckets for elevators will reduce the power consumption by 10 per cent. It is recommended to install voltage stabilizer for constant and optimum voltage supply. By optimizing voltage supply, the power consumption of the rice milling equipment reduces by 10 to 15 per cent of the total power consumption.[2]

The main industries involved in agro and food processing are agro malls, dairies, fruit and vegetables processing, spice processing, fish drying and others. Considering the huge diversity in industry products, processes and unit sizes, several case studies were analysed in addition to a documented report of the Energy Management Centre, Kerala that identified the savings potential in this sector.

One case study from MSME's newsletter[3] is a study of rice mill clusters in Kadali. The study indicated a saving potential of 15 per cent

---

[1] ClimateTechWiki.n.d. "Energy Efficiency and Saving in the Agro-food Industry". http://www.climatetechwiki.org/technology/energy-saving-agri-food-industry, accessed on 24 April 2015.
[2] BEE.n.d. *Manual on Energy Conservation Measures in Textile Cluster Solapur*. Bureau of Energy Efficiency, Ministry of Power, Government of India. http://sameeeksha.org/pdf/clusterprofile/Solapur_Textile_Industries.pdf, accessed on 17 May 2015.
[3] Winrock. 2010. "Energy Efficiency Potential and Way Forward in Kerala". *MSME Energy Saving Project.Issue 4 (July-September)*. Winrock International India. http://www.inspirenetwork.org/pdf/4.Jul-Sep10.pdf, accessed on 17 May 2015.

simply through better operational practices like reducing excess air in combustion boiler, hot water recovery, use of variable frequency motor drive, load side power factor management etc.

The other study on sea food processing cluster in Aroor indicated an energy saving potential of 20 per cent in heat use by passive initiative like use of air curtains, optimization of freezer temperature, better insulation, use of variable frequency motor drive, etc. On the other hand, the energy saving potential identified by the Energy Management Centre, Kerala indicated a saving potential of 20 per cent in electricity in the agricultural sector.[4]

Considering all the above studies, an energy reduction target of 15 per cent in electricity and 10 per cent in heat demand starting 2020 was assigned for this sector.

Textile

Textile industry in Palakkad mainly include cotton/textiles knitted hosiery, fabrication, garments, cotton yarn, printing yarn, bleaching, dyeing clothes, blended yarn, mostly under the MSME sector. The main process in a typical textile industry include doubling yarn, reeling, dyeing, drying, winding, warping, looms, stitching and packing; dyeing being the most energy intensive process requires both electrical and thermal energy. Energy cost is around 8 to 10 percent of the manufacturing cost in typical manufacturing unit, out of which the cost of thermal energy works out to 42 per cent of the total energy cost and remaining accounts for electrical energy.[5]

The study findings show that by efficient use of boilers in the textile industries, thermal energy, mainly from wood can be decreased by 40 per cent. Another study by BEE (DPR on installing VFD in textile industries),[6] shows that by installing VFD on doubling yarns, which are usually connected to constant spin drives, can save electricity up to 12 per cent. Another study which focused on the implementation of solar water heating in traditional textile industry can replace wood or other fuel completely used for conventional boiler/chulhas, whose efficiency on an average is only 6.5 per cent.

Based on the TERI study[7] findings, by the use of new spinning technologies like friction spinning/air jet spinning, high speed drying machines, and use of solar process heating technologies for water heating, the textile industry have the potential to reduce electricity demand by 10 per cent and heat demand by 11 per cent. However the potential estimated for energy conservation, as estimated by EMC for large textile units, is 25 per cent in electricity use. Considering all these measures a 2021 target of an average of 22 per cent savings potential in electricity and 11 per cent in heat demand are assigned.

---

[4] IREDA and CII.n.d.*Investors Manual for Energy Efficiency*. Indian Renewable Energy Development Agency and Confederation of Indian Industry.http://www.ireda.gov.in/writereaddata/IREDA-InvestorManual.pdf, accessed on 17 May 2015.
[5] BEE. 2010. *Detailed Energy Project on Energy Efficient Boiler (200 kg/hr) (Solapur Textile Cluster)*. Bureau of Energy Efficiency, Ministry of Power, Government of India.http://www.dcmsme.gov.in/reports/solapurtextile/03EnergyEfficientBoiler200Kg.pdf, accessed on 17 May 2015.
[6] BEE. 2010. *Detailed Project Report on Variable Frequency Drives for FD & ID Fan (Solapur Textile Cluster)*. Bureau of Energy Efficiency, Ministry of Power, Government of India.http://www.dcmsme.gov.in/reports/solapurtextile/15VariablefrequencyDriveinFDFan.pdf, accessed on 17 May 2015.
[7] TERI. 2006. *National Energy Map of India: Technology Vision 2030*. Office of the Principal Scientific Advisor to the Government of India, The Energy and Resource Institute. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 17 May 2015.

Paper and Pulp

Palakkad has very few paper and pulp industries, including few mini paper plants, straw board plants, paperboards, multi-layer paper etc. Pulp and paper is an energy-intensive industry. Pulp and paper production is highly energy intensive with 75 to 85 per cent of the energy requirement being used as process heat and 15 to 25 per cent as electrical power. Papermaking process can be broadly divided into three stages; wood preparation, pulping, bleaching, chemical recovery, paper making and finishing. Most of the energy is used in the form of heat within the pulping process (digester, evaporator and washing) when raw materials have to be cooked and mechanically or chemically treated for further use in the production chain.[8]

There is a lot of scope of energy intensity improvements in the sector. Comparing Indian energy consumption to international energy consumption showed a big gap. Though, due to India's distinct structure which is highly based on agro-based small paper mills, the best achievable energy consumption for India cannot be set equal to international standards. The best achievable energy consumption differs by process type and technology. Energy savings of up to 60 per cent could be achieved.[9]

A study by Petroleum Conservation Research Association (PCRA)[10] indicates an energy saving potential of 20 per cent in these industries, by introducing different technologies for energy conservation. PCRA has indicated this value based on various energy conservation studies and feedback from industries.

Some of the energy efficiency measures that can be taken in paper and pulp industry include design mill electrification to optimize energy use, design optimized pulp electrification system, improve efficiency of motors, install VFD's to constant drives, understand how and where you use energy, and provide energy use decision support.

Based on a study by BEE the paper and pulp based industry clusters,[11] by controlling the excess air in the boiler for pulp making, could save up to 12 per cent fuel. Considering the above studies, a reduction target of 20 per cent in electricity and 12 per cent in heat starting 2020 is assigned to the sector

Petrochemicals

Considering the complexity of petrochemicals manufacturing, it is very difficult to apply best available technology (BAT) or best practice technology (BPT) analysis to the petrochemicals industry. Literature review of energy efficiency sectors (IEA and TERI) has also not covered this sector in details. However, the energy saving potential estimated by the Energy Management Centre, Kerala for this sector was 10 per cent in electricity demand. A study by International Energy Agency indicates

---

[8] Schumacher, Katja and Sathaye, Jayant. 1999. *India's Pulp and Paper Industry: Productivity and Energy Efficiency*. Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory. http://www.yieldopedia.com/paneladmin/reports/07dc15673834d4ced6b89a854c4b2980.pdf, accessed on 17 May 2015.
[9] Ibid.
[10] PCRA. 2009. "Chapter 11. Paper and Pulp".*In Practical Guide to energy Conservation*. Petroleum Conservation Research Association. New Delhi, India. pp. 345-67.
[11] BEE.n.d.*Manual on Energy Conservation Measures in Paper Cluster, Muzaffarnagar*. Bureau of Energy Efficiency, Ministry of Power, Government of India. http://sameeeksha.org/pdf/dpr/Muzaffarnagar_Paper.pdf, accessed on 17 May 2015.

that by introducing BPT in the petrochemical industries can reduce energy consumption by 5 to 15 per cent depending on the different processes in a particular industry.[12] In line with EMC's estimation, a 2021 energy conservation target of 10 per cent electricity is assigned for this sector.

Chemicals

The chemicals sector is represented by industry chemicals (caustic soda, organic chemicals), fertilizers etc. The technology mainly used in caustic soda manufacturing process is membrane cell technology which uses a semi-permeable membrane to separate the anode and cathode compartments with porous chemically active plastic sheets that allow migration of sodium ions where they react with de-mineralized water to produce caustic soda and hydrogen gas. Almost 90 per cent of the total electricity used is utilized in the electrolytic cells. According to TERI's[13] study, the main technology options for caustic soda manufacturing are a move from existing technology to Oxygen Depolarized Cathodes (ODC) technology. The study assumes increasing penetration of ODC technology in India with an energy intensity reduction potential of 17 per cent in electricity for about 9 per cent increase in heat requirements. Based on the above studies and estimates, a 2021 target of 17 per cent reduction target in electricity consumption is assigned.

Rubber

The rubber industries in Palakkad include tire, latex, conveyors and crumb rubber manufacturers. The main raw materials for tire industry include rubber bales, chemicals, textiles and steel. The process begins with the mixing of basic rubbers with chemicals, carbon black, antioxidants, and other additives. These ingredients are mixed in giant blenders operating under high heat and pressure to produce a homogenized batch of black material which is the raw material for the processing and machining phase, which also uses substantial energy.

Conveyor belt manufacturing also includes a similar process. The raw rubber batches are then usually processed into cover sheets either in a calendar for textile conveyor belts or in an extruder for steel cord conveyor belts. After confectioning the rubber sheets with the tensile member, the entire matrix is cured in a press, initializing the vulcanization.

Latex is usually manufactured using either 'Talalay' or 'Dunlop' Process. The Talalay process can give softer finish and is used for manufacturing medical products and contraceptives. Both the processes can use natural rubber, synthetic rubber or a mix of both. In the Talalay process, liquid latex formulation is poured into a mould, sealed closed in a vacuum and is flash frozen. The frozen latex is flash-heated to "gel" into a permanent solid form and is allowed to cool before being removed from the mould. The latex mould is then used as a raw feed for a variety of end products.

Crumb Rubber is a high quality product and usually uses latex as feed material. Production of block rubber from field latex or field coagulum

---

[12] IEA. 2009. *Chemical and Petrochemical Sector: Potential of Best Practice Technology and Other Measures for Improving Energy Efficiency*. IEA Information Paper.International Energy Agency. https://www.iea.org/publications/freepublications/publication/chemical_petrochemical_sector.pdf, accessed on 17 May 2015.

