Kingdom of Bhutan

TECHNOLOGY NEEDS ASSESSMENT AND BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT MITIGATION

"March 2013"

National Environment Commission
Royal Government of Bhutan

TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY ACTION PLANS FOR CLIMATE CHANGE ADAPTATION

Disclaimer

This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP Risoe Centre (URC) in collaboration with the Regional Centre (from the corresponding region), for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein are a product of the National TNA team, led by the National Environment Commission, Royal Government of Bhutan.

Bhutan Technology Needs Assessment Project Team

1. Mr. Karma Tshering, National Coordinator, National Environment Commission
2. Mr. Jigme Thinley, Finance Officer, National Environment Commission
3. Mr. Aloke Barnwal, Principal Consultant, Emergent Ventures India Pvt. Ltd
4. Mrs. Ishita Signh, Associate Consultant, Emergent Ventures India Pvt. Ltd
5. Mrs. Prima Madan, Senior Consultant, Emergent Ventures India Pvt. Ltd
6. Mr. Ugyen P. Norbu (National Consultant from Bhutan)

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FOREWORD

PRIME MINISTER

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Royal Government of Bhutan

28 March, 2013.

Foreword

Bhutan, with its commitment to preserve the natural environment, has been actively participating in the fight against one of the most pressing challenges of the current times, the climate change. The country has undertaken the Technology Needs Assessment process to identify, evaluate, and prioritize technologies that fit in the overall development context of the nation while allowing the country to adapt to and mitigate climate change. At the Conference of Parties (COP) 14 in 2008, the Poznań Strategic Programme on Technology Transfer was adopted as a step towards *scaling up the level of investment in technology transfer in order to help developing countries address their needs for environmentally sound technologies*. As part of this programme, in 2010, on behalf of Global Environment Facility (GEF), the United Nations Environment Programme (UNEP) started the implementation of Technology Needs Assessment (TNA) for 36 countries.

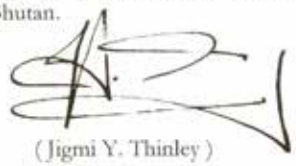
Taking forward its commitment at the international forums, I am pleased that the National Environment Commission (NEC) Secretariat has completed the Technology Needs Assessment for Climate Change (TNA) and that it led to the formulation of a Technology Action Plan (TAP) for implementation of the prioritized technologies for adaptation and mitigation. These initiatives fit in the larger scheme of things that we are pursuing for low-carbon and climate-resilient development and will contribute to the development of the 11th Five Year Plan of the country, to be finalized soon.

As a party to the UNFCCC, Bhutan is fully committed to developing and implementing policies, programmes and projects to address the many challenges posed by climate change. We have also adopted a new Economic Development Policy in 2010, which embraces the concept and principles of green economic development. We are now formulating a national strategy for low-carbon and climate-resilient development.

Application of collective knowledge and skills is crucial in developing solutions for combating the challenges of climate change. In this regard, I am encouraged to note that various stakeholders not only from government agencies, but also from the civil society and private sector have been involved in the TNA process and have contributed extensively in selecting the prioritized technologies, identifying the key barriers to technology development and deployment, preparing the Technology Action Plans for overcoming the identified barriers and identifying the implementable project ideas for each technology. I would like to commend all the individuals and organizations that have contributed to the TNA process particularly, the TNA Taskforce members, the respective government departments and agencies and the National Environment Commission for effectively leading this exercise.

I look forward to seeing the findings and recommendations of the TNA project feed into the national strategy for combating climate change in Bhutan.

Tashi Delek !



(Jigmi Y. Thinley)
Prime Minister, and
Chairman of NEC

PREFACE

Given Bhutan's vulnerability to the impacts of climate change, the nation has accorded climate change a high priority. The nation's commitment to remain carbon neutral while ensuring overall social-economic development reflects its vision to address the challenges of climate change and move towards a sustainable future.

The challenges of addressing climate change, particularly by developing and least developed countries have been recognized at various international forums. Technology transfer as a vital instrument to overcome these challenges has been identified by the UNFCCC in Article 4.5. Subsequently, the need and importance of technology transfer has been reiterated at various Conference of Parties (COP) of the UNFCCC. At COP 14 in 2008, the Poznań Strategic Program on Technology Transfer was adopted as a step towards *scaling up the level of investment in technology transfer in order to help developing countries address their needs for environmentally sound technologies.* As part of this programme, in 2010, on behalf of Global Environment Facility (GEF), the United National Environment Programme (UNEP) started the implementation of Technology Needs Assessment (TNA) for 36 countries.

Bhutan has undertaken the TNA process to identify, evaluate, and prioritize technologies that fit in the overall development context of the nation while allowing the country to combat climate change. The National Environment Commission Secretariat is the nodal agency for the TNA project and has constituted a TNA Task Force involving representatives from various sectors to provide inputs to the TNA project and most importantly in preparing the Technology Action Plan for identified technologies.

In the Part I of the TNA report, for each prioritized sub-sector in climate change adaptation and mitigation sectors one technology was prioritized based on a technology prioritization framework prepared through secondary research and rigorous stakeholder consultation. With a view of preparing the detailed technology action plans of the identified technologies, it was felt necessary to identify key barriers to technology development and deployment. The Barrier Analysis and Enabling Framework report, as part II of the TNA project, sets preliminary targets for diffusion of the prioritized technologies, identifies key barriers and suggests high level enabling measures that can address these barriers.