[13] TERI. 2006. National Energy Map of India: Technology Vision 2030. Office of the Principal Scientific Advisor to the Government of India, The Energy and Resource Institute. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 17 May 2015.

grade involves unit operation such as pre-cleaning, blending, washing, final size reduction, coagulation, dripping, drying, baling as 25kg blocks, packing, testing and grading.

To assess the potential for energy conservation in this sector, a case study of MSME Newsletter[14] was referred, which estimated that the energy saving potential of crumb rubber manufacturing cluster in Kottayam was 15 per cent in heat and 10 per cent in electricity use mainly through optimizing grinding media ratios, optimizing humidity control, heat (and waste heat) recovery from dryers, better water management etc.

In addition, based on EMC Kerala's assessment,[15] the energy saving potential in the rubber industry was identified to be 15 per cent in electricity. On the basis of the two assessments, a 2021 target of 15 per cent reduction in heat and electricity is assigned to this sector.

Minerals and Materials

The minerals and materials sector is mainly represented by cement, abrasives, clay and other construction materials. The main process used in the cement industry is dry process, which can be further categorized into three main categories: (a) 4-stage pre-heater pre-calcinator, (b) 5-stage preheater pre-calcinator, and (c) 6-stage pre-heater, twin stream, pre-calcinator, pyrostep cooler.[16] The energy efficiency options for the cement industry are conversion of 4- and 5- stage cement plants to modern 6-stage plants and moving towards producing a higher share of blended cement in the total cement production to reduce clinker cement ratio (clinker production is the most energy-intensive process in the manufacturing of cement accounting for almost 80 per cent of total energy use). According to the study by TERI,[17] the potential reduction in energy intensity in moving from a 4-stage process to a 6-stage process is about 16 per cent in heat and 35 per cent in electricity.

However, IEA's 2011 report on Indian industry,[18] suggests that there may be very little potential for energy saving in the Indian cement industry; to the tune of about 18 per cent, mostly in heat requirement as the specific electricity consumption of Indian cement industry is among the lowest in the world. On the other hand, the estimates by EMC Kerala[19] project an energy saving potential of 15 per cent in electricity consumption for the cement industry.

In line with other studies, cement industry is considered as a marker for this category. Based on above assessments, a target of 15 per cent energy reduction in both electricity and heat by 2021 is assigned.

---

[14] Winrock. 2010. "Energy Efficiency Potential and Way Forward in Kerala". MSME Energy Saving Project. Issue 4 (July-September). Winrock International India. http://www.inspirenetwork.org/pdf/4.Jul-Sep10.pdf, accessed on 17 May 2015.
[15] Limaye, Dilip R., Natarajan, Bhaskar, Kumar, B. Anil, Lal, Swati and Pradeep Tharakan. 2009. *Kerala State Energy Conservation Fund (KSECF): Financing Schemes*. USAID Asiaand EMC, Kerala. http://www.keralaenergy.gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20CONSERVATION%20FUND%20%28KSECF%29%20FINANCING%20SCHEMES.pdf, accessed on 17 May 2015.
[16] TERI. 2006. *National Energy Map of India: Technology Vision 2030*. Office of the Principal Scientific Advisor to the Government of India, The Energy and Resource Institute. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 17 May 2015.
[17] Ibid.
[18] Trudeau, Nathalie, Tam, Cecilia, Graczyk, Dagmar and Peter Taylor. 2011. *Energy Transition for Industry: India and the Global Context*. International Energy Agency. Paris, France. https://www.iea.org/publications/freepublications/publication/india_industry_transition_28feb11.pdf, accessed on 17 May 2015.
[19] Limaye, Dilip R., Natarajan, Bhaskar, Kumar, B. Anil, Lal, Swati and Pradeep Tharakan. 2009. *Kerala State Energy Conservation Fund (KSECF): Financing Schemes*. USAID Asia and EMC, Kerala. http://www.keralaenergy.gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20CONSERVATION%20FUND%20%28KSECF%29%20FINANCING%20SCHEMES.pdf, accessed on 17 May 2015.

Metals and Alloys

The main industries in this sector are castings and forgings, metal processing, etc. Indian foundry industry is very energy intensive. The energy input to the furnaces and the cost of energy play an important role in determining the cost of production of castings. Major energy consumption in medium and large-scale foundry industry is the electrical energy, which is used in an induction and Arc furnace. In a typical process, the furnace which melts the raw metal feed is usually fired by petroleum fuels. The molten metal is then transferred to an electrical induction furnace (called the holding furnace), which is used to maintain the required temperature. The melting process in this sector accounts for 86 per cent of total energy used. The molten metal is then poured into predesigned casts and allowed to cool before being removed and processed.

Metal processing involves processing of metal products to desired specifications. Typical applications are rolling mills, sheet metal, etc. Based on case study of MSME Newsletter,[20] the energy saving potential of rerolling manufacturing cluster in Kanjikode was assessed at 20 per cent in heat and 15 per cent in electricity use mainly through simple measures like control of excess air, closing furnace door, maintaining optimum fuel preheat temperatures, optimum furnace loading, use of ceramic insulation, use of variable frequency drives, etc. EMC Kerala estimates the energy conservation potential in this industry at 10 per cent in electricity use. Metal processing as a marker for this sector and based on the assessments of local industries, an energy saving target of 20 per cent in heat and 10 per cent in electricity is assigned for this sector.

Engineering and Industrial Goods

This sector mainly comprises manufacturers of automobile products, electrical and electronic equipment, etc and accounts for 2.9 per cent of total industrial electricity requirement and about 1.9 per cent of total heat demand. EMC Kerala[21] estimates a reduction potential of 15 per cent in electricity use. In line with EMC estimates, an energy saving target of 10 per cent in electricity by 2021 is assigned for this sector.

Others

For this sector, a target of 10 per cent in both electricity and heat requirements by 2021 is assigned.

To ensure these targets are achieved, audits should be made regularly and steps should be taken to confirm that the modifications prescribed are compiled by the industry. Many plant operators do not have transparency into how much energy is being used and where. Many industries do not have a baseline for energy efficiency, so it's difficult to measure performance other than by monitoring the cost of electricity.

---

[20] Winrock. 2010. "Energy Efficiency Potential and Way Forward in Kerala". *MSME Energy Saving Project*.Issue 4 (July-September).Winrock International India.http://www.inspirenetwork.org/pdf/4.Jul-Sep10.pdf, accessed on 17 May 2015.
[21] Limaye, Dilip R., Natarajan, Bhaskar, Kumar, B. Anil, Lal, Swati and Pradeep Tharakan. 2009. *Kerala State Energy Conservation Fund (KSECF): Financing Schemes*. USAID Asia and EMC, Kerala. http://www.keralaenergy.gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20CONSERVATION%20FUND%20%28KSECF%29%20FINANCING%20SCHEMES.pdf, accessed on 17 May 2015.

ANNEXURE 5C
ENERGY REDUCTION POTENTIAL - TRANSPORT SECTOR

Annexure 5C covers the detailed explanation of the transport sector interventions considered in the study.

DEVELOPING ENERGY CONSERVATION AND ENERGY EFFICIENCY MEASURES FOR COMMERCIAL TRANSPORT

Trucking industry in India is very energy intensive and is also very inefficient. The current maximum annual running distance of HCVs in India is to the tune of 75,000km as against an annual running distance of 175000 to 200000km by HCVs in advanced countries. Past studies on India trucking industry efficiency consistently point out that the reasons for the low kilometrage include bad roads, inefficient loading/unloading practices, bad driving and excessive waiting times at check points and other clearance points. The BAU scenario and proposed curtailment for rail and road transport is shown in table below.

Though the efficiency of vehicles has improved greatly over the last several decades, there is still a potential for enormous gains in fuel efficiency. Even wider implementation of technically mature advances could yield energy savings of 25 to 50 per cent in the near term, with low incremental costs.[1] Nevertheless immediate energy savings are possible through measures that encourage energy-efficient operation and maintenance of vehicles.

A study by EMC indicates that good driving practice like, accelerate gradually, drive smoothly and with care and it can see as much as a 20 percent gain in fuel economy compared with what you'd get with an aggressive driving style. In line with these studies it is assumed that a 20 per cent reduction can be achieved for all vehicles by better maintenance and proper driving practices.

For goods vehicles, maximum vehicle speeds, rate of accelerations and decelerations, frequencies of stop and start, idling time and total duration apart from actual driving pattern, are very important factors that affect the efficiency of the vehicles. In addition, past studies also emphasize that better driving practices have the potential to reduce energy intensity by about 10 per cent.[2] It is assumed that a combination of better road surfaces, better check posts management and mandatory driving courses for trucking industry can effect a reduction of 15 per cent in fuel consumption. Fuel consumption of heavy vehicles (Bus and

---

[1] Gellings, Clark W. andParmenter, Kelly E. n.d. "Energy Efficiency in Passenger Cars and Light Truck". *In Efficient Use and Conservation of Energy*. Electric Power Research Institute. USA. http://www.eolss.net/sample-chapters/c08/E3-18-03-03.pdf, accessed on 17 May 2015.
[2] Dalkmann, Holger and Sakamoto, Ko. 2011. *Transport: Investing in Energy and Resource Efficiency*. Transport Research Laboratory. UK. http://www.unep.org/transport/lowcarbon/newsletter/pdf/GER_10_Transport.pdf, accessed on 17 May 2015.

Trucks) forms major portion of the fuel consumed by road vehicles. To estimate the fuel efficiency scenarios of these vehicles a study by Central Road Research Institute was referred.[3] Based on case studies from Japan and US, the study suggested that through proper policy push in the sector like information and labelling, regulatory actions and fiscal measures the efficiency of the vehicles can be increased substantially. India began labelling of vehicles in 2011-12. The study proposes the levels of fuel efficiency for buses, HCV and LCV as shown in Table An5C.1.

TABLE AN5C.1: FUEL EFFICIENCY SCENARIO FOR BUSES, LCV'S AND HCV'S

	2011	2020	2025	2030
Buses	5.5	6.3	6.98	8.05
LCV	8.58	9.8	11.3	13
HCV	3.39	5.05	5.75	5.1

Combining all the strategies, the Table An5C.6 summarizes the effective energy reduction in all transport modes by 2030.

TABLE AN5C.2: EFFECTIVE ENERGY REDUCTION FOR ALL VEHICLES

Vehicle Type		2030
Long Distance Bus	Diesel	32%
Short Distance Bus	Diesel	32%
	Electric	20%
Cars		16%
Taxi Cars		16%
Jeeps		16%
Three Wheelers		16%
Two-Wheelers	Gasoline	16%
	Electric	10%
HCV	Diesel	32%
LCV	Diesel	34%
	Electric	20%

MIGRATING TOWARDS MORE EFFICIENT VEHICLES

In the reference BAU scenario the new vehicle technology penetration (hybrid) is included to reflect the technology changes that are happening by market forces without ant policy push. However, a focused policy migration towards early adoption of more efficient technologies is identified as a key intervention. Technology adoption is slow process in developing economies but government and institutional support in technology transfer, target-based regulation, capacity building and media campaigns have the potential to significantly accelerate technology adoption. It is assumed that this happens in the form of a new transport technology policy that defines technologies of choice and stipulates timeframes for addition of new technologies. Considering average vehicular life of 8-15 years and a strong policy stipulation in 2020 supporting efficient technology, it is assumed that 50 per cent or more penetration of efficient technologies happens by 2030. The

---

[3] CRRI. 2014. *Fuel Efficiency Standards of Heavy Duty Vehicles*. Central Road Research Institute and Shakti Sustainable Energy Foundation. New Delhi, India. http://shaktifoundation.in/wp-content/uploads/2014/02/Fuel-Efficiency-Standards-of-HDV-in-India.pdf, accessed on 17 May 2015.

following table summarizes the values. (This scenario does not assume any changes in the penetration of electric vehicles compared to a BAU scenario as the intervention from EVs are considered in the last scenario separately). The revised penetration of road vehicle technologies is shown in Table An5C.3.

TABLE AN5C.3: CURTAILED SCENARIOS BASED ON SHARE OF ENERGY CARRIER

Intervention	2020	2025	2030
Short Distance Buses (Percentage Share)			
Diesel	100	97	95
Electricity	0	3	5
Long Distance Buses (Percentage Share)			
Diesel	100	100	100
Rickshaws (percentage share)			
Gasoline	85	65	45
Hybrid Gasoline	10	20	30
Hybrid CNG	5	15	25
Taxis (percentage share)			
Gasoline	10	5	0
Diesel	80	70	50
Hybrid Gasoline	2	5	10
Hybrid Diesel	8	20	40
Cars (percentage share)			
Gasoline	55	40	20
Diesel	30	17	10
Hybrid Gasoline	10	22.5	40
Hybrid Diesel	5	18	25
EV	0	2.5	5
Jeeps (percentage share)			
Diesel	95	75	50
Hybrid Diesel	5	25	50
Two Wheelers (percentage share)			
Petrol Two Stroke	0	0	0
Petrol Four Stroke	97	96	95
EV	3	4	5
HCVs (percentage share)			
Diesel	100	100	100
LCVs (percentage share)			
Diesel	100	98	95
EV	0	2	5

OPTIMAL USAGE AND TRAFFIC PATTERNS

One of the main strategies for optimal usage pattern for vehicles is resource pooling. Resource pooling, mainly car pooling is one of the most effective way of reducing energy intensity and saving money. It is the sharing of journey so that more than one people travel in a car. Car pooling commuting are more popular for people who work in places with more jobs nearby, and who live in places with higher residential densities. Car pools could be an ideal way for commuting to work for service sector professionals working in clustered commercial or industrial areas, for example industrial parks in Palakkad.

Similar to car pooling, van pooling can also be adopted for covering larger distances. Service clusters can take initiative to start a bus services for people commuting through the same route. Vanpool operating costs are typically divided among vanpool members, Employers can provide vanpool services directly to employees or encourage employees to participate in vanpools by providing information on local vanpool programs. Considering the growth in urbanization, increasing growth of industry and service sector, even a shift of 1 per cent of total personal on-road car transport into a car pool and 2 per cent into a pooled bus service by 2022 would have substantial impact. In number terms, this would mean a diversion of about 1385 cars in 2022 (Considering a car pool of 4 passengers and vanpool of 20 passengers). At the district level, this would translate roughly into a 77.5 per cent reduction in on road traffic density. In line with the proposed strategy, a target based achievement of converting 1 per cent of car transport into car pool and 2 per cent into a bus pool is assumed by 2022. This would mean an effective reduction of 3 per cent cars on account of car pool.

Another workable resource pooling strategy could be shared rickshaws/ taxi services. Shared rickshaws are actually working very effectively in large urban areas and provide better frequency and a comfortable last mile travel on high density routes, which cannot be otherwise frequently serviced by buses. The focus strategy here is development of such a hub and wheel shared transport infrastructure that connects bus/rail passengers from hub locations to last mile destinations through shared rickshaw transport. Development of such an infrastructure would be the starting point of large scale modal migration especially from two wheelers to shared bus and rickshaw transport. It is assumed that 5 per cent of the rickshaw population is converted into a pooled rickshaw service by 2020. This would mean a reduction of 2 per cent in the distance travelled in 2020.

These services can ensure that the on-road vehicle population can be controlled. Improving transport management, infrastructure and congestion management can decrease the energy intensity because of efficient vehicle flow. For such a strategy, local government should widen the roads, continuously maintain the roads, and narrow roads should be converted to one-way, so that maximum congestion can be avoided.

SHIFTING FROM LESS TO MORE SUSTAINABLE TRANSPORTATION MODES

The strategy adopted is a shift in intra-modal share in roads from more energy intensive modes (cars and two wheelers) to buses and inter modal shift from road to rail. The existing and projected passenger and freight share between public (Buses) and private modes (cars, two wheelers) is as shown in Table An5C.4

TABLE AN5C.4:
ROAD PASSENGER INTRA-MODAL SHARE IN THE BAU SCENARIO

Modal Share Road Passenger (percentage)	2015	2020	2025	2030
Contract Carriage	27.3	26.1	25.2	24.3
Stage Carriage	48.1	45.9	44.4	42.9
Three Wheelers	10.3	10.3	10.3	10.1
Cars	2.1	2.7	3.8	4.2
Taxi Cars	2.7	3.1	3.7	4.6
Jeeps	0.1	0.0	0.0	0.0
Two Wheelers	9.5	11.9	12.5	13.9

Ironically, the rapid increase in share of cars and two wheelers not only adds to the traffic but also adds exponentially to the energy demand as these modes are very energy intensive as compared to public transport modes. The main strategy presumed here is to freeze the share of personal vehicles in total passenger volume in 2030 at 2020 levels. This can be done provided public transport is strengthened, improved and overhauled to absorb the migration. In line with the delineated strategies, it is assumed that the share of cars in total passenger transport traffic can be brought down to 2020 levels by 2030. For two wheelers, a more ambitious target of freezing the two wheeler share to 11.9 per cent from 2020. This would mean a moderate increase in activity of two wheelers as compared to present levels. It is further assumed that the decrease in the share of two wheelers, cars is transferred to short distance buses and shared rickshaws Based on the above, the final intra-modal share of passenger vehicles is as shown in table

TABLE AN5C.5:
PROPOSED INTRA-MODAL SHARE FOR ROAD PASSENGER TRAFFIC

Modal Share Road Passenger (percentage)	2015	2020	2025	2030
Contract Carriage	27.3	26.1	25.2	24.3
Stage Carriage	48.1	45.9	46.7	47.6
Three Wheelers	10.3	10.3	10.3	10.3
Cars	2.1	2.7	2.7	2.7
Taxi Cars	2.7	3.1	3.1	3.1
Jeeps	0.1	0.0	0.0	0.0
Two Wheelers	9.5	11.9	11.9	11.9

ENCOURAGE BICYCLING AND WALKING

Particularly for short trips, bicycling and walking can be viable alternatives to vehicle use, with additional benefits of improving health and making neighbourhoods more vibrant. For such a shift local government should improve the infrastructure to make the roads more cycling and walking friendly. To support walking and bicycling, municipalities can provide bicycle racks, shower and/or locker facilities, and bicycle or walking maps. Many cities use street marking to define bike lanes, and some cities provide dedicated bicycling and walking trail systems. In addition, municipalities encourage cycling and walking by improving safety features, such as crosswalks, sidewalks, and streetlights

In addition, a moderate level of voluntary shifting from personal motorized transport to non-motorized transport or walking is also assumed. This shift would not necessarily mean a reduction in consumption but would mean a reduction in intensity of use. (Even though in reality, there could be involuntary shifts from motorized transport on account of increasing fuel prices or medium term disruptions in supplies, such changes have not been factored. A shift of 5 per cent of motorized transport (mainly from cars) to non-motorized modes is assumed to be in place by 2030.

TRAVEL AVOIDANCE

Travel avoidance is a conscious policy by many of the companies to reduce travel and face-to-face meeting wherever they can. As the industrialization and service sector is progressing in Palakkad, it can be expected that travel demand may continue to increase. Under avoidable circumstances these travel can be reduced by incorporating technology innovations like video conferencing, tele-conferencing etc. Even though this factor cannot be quantified, it is expected that this strategy can reduce the total passenger fleet.

INTERVENTION SCENARIO 2: CARRIER SUBSTITUTION

The main strategy for this intervention is a migration towards electric mobility. Electric vehicles are already a reality. Tesla motors in the USA has already developed and commercialized luxury electric sedan model (model S) that has a range of 480kmph, a top speed of 192kmph, and a fuel efficiency of about 0.15kWh/km at a speed of 80kmph. In energy terms this translates into an energy intensity that is 20 per cent of the energy intensity of the gasoline based cars currently available in markets.

The idea of a mission-mode migration has already been mooted at the central government level with the announcement of the *National Electric Mobility Mission Plan 2020*.[4] The NEMMP 2020 document acknowledges that the past attempts at electric mobility were not very successful because of high costs, battery technology constraints, consumer mind-set and lack of a coherent centralized vision. The projections for demand of all electric and hybrid electric vehicles by 2020 indicate a national level demand of about 3.5-5 million two wheelers, 0.2 to 0.4 million other all electric vehicles (cars, three-wheelers, buses) and 1-3-1.4 million demand for electric hybrids. The NEMMP underscores the demand projections with the fact that these projections would come to fruition only with adequate government support for industry. GoI is currently studying the prospects for creating a market and creating a domestic manufacturing facility of clean electric vehicles in the country

Considering Kerala's industrial policy focus on non-polluting and value creating industry, Kerala could be one of the best placed states to promote manufacturing of EVs and formulate a state mission for EV penetration. For this scenario, it is assumed that a low penetration

[4] Department of Heavy Industry. 2012. *National Electric Mobility Mission Plan 2020*. Ministry of Heavy Industries & Public Enterprises, Government of India. http://dhi.nic.in/NEMMP2020.pdf, accessed on 17 May 2015.

targets for EVs, considering the long gestation of technology development and commercialization. The main thrust modes for promoting EVs are two wheelers, three wheelers, cars, stage carriages, light commercial vehicles.

TABLE AN5C.6: PROPOSED ELECTRIC VEHICLE PENETRATION

Intervention	2020	2025	2030
Short Distance Buses (percentage share)			
Diesel	98	92	85
Electric	2	8	15
Rickshaws (percentage share)			
Gasoline	70	60	40
Hybrid Gasoline	20	20	30
Electric	5	20	30
Cars (percentage share)			
Gasoline	52.5	35.5	10
Diesel	27.5	14	5
Hybrid Gasoline	10	22.5	40
Hybrid Diesel	5	18	25
Electric	5	10	20
Two Wheelers (percentage share)			
Petrol Four Stroke	95	70	45
Electric	5	30	55
LCVs (percentage share)			
Diesel	98	95	90
Electric	2	5	10

ANNEXURE 6
PALAKKAD DISTRICT INVESTMENT CONSIDERATION FOR TRANSITION

One of the most critical metrics for facilitating the 100 per cent RE energy scenario is the cost associated with the proposed transition strategies. In line with inputs from stakeholders, the objective is to assess the level of direct investments required from the state in new infrastructure development and other capital investments required to facilitate the transition.

It is assumed that the envisaged role of the government/state/district is to be an initiator, incubator and a facilitator and it will play a role only in investments deemed essential; investments which may not have immediate economic benefit or would be considered risky and hence would not be taken up by private sector under normal circumstances. The focus is on infrastructure and large capital investments in equipment. It is assumed that for most of the other strategies where state sector investment is not earmarked, the bulk of investments will come from the private sector which will find business opportunities in these strategies under the new business environment created by policy and regulatory forcings.

The methodology for determining investment implications for the district involves determination of State Investments (CAPEX (Capital Expenditure) and OPEX (Operational Expenditure) and the revenue realization potential/ savings accrued, if any for the investments.

CAPEX and OPEX is estimated based on available literature/empirical data. Revenue realized and savings accrued are dependent on the technical implications of the intervention.

Based on these assumptions, the sector-wise investment assessments are estimated below.

TRANSPORT SECTOR

The main intervention strategies considered in the transport sector include resource pooling, better traffic management, modal shift to rail transport, intramodal shift to public transport (mainly buses) and a considerable penetration of electric vehicles. For most of the strategies, necessary policy and regulatory support can develop a facilitating environment for private investments.

Investment in New Buses and Road Based Public Transport Infrastructure

Additional district level investment in public transport infrastructure, especially buses and mini buses for local and long distance travel can facilitate the reversal of the trend of the increasing preference for personal transport. The proposed intra-modal intervention of shifting cars and two wheelers share in road transport to public transport and maintaining two wheeler and car share at 11.9 per cent and 2.7 per cent, respectively translates into additional passenger load of 0.55 billion p-km to public transport (Long distance buses, short distance buses) in 2025. This additional passenger load increases to 1.35 billion p-km in 2030. The state will have to take a leading role in making investment in new state transport buses.

The estimated passenger shift to public transport translates into an additional requirement of about 235 buses by 2025 and increases to about 581 new buses by 2030. Assuming present cost of about Rs. 16.5 lakh (Rs. 1.65 million) for a single 50-seater bus.[1] The total investment requirement in terms of present costs works out to be Rs. 38.8 Cr and Rs. 95.9 Cr in 2025 and 2030, respectively.

Based on data available from the website of Kerala road transport Kerala State Road Transport Corporation, the average annual distance travelled per bus assuming 330 days of full service operations is about 82860km. Assuming a fuel efficiency of 5.5km/lit and a fuel cost of Rs. 60/lit, the total fuel cost per bus is estimated at Rs. 11.05 lakh/year. The total fuel cost for all the buses is about Rs. 80.48 Cr for the period 2021-25 and Rs. 231.5 Cr for the period 2026-30.

In line with the World Bank study on analyzing operational cost break-up of public buses in India, it is assumed that fuel costs represent 50 per cent of total operational costs.[2] This translates into an operational cost[2] of Rs. 10.12 lakh/year/bus. The total OPEX for all the buses is about Rs. 161 Cr for the period 2021-25 and Rs. 463.1 Cr for the period 2026-30.

On the other hand, based on data available from Kerala state road Transport Corporation's website, average earnings per km are reported as Rs. 33.04/km in 2014. Considering an average annual run of 82860km per bus, the total earnings from a bus are estimated to be Rs. 27 Lakh/year/bus.

Based on the above calculation table below summarizes the investment requirement from the district in public transport.

TABLE AN6.1: STATE INVESTMENTS REQUIREMENTS FOR NEW BUSES

Investment in new buses and public transport (Cr)	2015-20	2021-25	2026-30
CAPEX	0	38.8	57.1
OPEX	0	161.0	463.1
TOTAL EXPENSES	0	199.7	520.2
REVENUE REALIZATION	0	199.6	574.3
NET PROFIT		-0.13	54.0

[1] EicherStarline. n.d. "Price List".http://www.truckaurbus.com/new-cv/eicher-trucks-buses/price:1074000-8312000/no-of-seats:35-42/emission:1/axle-configuration:1, accessed on 29 May 2015.
[2] PPIAF and World Bank.n.d. *Cost Estimation: Introduction to Public Transport Planning and Reform.* Public Private Infrastructure Advisory Facility and The World Bank. http://siteresources.worldbank.org/EXTURBANTRANSPORT/Resources/341448-1269891107889/6914036-1278599591319/7230414-1278599610386/costs.pdf, accessed on 17 May 2015.

AGRICULTURE SECTOR

The main interventions proposed for this sector include adoption of micro-irrigation, phasing out of Diesel Pumps, and use of BEE labelled water pumps (electricity based initially and solar energy based subsequently). All of the proposed interventions will require an early policy push for facilitating adoption of the proposed measures.

GoK provides a subsidy of 10 per cent for a maximum beneficiary area of 5Ha. The average cost of a micro-irrigation set up is Rs. 32000/Ha. Considering the penetration target of 50 per cent of irrigated land with micro-irrigation, the total subsidy to be provided by the government works out to be Rs. 58.43 Cr in 2030. Based on assumptions made in chapter 9, a 25 per cent reduction in energy use from micro-irrigation is assumed. Based on this, the cumulative savings in electricity are calculated across each five year interval. Assuming net savings to the state of Rs. 3.3/kWh (average cost of supply of utility of Rs. 4.5/kWh – Average Agricultural tariff Rs. 1.2/kWh; Reference: KSEBL ARR&ERC petition for the year 2013-14), the cumulative cost savings is calculated up to 2030. Table An6.1 below calculates the investment and the savings

TABLE AN6.2: STATE INVESTMENT REQUIREMENTS FOR MICRO-IRRIGATION

Investment in Micro-irrigation (Rs. in Cr)	2015-20	2021-25	2026-30
CAPEX	11.69	29.22	58.43
SAVINGS	8.5	24.7	43.3
NET OUTFLOW	3.20	4.53	15.12

However, one area where state investments can make an impact is providing financial support to switch from existing low-efficiency pump-sets to energy efficient pump-sets. In fact, in states where supply to agriculture is heavily subsidized or is free, 100 per cent financial support for acquiring BEE star labelled pumps has also been financially justified in some cases with the cost burden being shared by the pump manufacturer and the government.[3]

In Palakkad, actual switchover from existing pump-sets would require financial support in addition to a policy push. Based on recent study by Netscribes,[4] the average cost of a locally manufactured pump-set is about Rs. 18000 while that of a branded pump-set is Rs. 26000. In contrast, the costs of a 3hp solar pump-set is Rs. 3.5 lakh but it is expected that these costs will come down significantly over time and it is assumed that they will achieve cost parity by 2030.

Government of India has launched Solar PV pumping scheme to be effective from April 2014 to March 2016 under which 30 per cent subsidy will be provided. Under this scheme, ANERT is already promoting the use of solar-powered water pumps among farmers in the state. In 2015, ANERT is planning to distribute 1380 solar-powered pumps to farmers in the state. The pumps will have a capacity ranging between 1HP and 5HP.

---

[3] IEI. 2010. *Efficient Well-based Irrigation in India: Compilation of Experiences with Implementing Irrigation Efficiency*. The International Energy Initiative and Prayas. Pune,India.

[4] Netscribe and Shakti. 2012. *Market Research of Agriculture Pump-sets Industry of India*. Shakti Sustainable Energy Foundation and Netscribes. http://shaktifoundation.in/wp-content/uploads/2014/02/Agriculture-Pump-Study_Report-Final_12th-June.pdf, accessed on 17 May 2015.

Since no state subsidy is provided for the efficient pumps/ solar water pumps, no state investment is considered for this intervention.

PUBLIC LIGHTING AND WATER WORKS

The main intervention strategies considered in this sector are reducing water pumping losses, adopting energy efficiency and energy conservation measures in public lighting and water supply and increased use of solar street lighting. Reduction in water pumping losses would mostly require strong regulation, better maintenance/refurbishment and moderate spares up gradation. While these measures would have cost implications they would be minor and are hence are not considered as infrastructure investments by the state. The key EE and EC interventions in public water works and public lighting would also incur costs. However considering the distributed nature of activities in these areas, these costs are also not considered as part of core infrastructure investments.

The major infrastructural investments in this sector would be related to replacement of 10 per cent, 25 per cent and 50 per cent existing street light fixtures with solar street by 2020, 2025 and 2030, respectively. Solar street lights are either CFL based or LED based. A standard LED based street light fitting having efficiency of 60-100 lumens/watt, 4m height and 10m span is taken as the representative solar street light model. The per-unit cost based on street light cost derived from Solar City Plan Document of Agra is assumed as Rs. 12,000.[5]

A standard conventional street light fixture using 70W HPSV (High Pressure Sodium Vapour) lamp consumes about 254kWh/year. Considering the total public lighting energy requirement of 39.51 MU in 2020 (based on energy demand after EC and EE interventions), and replacement target of 10 per cent (in energy terms), a displacement of about 15555 conventional street lights will be required by 2020. To deliver equivalent lumens in the replacement locations, a lower span of 10m would necessitate two solar street lights in place of one conventional fixture.

Based on this assumption, Rs. 37.33 Cr investment will be required by 2020. Assuming the existing central subsidy support of 50 per cent to be available, the actual cost to the district would be Rs. 18.6 Cr. Similarly, additional investments required in the period 2021-25 and 2026-30 to meet 25 per cent and 50 per cent target would be Rs. 38.37 Cr and Rs. 96.45 Cr, respectively. On the other hand, the savings accruing to the public utilities from the replacements are estimated assuming an electricity tariff of Rs. 5/kWh.

TABLE ANG.3: DISTRICT LEVEL INVESTMENT REQUIREMENTS FOR SOLAR STREET LIGHTING

State Investments in Street Lighting (Rs. in Cr)	2015-20	2021-25	2026-30
Capital Investment for Subsidy	18.66	38.37	96.45
Savings	7.38	18.5	42
Net Outflow	11.3	19.9	54.5

[5] ICLEI and MNRE.n.d. *Development of Agra Solar City: Final Master Plan*. Ministry of New and Renewable Energy, Government of India, and ICLEI South Asia. New Delhi, India. http://mnre.gov.in/file-manager/UserFiles/agra_solar_city_master_plan.pdf, accessed on 17 May 2015.

COMMERCIAL BUILDINGS

The main public sector investment requirements in this sector mainly centre on retrofitting of existing government buildings. These buildings are spread across various categories like shops/offices, school/colleges, work shed/factory, hospital/dispensary, hotels, places of worship etc.

For each of these categories, standard floor area availability is assumed in line with the assumptions stated in rooftop PV potential assessment. Depending on the type of institution, the share of state owned buildings in each category is either assigned a value 5 per cent or 10 per cent. Assuming single storied structures, the total floor area available in public sector buildings for retrofit is estimated.

To assess the costs of retrofits in terms of floor area, the NRDC study[6] on retrofitting of Godrej Bhavan Building in South Mumbai was referred. According to empirical data available in the study, the total retrofit investments including investments in energy efficient equipment (lighting, refrigeration, fans, etc), accessory fittings (improved louvers, glass films, etc) and water harvesting was about Rs. 2,473/m^2 of floor area.

Assuming retrofit costs of Rs. 2,500/m^2 and the assumptions stated above, the total state sector investment in buildings sector is calculated in below.

TABLE AN6.4: ASSESSMENT OF INVESTMENT REQUIREMENTS IN PUBLIC BUILDINGS

Categories of Institutional/ Commericial establishments in Palakkad	Shop/ office (Nos)	School/ College etc.(Nos)	Hotel, Lodge, Guest Houses etc. (Nos)	Hospital/ Dispensary etc. (Nos)	Factory/ Work shop/ Work shed etc. (Nos)	Place of Worship	Total
Total number of commercial institutional buildings with concrete roofs	68,016	6,073	3,303	2,441	12,867	12,654	105,354
Area available m^2 assumed	30	1500	450	750	1500	450	
Total Floor area available (m^2)	2,040,480	9,109,500	1,486,350	1,830,750	19,300,500	5,694,300	39,461,880
Assumed public sector ownership (%)	5	10	5	5	5	10	
Total commercial floor area under public sector	102,024	910,950	74,318	91,538	965,025	569,430	2,713,284
Total cost at present retro-fitting rate of Rs. 2500/m^2 (Cr)	25.51	227.74	18.58	22.88	241.26	142.36	678.32

[6] NRDC. 2013. *Saving Money and Energy: Case Study of the Energy-Efficiency Retrofit of the Godrej Bhavan Building in Mumbai*. NRDS Case Study.Natural Resources Defense Council and Administrative Staff College of India. http://www.nrdc.org/international/india/files/energy-retrofit-godrej-bhavan-CS.pdf, accessed on 17 May 2015.

To compare the implications of investment over the baseline scenario, only CAPEX and savings are captured. The savings reported in the NRDC study indicated that electricity use reduced from 271kWh/m^2 to 238kWh/m^2; a reduction of 33kWh/m^2.

Considering 50 per cent of the old building will be retrofitted by 2030 and assuming similar level of reduction and a commercial electricity supply rate of Rs. 10, the cumulative savings upto 2030 would be about Rs. 246.2 Cr. Based on the above level of interventions, the state level investment requirements are as shown in Table An6.4 below.

TABLE AN6.5: STATE INVESTMENT REQUIREMENTS FOR ENERGY EFFICIENT RETROFITS IN PUBLIC SECTOR

Cost of Energy-Efficient Retrofitting and Water Harvesting in Public Sector Buildings (Rs. in Cr)	2015-20	2021-25	2026-30
CAPEX	-	169.58	169.58
Savings	-	67.15	179.07
Net Outflow	-	102.43	160.08

INDUSTRIAL SECTOR

A majority of the industries in the district are owned by private sector, except for a handful of few large industries that are owned by the state. It is to be noted that one distinctive feature of the proposed energy efficiency or energy conservation measures in the industry sector are the self-paying nature of EC and EE interventions. In all the reviewed case studies and literature available related to costs of passive measures like heat/electricity conservation, better insulation, and even equipment level replacements, variable frequency drives, super-efficient motors, etc., the payback period was seldom more than six years old. In some cases, it was less than six months.

In this sense, investments in EC and EE for public sector manufacturing units would not imply a one way outflow of state funds. Additionally, all the major state owned industries have their own management and in that sense they are independent from government control and decisions related to industry unit level EE/EC interventions will be evaluated and approved internally and will be financed through the company's own reserves. In addition, most of the proposed interventions would make economic sense as the initial investments will be recoverable through savings. In this sense, it is assumed that there would be no direct implication on the state in terms of a separate budgetary outflow.

SUMMARY OF DISTRICT LEVEL INVESTMENTS

Figure An6.1 below summarizes the total district level investments for the interventions

FIGURE AN6.1: SUMMARY OF DISTRICT-LEVEL INVESTMENT REQUIREMENTS FOR THE TRANSITION

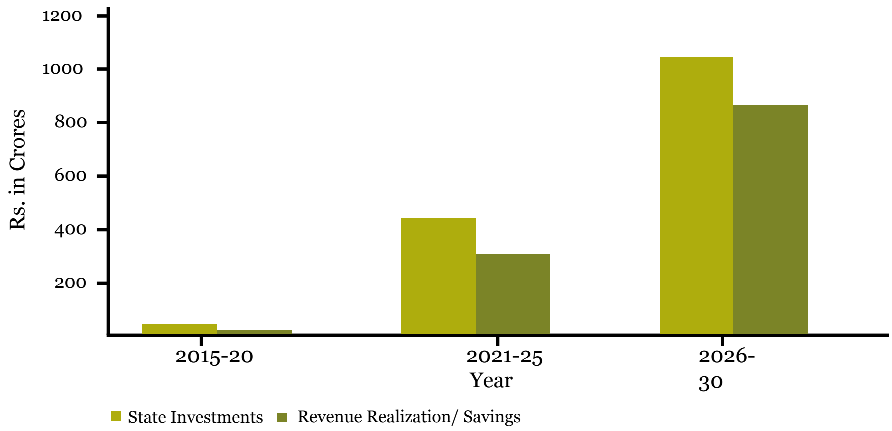


TABLE AN6.6: SUMMARY OF DISTRICT-LEVEL INVESTMENT REQUIREMENTS FOR THE TRANSITION

STATE INVESTMENT- CAPEX AND OPEX (Rscr)	2015-20	2021-25	2025-30
Total Investment in New Buses and Public Transport	0	199.74	520.19
State Investments for Micro-irrigation	16.69	38.22	67.43
State Investments in Street Lighting	18.66	38.37	96.45
State Investment in Building Retrofitting	0	169.58	339.16
TOTAL INVESTMENT	**35.35**	**445.90541**	**1,023.234**
REVENUE REALIZATION/SAVINGS			
Revenue Realization from New Buses	0	199.61	574.28
Savings to the State from Micro-irrigation	8.5	24.7	43.3
Savings to the State from Street Lighting	7.38	18.5	42
Savings from Building Retrofitting	0	67.15	179.07
NET OUTFLOW/INFLOW(-)	**19.5**	**135.95**	**184.6**

It has to be noted that the cost estimates in above calculations are based on present costs and actual cost trajectories of services, equipment and commodities may follow a different path altering the final investment requirements. However, any deviation in the figures would mostly be one sided as the costs of action would far outweigh the costs of inaction because the prices of conventional services, commodities and equipment will increase over time.

REFERENCES

REFERENCES

- Aguirre, Kimberly et al. 2012. *Lifecycle Analysis Comparison of a Battery Electric Vehicle and a Conventional Gasoline Vehicle*. California Air Resources Board, California, USA. http://www.environment.ucla.edu/media/files/BatteryElectricVehicleLCA2012-rh-ptd.pdf, accessed on 24 April 2015.
- Anonymous. n.d. "What do you Mean by Gasification?".http://projects.nri.org/biomass/conference_papers/gasification_process.pdf, accessed on 23 April 2015.
- Areva E-bike (advertisement).http://oreva.com/images/pdf/bike_catalog.pdf, accessed on 14 April 2015.
- BEE. 2008. "State -wise Electricity Consumption & Conservation Potential in India". Bureau of Energy Efficiency, National Productivity Council, New Delhi, India.
- BEE. 2010. "Energy Efficiency Guide - Buying and Maintaining an Energy-Efficient Home Refrigerator". Bureau of Energy Efficiency. New Delhi, India. http://www.beeindia.in/schemes/documents/ecbc/eco3/SnL/Guide%20on%20Energy-Efficient%20Home%20Refrigerator.pdf, accessed on 27 April 2015.
- BEE. 2010. "Energy Efficiency Guide - Buying and Maintaining an Energy-Efficient Room Air Conditioner". Bureau of Energy Efficiency. New Delhi, India. http://www.beeindia.in/schemes/documents/ecbc/eco3/SnL/Guide%20on%20Energy-Efficient%20Room%20Air%20Conditioner.pdf, accessed on 27 April 2015.
- BEE. 2010. *Detailed Energy Project on Energy Efficient Boiler (200 kg/hr) (Solapur Textile Cluster)*. Bureau of Energy Efficiency, Ministry of Power, Government of India. http://www.dcmsme.gov.in/reports/solapurtextile/03EnergyEfficientBoiler200Kg.pdf, accessed on 17 May 2015.
- BEE. 2010. *Detailed Project Report on Variable Frequency Drives for FD & ID Fan (Solapur Textile Cluster)*. Bureau of Energy Efficiency, Ministry of Power, Government of India. http://www.dcmsme.gov.in/reports/solapurtextile/15VariablefrequencyDriveinFDFan.pdf, accessed on 17 May 2015.
- BEE. n.d. *Manual on Energy Conservation Measures in Paper Cluster, Muzaffarnagar*. Bureau of Energy Efficiency, Ministry of Power, Government of India. http://sameeeksha.org/pdf/dpr/Muzaffarnagar_Paper.pdf, accessed on 17 May 2015.
- BEE. n.d. *Manual on Energy Conservation Measures in Textile Cluster Solapur*. Bureau of Energy Efficiency, Ministry of Power, Government of India. http://sameeeksha.org/pdf/clusterprofile/Solapur_Textile_Industries.pdf, accessed on 17 May 2015.
- Bose, R. K. and Chary, V. S. *"Road Transport in India Cities:*

Energy Environment Implications". Energy Exploration and Exploitation 2(2):154-180.

- BYD. n.d. "Electric Bus Feature". BYD Company Limited. http://www.byd.com/ap/ebus.html#spec, accessed on 24 April 2015.
- C.G. Heaps. 2012. Long-range Energy Alternatives Planning (LEAP) System. Stockholm Environment Institute, Somerville, MA, USA. www.energycommunity.org.
- CEA. 2011. *Report on Eighteenth Electric Power Survey of India*. Central Electricity Authority, New Delhi.
- Census of India. 2012. *Houses, Households and Amenities - 2011*. Office of Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India, New Delhi.
- CGPL. 2009. Biomass Resource Atlas of India, Residue Generation per kg of Crop". Combustion Gasification & Propulsion Laboratory, Banglalore. http://lab.cgpl.iisc.ernet.in/Atlas/Downloads/CropImages_with_residuedetails.pdf, accessed on 20 April 2015.
- CGWB. 2012. "Ground Water Level Scenario in India". Central Ground Water Board. Ministry of Water Resources, Faridabad. http://www.cgwb.gov.in/documents/GROUND%20WATER%20LEVEL%20SCENARIO_November-12.pdf, accessed on 13 April 2015..
- Chunekar, Aditya, Kadav, Kiran, Singh, Daljit and Girish Sant. 2011. *Potential Savings from Selected Super-Efficient Electric Appliances in India: A Discussion Paper*. Prayas Energy Group, Pune, India.
- ClimateTechWiki. n.d. "Energy Efficiency and Saving in the Agro-food Industry". http://www.climatetechwiki.org/technology/energy-saving-agri-food-industry, accessed on 24 April 2015.
- CRISIL. 2012. *CRISIL-CRB Customized Research Bulletin: Automobiles*. CRISIL Research (September).http://www.crisil.com/pdf/research/CRISIL-Research-cust-bulletin_sept12.pdf, accessed on 24 April 2015.
- CRRI. 2014. *Fuel Efficiency Standards of Heavy Duty Vehicles in India*. Central Road Research Institute, New Delhi. http://shaktifoundation.in/wp-content/uploads/2014/02/Fuel-Efficiency-Standards-of-HDV-in-India.pdf, accessed on 13 April 2015.
- CSE. n.d. "Lighting". Centre for Science and Environment. http://cseindia.org/content/lighting, accessed on 24 April 2015.
- Dalkmann, Holger and Sakamoto, Ko. 2011 *Transport: Investing in Energy and Resource Efficiency*. Transport Research Laboratory, UK. United Nations Environment Program. http://www.unep.org/transport/lowcarbon/newsletter/pdf/GER_10_Transport.pdf, accessed on 13 April 2015.

- Department of Economics and Statistics. 2011. Panchayat Level Statistics, 2011 – Palakkad District. Government of Kerala, Palakkad.
- Department of Heavy Industry. 2012. *National Electric Mobility Mission Plan 2020*. Ministry of Heavy Industries & Public Enterprises, Government of India. http://dhi.nic.in/NEMMP2020.pdf, accessed on 17 May 2015.
- Department of Information and Public Relations. 2003. *District Handbooks of Kerala – Palakkad*. Government of Kerala, Palakkad, Kerala. 46pp.
- Department of Town and Country Planning. 2013. *Integrated District Development Plan – Palakkad*. Volume I. Special Technical Advisory Group, District Planning Committee, Palakkad, Kerala.
- Directorate of Agriculture. 2013. "National Mission on Micro Irrigation (NMMI) – Implementation of the Scheme 2013-14". Government of Kerala. http://www.keralaagriculture.gov.in/pdf/wi_16012014_02.pdf, accessed on 13 April 2015.
- Directorate of Economics & Statistics. 2011. *Agricultural Statistics 2009-10, Government of Kerala, Palakkad, , Kerala*. pp. 78-81; Directorate of Economics & Statistics. 2012. Agricultural Statistics 2010-11, Government of Kerala, Palakkad, Kerala. pp. 32-39.
- District Planning Committee. 2013. *Integrated District Development Plan Palakkad,* Volume 1: *Perspective Plan*. Department of Town and Country Planning, Kerala.
- EMC. 2007. *Reduce Speed of Your Ceiling Fan Save Energy up to 60% - Technical Fact Sheet/ Ceiling Fan-Speed Control*. Energy Management Centre, Kerala. http://www.keralaenergy.gov.in/pdf/fan%20regulator.pdf, accessed on 27 April 2015.
- EMC. n.d. "New Thermal Cooker". Department of Science & Technology, Government of India, New Delhi. http://www.keralaenergy.gov.in/pdf/urja2.pdf, accessed on 13 April 2015.
- Envergent. n.d. "The Production of Electricity from Wood and Other Solid Biomass". Table 1. EvergentTech.com. http://www.envergenttech.com/files/envergent_electricity_5406_en_wp_10v1.pdf, accessed on 20 April 2015.
- ESTAP. 2013. "Two and Three Wheeled Vehicles and Quadricycle – Technology Brief". Energy Technology Systems Analysis Programme, International, Energy Agency. 19 January.
- FAO. 1990. *Energy Conservation in the Mechanical Forest Industries*. FAO Forestry Paper No. 93, Food and Agriculture Organization, Rome.
- FRIM. 1992. "Utilization of Industrial Wood Residues". Paper presented at the workshop on Logging and Industrial Wood Residues Utilization in Jakarta, Indonesia (24 August).

- Frost, Peter and Gilkinson, Stephen. 2010. *Interim Technical Report: First 18 Month Performance Summary for Anaerobic Digestion of Dairy Cow Slurry at Afbi Hillsborough. Agri-Food and Bioscience Institute*. Hillsborough. http://www.afbini.gov.uk/afbi-ad-18-months-v05.pdf, accessed on 20 April 2015.

- Gellings, Clark W. and Parmenter, Kelly E. n.d. "Energy Efficiency in Passenger Cars and Light Truck". *In Efficient Use and Conservation of Energy*. Electric Power Research Institute. USA. http://www.eolss.net/sample-chapters/c08/E3-18-03-03.pdf, accessed on 17 May 2015.

- GoK. 2011. "Kerala State Housing Policy (Draft)". Department of Housing, Government of Kerala. (August). http://www.kerala.gov.in/docs/policies/drafthpolicy11e.pdf, accessed on 13 April 2015.

- GoK. 2011. "*Green Building Policy (Draft)*". PWD Architecture Wing, Government of Kerala. http://www.keralapwd.gov.in/keralapwd/eknowledge/Upload/documents/1599.pdf, accessed on 13 April 2015.

- GoK. 2013. *Kerala Perspective Plan (Vision) -2030*. Chapter 9 – Industry. State Planning Board, Government of Kerala. p. 337.

- GoK. 2014. *Annual Plan Write-up 2014*. Chapter V. "Energy". *Kerala Budget 2014-15*. Finance Department, Government of Kerala. pp. 151. http://www.finance.kerala.gov.in/index.php?option=com_docman&task=doc_download&gid=6378&Itemid=57, accessed on 13 April 2015.

- GoK. 2014. Kerala Budget 2014-15. Chapter V – Energy. Department of Finance, Government of Kerala. http://www.finance.kerala.gov.in/index.php?option=com_docman&task=doc_download&gid=6378&Itemid=57, accessed on 27 April 2015.

- Harikumar, R. n.d. "Induction Cooker – A Brief Investigation". Energy Management Centre, Kerala. http://www.keralaenergy.gov.in/emc_reports/Induction%20Cooker_a%20brief%20investigation.pdf, accessed on 15 April 2015.

- *Hero Electric e-bikes, http://heroelectric.in/products-page, accessed on 14 April 2015.*

- Hero Electric, e-sprint 2, http://heroelectric.in/e-sprint-2/?view-product=y, accessed on 14 April 2015.

- ICLEI and MNRE. n.d. *Development of Agra Solar City: Final Master Plan*. Ministry of New and Renewable Energy, Government of India, and ICLEI South Asia. New Delhi, India. http://mnre.gov.in/file-manager/UserFiles/agra_solar_city_master_plan.pdf, accessed on 17 May 2015.

- IEA. 2004. *The Sustainable Mobility Project. International Energy Agency*. http://www.oecd.org/sd-roundtable/papersandpublications/39360485.pdf, accessed on 24 April 2015.

- IEA. 2009. *Chemical and Petrochemical Sector: Potential of Best Practice Technology and Other Measures for Improving Energy Efficiency*. IEA Information Paper. International Energy Agency. https://www.iea.org/publications/freepublications/publication/chemical_petrochemical_sector.pdf, accessed on 17 May 2015.
- IEI. 2010. *Efficient Well-based Irrigation in India: Compilation of Experiences with Implementing Irrigation Efficiency*. The International Energy Initiative and Prayas. Pune, India.
- International Resources Group and EMC. 2009. *Kerala State Energy Conservation Fund (KSECF) Financing Schemes*. International Resources Group Ltd. and Energy Management Centre, Department of Power, Kerala. (November) pp. 8. http://www.keralaenergy.gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20CONSERVATION%20FUND%20%28KSECF%29%20FINANCING%20SCHEMES.pdf, accessed on 13 April 2015.
- International Resources Group and EMC. 2009. *Kerala State Energy Conservation Fund (KSECF) Financing Schemes*. International Resources Group Ltd. and Energy Management Centre, Department of Power, Kerala. (November) pp. 21. http://www.keralaenergy.gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20CONSERVATION%20FUND%20%28KSECF%29%20FINANCING%20SCHEMES.pdf, accessed on 13 April 2015.
- IPEEC. 2014. "Can India Save Energy with Super-Efficient Fans?". International Partnership for Energy Efficiency Cooperation. 7 April. http://www.ipeec.org/blog/view/id/796.html, accessed on 27 April 2015.
- IREDA and CII. n.d. *Investors Manual for Energy Efficiency. Indian Renewable Energy Development Agency and Confederation of Indian Industry*. http://www.ireda.gov.in/writereaddata/IREDA-InvestorManual.pdf, accessed on 17 May 2015.
- Johnson, Alissa, Phadke, Amol and Rue du Can, Stephane de la. 2014. *Energy Savings Potential for Street Lighting in India*. Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory. pp. 13. http://eetd.lbl.gov/sites/all/files/lbnl6576e.pdf, accessed on 13 April 2015.
- JPS Associates. 2011. *Study on Volume of Goods and Passenger Traffic on Indian Roads*. JPS Associates and Ministry of Road Transport and Highways (MoRTH), Government of India.
- K. O. Lim, Zainal, Z.A., Quadir, G.A. and M.Z. Abdullah. 2000. "Plant Based Energy Potential and Biomass Utilization in Malaysia". *International Energy Journal* 1 (2): 81, http://www.thaiscience.info/journals/Article/Plant%20based%20energy%20potential%20and%20biomass%20utilisation%20in%20malaysia.pdf, accessed on 24 April 2015.

- Kapoor, Mahesh. 2002. *Vision 2020: Transport*. Report prepared for the Planning Commission, New Delhi, India.
- Kerala State Road Transport Corporation. 2015. "Financials". http://www.keralartc.com/html/financials.html, accessed on 14 April 2015.
- Koopmans, Auke and Koppejan, Jaap. 1997. "Agriculture and Forest Residue: Generation, Utilization and Availability". Paper presented at the Regional Consultation on Modern Applications of Biomass Energy, Kuala Lumpur, Malaysia (January 6-10).
- KSERC. 2013. *Annual Revenue Requirements (ARR), Expected Revenue from Charges (ERC) and Tariff order for KSEB – 2013-14*. Kerala State Electricity Regulatory Commission, Thiruvananthapuram, Kerala.
- Kumar, D. Sendil and Pugazhvadivu, M. 2012. "Green Buildings: Prospects and Potential". *Journal of Engineering Research and Studies*. http://www.technicaljournalsonline.com/jers/VOL%20 III/JERS%20VOL%20III%20ISSUE%20IV%20OCTOBER%20 DECEMBER%202012/Article%202%20Vol%20III%20Issue%20 IV.pdf, accessed on 13 April 2015.
- Kumar, S. and Gaikwad, S.A. 1996. "Municipal Solid Waste Management in Indian Urban Centres: An Approach for Betterment". In K.R. Gupta (ed), *Urban Development Debates in the New Millennium. p. 2004*. Atlantic Publishers & Distributors, New Delhi, India.
- Lehra. n.d. "Calorific Value". Lehra Fuel Tech Pvt. Ltd. http:// www.lehrafuel.com/briquetts-calorific-value.html, accessed on 20 April 2015.
- Limaye, Dilip R., Natarajan, Bhaskar, Kumar, B. Anil, Lal, Swati and Pradeep Tharakan. 2009. Kerala State Energy Conservation Fund (KSECF) Financing Schemes: Final Report. International Resources Group, KSECF and USAID. http://www.keralaenergy. gov.in/emc_Downloads/KERALA%20STATE%20ENERGY%20 CONSERVATION%20FUND%20%28KSECF%29%20 FINANCING%20SCHEMES.pdf, accessed on 16 April 2015.
- Local Self Government Department. 2006. *District Level Database, Palakkad District – 2006*. Government of Kerala.
- Local Self Government Department. 2007. *District Level Database - Palakkad District 2006*. Government of Kerala, Palakkad, Kerala. 54pp.
- Mahindra Reva, http://mahindrareva.com/faqs/savings, accessed on 14 April 2015.
- Mahindra Reva, Price List, http://mahindrareva.com/buy/price-list, accessed on 14 April 2015.
- MNRE. 2011. "*Minimum Requirements for Installation of Solar Water Heating Systems in Field*". Ministry of New and Renewable

Energy, Government of India. http://mnre.gov.in/file-manager/UserFiles/minimum_technical_specicifications_SWHS.pdf, accessed on 12 April 2015.

- MNRE. 2011. *Development of Agra Solar City: Final Master Plan*. Ministry of New and Renewable Energy, Government of India, and ICLEI South Asia, New Delhi, India. http://mnre.gov.in/file-manager/UserFiles/agra_solar_city_master_plan.pdf, accessed on 16 April 2015.
- MNRE. 2011. *Identification of Industrial Sectors Promising for Commercialization of Solar Energy. Ministry of New and Renewable Energy, Government of India*. http://mnre.gov.in/file-manager/UserFiles/identification_of_insdustrial_sectors_promising_for%20_commercialisation_of_solar_energy_ComSolar.pdf, accessed on 13 April 2015.
- Mohod, Atul, Jain, Sudhir and Powar, Ashok. 2011. "Cashew Nut Shell Waste: Availability in Small-Scale Cashew Processing Industries and Its Fuel Properties for Gasification". *ISRN Renewable Energy 2011*. http://www.hindawi.com/journals/isrn/2011/346191, accessed on 20 April 2015.
- MP&NG. 2012. *Basic Statistics on Indian Petroleum & Natural Gas*. Ministry of Petroleum & Natural Gas, Government of India. http://petroleum.nic.in/petstat.pdf, accessed on 19 May 2015.
- Musk, Elon and Straubel, J. B. 2012. "Model S Efficiency and Range". TESLA Blog (9 May). http://www.teslamotors.com/blog/model-s-efficiency-and-range, accessed on 24 April 2015.
- National Informatics Centre, "Services", http://vidcon.nic.in/AboutUs.htm#Services, accessed on 14 April 2015.
- NEERI. 1996. *Municipal Solid Waste Management in Indian Urban Centres*. National Environmental Engineering Research Institute, Nagpur, India.
- Netscribe and Shakti. 2012. *Market Research of Agriculture Pump-sets Industry of India*. Shakti Sustainable Energy Foundation and Netscribes. http://shaktifoundation.in/wp-content/uploads/2014/02/Agriculture-Pump-Study_Report-Final_12th-June.pdf, accessed on 17 May 2015.
- NRDC. 2013. *Saving Money and Energy: Case Study of the Energy-Efficiency Retrofit of the Godrej Bhavan Building in Mumbai*. Natural Resources Defense Council and Administrative Staff College of India.http://www.nrdc.org/international/india/files/energy-retrofit-godrej-bhavan-CS.pdf, accessed on 14 April 2015.
- NRDC. 2013. *Saving Money and Energy: Case Study of the Energy-Efficiency Retrofit of the Godrej Bhavan Building in Mumbai*. NRDS Case Study. Natural Resources Defense Council and Administrative Staff College of India. http://www.nrdc.org/international/india/files/energy-retrofit-godrej-bhavan-CS.pdf, accessed on 17 May 2015.

- PCRA. 2009. “Chapter 11. Paper and Pulp”. *In Practical Guide to energy Conservation*. Petroleum Conservation Research Association. New Delhi, India. pp. 345-67.

- Pilon, Guillaume. 2007. “Utilization of Arecanut (Areca catechu) Husk for Gasification”. Unpublished Thesis. Department of Bioresource Engineering, McGill University, Montreal. p. 29. http://webpages.mcgill.ca/staff/deptshare/FAES/066-Bioresource/Theses/theses/353GuillaumePilon2007/353GuillaumePilon2007.pdf, accessed on 24 April 2015.

- Planning Commission. 2014. *The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth*. Planning Commission, Government of India, New Delhi. pp. 54. India. http://planningcommission.nic.in/reports/genrep/rep_carbon2005.pdf, accessed on 13 April 2015.

- Planning Commission. n.d. User *Guide for Agricultural Sector*. India Energy Security Scenario, 2047.Government of India, New Delhi, India.http://indiaenergy.gov.in/doc/d9_deatledAgriculture.pdf, accessed on 13 April 2015.

- Poovanna, Sharan and Saha, Samiran. 2013. “Car Makers Run into Diesel Dilemma”. *The Indian Express* (19 May). http://www.newindianexpress.com/business/news/Car-makers-run-into-diesel-dilemma/2013/05/19/article1596282.ece, accessed on 24 April 2015.

- PPIAF and World Bank. n.d. *Cost Estimation: Introduction to Public Transport Planning and Reform*. Public Private Infrastructure Advisory Facility and The World Bank. http://siteresources.worldbank.org/EXTURBANTRANSPORT/Resources/341448-1269891107889/6914036-1278599591319/7230414-1278599610386/costs.pdf, accessed on 17 May 2015.

- Raghavan, Krishna. 2010. *Biofuels from Coconut*. FACT. http://fact-foundation.com/sites/default/files/library/documents/17._biofuels_from_coconuts.pdf, accessed on 20 April 2015.

- Ramachandra, T.V. and Kamakshi, G. 2005. *Bioresource Potential of Karnataka [Talukwise Inventory with Management Options]*. Chapter 5: Methodology. Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India. http://www.ces.iisc.ernet.in/energy/paper/TR109/TR109_TVR.pdf, accessed on 23 April 2015.

- Rao, M.S. and Singh, S.P. 2003. “Bioenergy Conversion Studies of Organic Fraction of MSW: Kinetic Studies and Gas Yield-organic Loading Relationships for Process Optimization”. Bioresource Technology 95: 173-185. See p. 183. http://mie.esab.upc.es/ms/informacio/compostatge_digestio_anerobia/digestio_anaerobia/MSW_DA.pdf, accessed on 20 April 2015.

- Saini, Sarabjot Singh. 2013.“Pump Set Energy Efficiency: Agricultural DSM Program”.*International Journal of Agriculture and Food Science Technology* 4 (5): 493-500.

- Saxena, Praveen. 2007. “Small Hydro Development in India”. International Conference on Small Hydropower - Hydro Sri Lanka, 22-24 October 2007. pp. 1-6. http://www.ahec.org.in/links/International%20conference%20on%20SHP%20Kandy%20Srilanka%20All%20Details%5CPapers%5CPolicy,%20Investor%20&%20Operational%20Aspects-C%5CC27.pdf, accessed 13 April 2015.
- Schumacher, Katja and Sathaye, Jayant. 1999. *India’s Pulp and Paper Industry: Productivity and Energy Efficiency*. Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory. http://www.yieldopedia.com/paneladmin/reports/07dc15673834d4ced6b89a854c4b2980.pdf, accessed on 17 May 2015.
- SEC. n.d. “Green Energy Portable Bio Gas Plant for Homes, Restaurants, Canteens etc.”.http://www.southelectric.in/PORTABLE%20BIOGAS-Mailer.pdf, accessed on 13 April 2015.
- Eicher Starline. n.d. “Price List”. http://www.truckaurbus.com/new-cv/eicher-trucks-buses/price:1074000-8312000/no-of-seats:35-42/emission:1/axle-configuration:1, accessed on 29 May 2015.
- State Planning Board. 2014. *Economic Review 2013*. Government of Kerala, Palakkad, Kerala. See Chapter 5 – “Infrastructure” and Appendix 5.10.
- *Tariff order for KSEB – 2013-14*. Kerala State Electricity Regulatory Commission, Thiruvananthapuram, Kerala.
- TERI. 2006. *National Energy Map for India: Technology Vision 2030*, Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 23 April 2015.
- TERI. 2009. *India’s Energy Security: New Opportunities for a Sustainable Future*. The Energy and Resource Institute, New Delhi, India. pp. 15. http://www.teriin.org/events/CoP16/India_Energy_Security.pdf, accessed on 13 April 2015.
- TERI. n.d. *High Performance Commercial Buildings in India: Initial Project Findings*. The Energy and Resource Institute. http://high-performancebuildings.org/pdf/HighPerformanceCommercial%20Buildings_Brochure.pdf, accessed on 14 April 2015.
- The Hindu. 2004. “Waiting for the Train of Hope”. *The Hindu* (June 24). http://www.thehindu.com/mp/2004/06/24/stories/2004062401020100.htm, accessed on 20 April 2015.
- The Hindu. 2013. “ANERT to Set Up 2-MW Solar Farm in Palakkad”. *The Hindu* (21 November). http://www.thehindu.com/todays-paper/tp-national/tp-kerala/anert-to-set-up-2mw-solar-farm-in-palakkad/article5374300.ece, accessed on 6 April 2015.

- The Hindu. 2014. "Palakkad to Host NHPC's First Wind Farm". *The Hindu* (7 January). http://www.thehindu.com/todays-paper/tp-national/palakkad-to-host-nhpcs-first-wind-farm/article5547790.ece, accessed on 6 April 2015.

- Trudeau, Nathalie, Tam, Cecilia, Graczyk, Dagmar and Peter Taylor. 2011. *Energy Transition for Industry: India and the Global Context*. International Energy Agency, Paris, France. https://www.iea.org/publications/freepublications/publication/india_industry_transition_28feb11.pdf, accessed on 12 April 2015;

- TERI. 2006. *National Energy Map for India: Technology Vision 2030*. Office of the Principal Scientific Advisor to the Government of India, The Energy and Resources Institute, New Delhi, India. http://www.teriin.org/div/psa-fullreport.pdf, accessed on 12 April 2015.

- Trudeau, Nathalie, Tam, Cecilia, Graczyk, Dagmar and Peter Taylor. 2011. *Energy Transition for Industry: India and the Global Context*. International Energy Agency. Paris, France. https://www.iea.org/publications/freepublications/publication/india_industry_transition_28feb11.pdf, accessed on 17 May 2015.

- Varma, R. Ajaykumar. n.d. "Status of Municipal Solid Waste Generation in Kerala and Their Characteristics". Suchitwa Mission, Government of Kerala. http://www.sanitation.kerala.gov.in/pdf/staeof_solidwaste.pdf, accessed on 24 April 2015.

- Wilaipon, Patomsok. 2010. "Density Equation of Cassava-Stalk Briquettes Under Moderate Die-Pressure". *American Journal of Applied Sciences 7 (5): 698-701*. http://thescipub.com/PDF/ajassp.2010.698.701.pdf, accessed on 20 April 2015.

- Winrock International and EMC. 2010. *Survey and Collection of Data Concerning Manufacturing, Sales of Household Appliances and Other Equipment at Kerala State Falling under the EC Act and Other Selected Equipments/Appliances and Submission of Data, Analysis, Presentation and Report complete. Final Report (Task 1)*. Winrock International, India and Energy Management Centre, Kerala. (March) pp. 11. http://www.keralaenergy.gov.in/emc_reports/Survey%20of%20Appliances%20and%20Equipments%20falling%20under%20EC%20Act%202001.pdf, accessed on 13 April 2015.

- Winrock International and EMC. n.d. *Impact of Energy Conservation Act in State of Kerala*. Winrock International, India and Energy Management Centre, Kerala. pp. 36. http://www.keralaenergy.gov.in/emc_reports/Impact%20of%20Energy%20Conservation%20Act%20in%20the%20State%20of%20Kerala.pdf, accessed on 13 April 2015.

- Winrock. 2010. "Energy Efficiency Potential and Way Forward in Kerala". *MSME Energy Saving Project*. Issue 4 (July-September). Winrock International India. http://www.inspirenetwork.org/pdf/4.Jul-Sep10.pdf, accessed on 17 May 2015.

- WISE. 2012. *Action Plan for Comprehensive Renewable Energy Development in Tamil Nadu*, World Institute of Sustainable Energy, Pune, India. pp. 21-26, 41-46. http://wisein.org/WISE_Projects/TN_ActionPlan_Web.pdf, accessed on 12 April 2015.

- World Bank. 2008. *Residential Consumption of Electricity in India: Documentation of Data and Methodology – India: Strategies for Low Carbon Growth*. The World Bank. http://www.moef.nic.in/downloads/public-information/Residentialpowerconsumption.pdf, accessed on 21 April 2015.

- WWF International. 2011. *The Energy Report: 100% Renewable Energy by 2050*. Avenue du Mont-Blanc, Switzerland.

- WWF-India and WISE. 2013. *The Energy Report – Kerala: 100% Renewable Energy by 2050*. WWF-India and World Institute of Sustainable Energy, New Delhi, India.

- Zhou, Nan et al. 2007. "What do India's transport energy data tell us? A bottom-up assessment of energy demand in India transportation sector". *In Saving Energy – Just Do It!*. In European Council for an Energy Efficient Economy – Summer Study. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_8/8.270/paper, accessed on 24 April 2015.

WWF-India is the largest conservation organisation in the country dealing with nature conservation, environment protection and development-related issues. Established as the Charitable Trust in 1969, it has an experience of over four decades in the field. Its mission is to stop the degradation of the planet's natural environment, which it addresses through its work in biodiversity conservation and reduction of humanity's ecological footprint.

WWF-India works across different geographical regions in the country to implement focused conservation strategies on issues like conservation of key wildlife species, protection of habitats, management of rivers, wetlands and their ecosystem, climate change mitigation, enhancing energy access, sustainable livelihood alternatives for local communities, water and carbon footprint reduction in industries, and combating illegal wildlife trade. WWF-India is actively engaged in promoting renewable energy uptake, enabling energy access, demonstrating renewable energy projects in critical landscapes, and overall promoting clean energy solutions.

WWF-India has been working on issues related to biodiversity conservation, sustainable livelihoods and governance, and climate change. The Climate Change and Energy Programme of WWF-India is working towards climate resilient future for people, places and species that support pathways for sustainable and equitable economic growth. Low carbon development and renewable energy at scale are the thrust areas of Climate Change and Energy Programme.

To know more, log on to: **www.wwfindia.org**

The World Institute of Sustainable Energy (WISE) is a not-for-profit institute established in 2004 in Pune, India, committed to the cause of promoting sustainable energy and sustainable development, with specific emphasis on issues related to renewable energy, energy security, and climate change. Influencing public policy through research, advocacy, development of action plans/roadmaps, capacity building, training and outreach activities, is the prime objective of WISE. These activities are channeled through WISE's specialist centres, namely Climate and Sustainability Policy, Renewable Regulation and Policy, Wind Power, Solar Energy, Communications, etc., who work in the true tradition of inter-disciplinary learning, team spirit, and knowledge sharing, to propel the country towards sustainability in the 21st century.

Since its inception, WISE has pioneered many important initiatives in the above areas. These include piloting a model Renewable Energy law for India, studying the role that conventional power technologies can play to support renewables and recommending a planned transition to a sustainable economy, developing a renewable energy pathway for achieving the target of 15% renewable energy by 2020, as specified by the National Action Plan on Climate Change (the Government of India has officially accepted WISE's findings for inclusion in the five-year plan targets), developing state-level action plans for climate mitigation through accelerated deployment of clean energy technologies, engaging in developing state-level policies and capacity building for renewable development agencies, communication and outreach activities to propagate the need for renewables, research initiatives to prove the long-term viability of renewables, etc.

To know more, log on to: **www.wisein.org**

WWF® & WISE

Report · 2015

100%
RECYCLED

Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

www.wwfindia.org

WWF-India, 172-B, Lodhi Estate, New Delhi 110003
www.facebook.com/wwfindia www.twitter.com/wwfindia

WWF-India Secretariat
172-B Lodi Estate, New Delhi - 110003
Tel: 011 4150 4814, Fax: 011 4150 4779

WORLD INSTITUTE OF SUSTAINABLE ENERGY

WORLD INSTITUTE OF SUSTAINABLE ENERGY
Plot No.44, Hindustan Estates, Road No. 2,
Kalyani Nagar, Pune 411 006
Tel: +91-20-26613832, 26613855
Fax: +91-20-26611438