The entire process to set targets, identify barriers and enabling measures has been country-driven and highly consultative involving a number of stakeholders from various agencies in the government, civil society and private sector.

Ugyen Tshewang, PhD
Secretary
National Environment Commission

ACKNOWLEDGMENT

The National Environment Commission Secretariat (NECS) sincerely acknowledges the Global Environment Facility (GEF) for the financial support provided for the Technology Needs Assessment (TNA) project in Bhutan. We would also like to thank UNEP Risø Centre (URC) and Asian Institute of Technology (AIT) for their technical guidance during the course of the TNA. The NECS is particularly grateful to Mr. Gordon Mackenzie, TNA country coordinator for Bhutan, for coordinating all the activities between the NECS, AIT and URC.

We would like to thank all the TNA taskforce members for their valuable contribution in prioritization of sectors and technologies, and for their comments on the draft report.

Further, we express our sincere appreciation to Emergent Ventures India and Norbu Samyul Consulting for facilitating the TNA process and putting together the TNA report.

ABBREVIATIONS

3 Rs	Reduce, reuse and recycle
AIT	Asian Institute of Technology
BRT	Bus Rapid Transit
EVI	Emergent Ventures India
FYP	Five-year plan
GHG	Greenhouse gases
GIS	Geographic Information System
GNH	Gross National Happiness
ICT	Information and Communication Technologies
IEA	International Energy Agency
ITS	Intelligent Transport System
INC	Initial National Communication
LPA	Logical Problem Analysis
MoWHS	Ministry of Works and Human Settlement
MCDA	Multi Criteria Decision Analysis
NAPA	National Adaptation Programme of Actions
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
SNC	Second National Communication
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UNFCCC	United Nations Framework Convention on Climate Change

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Part II
Barrier Analysis and Enabling Framework Report

Executive Summary

In the Part I of the TNA report, technologies relevant to ameliorating the effects of climate change mitigation in Bhutan were selected and prioritized. For each prioritized sub-sector in climate change mitigation one technology was prioritized based on a technology prioritization framework which was prepared through secondary research and rigorous stakeholder consultation. As a precursor to developing detailed technology action plans of the identified technologies, it is imperative that key barriers be identified which the action plan should address. Although key barriers to the adoption of the mitigation technologies were duly considered by the TNA Task Force of Bhutan while prioritizing the technologies, in this report barriers that exist in diffusion of the technologies have been identified and an enabling framework for addressing these barriers has been developed.

A two step process was followed for barrier analysis and enabling framework development for identified mitigation technologies in Bhutan. In the first step, secondary research was conducted in which Bhutan's policies and other feasibility studies were referred to for the identified technologies. In the second step, a stakeholder workshop was organized in Paro, Bhutan in which TNA Task Force members provided their inputs on key barriers and the enabling framework. In addition sector specific roundtable discussions were conducted in the month of October 2012 to discuss in depth, sector wise barriers and resultant action plan.

The barrier analysis and enabling framework report primarily consists of setting preliminary targets for diffusion of the prioritized technologies and identifying key barriers and suggesting high level enabling measures that can address these barriers. A brief summary of this for each sector in mitigation is provided below:

Transport

The technology prioritized in the transport sector is the Intelligent Transport System (ITS). The target cities for ITS implementation have been identified as Thimpu and Phuentsholing where the technology will aim to enhance the effectiveness of public transport.

Barriers to application of these have been categorized broadly into economic and financial barriers and non-financial barriers. While high upfront cost in installing ITS have been identified as the key financial barrier, lack of technical capacity and policy uncertainty have been identified as key non-financial barriers.

There are various international funds which aim at promoting low carbon transport worldwide. These funds can be availed along with existing government fund allocations for promoting urban transport in Bhutan to address the financial barriers that exist in implementation of ITS in Bhutan.

Waste disposal on land

Commercial scale composting is the prioritized technology in solid waste sector in Bhutan. The target for commercial composting has been set for prominent urban centres including Thimpu, Pheuntsholing and other cities by 2015.

Key barriers for uptake of this technology have been high initial investment cost. In addition, non-financial barriers such as lack of technology know how and availability of a skilled work force is also hindering diffusion of commercial scale composting in the country. In addition, there is also limited information available regarding the potential and feasibility of setting up composting units in the country.

An enabling framework for attracting private sector participation can ensure diffusion of this technology in Bhutan. Proper financing support along with attractive policy incentives would be essential in this regard. Non-financial barriers could be removed by improving the technology knowledge base of this technology in the country by conducting detailed techno-economic studies and establishing partnerships for technology and knowledge transfer.

Manufacturing industries

Waste heat recovery has been prioritized as the top technology in manufacturing industries sector in Bhutan. The preliminary target for diffusion of this technology has been set for iron and steel and ferro alloy industries in Bhutan.

There has been very limited application of this technology in Bhutanese industries despite the huge potential of this technology in promoting industrial energy efficiency. While the high upfront cost of the technology is one of the financial barriers as with other technologies, the low rate of return and long payback period due to low energy prices in Bhutan has also been another financial barrier for uptake of this technology. Lack of policy and regulatory framework for promoting energy efficiency in industries, information about application of this technology and availability of technical experts are the key non-financial barriers for diffusion of this technology.

Financial support by creating funds (using domestic and international funds) for promoting energy efficiency in industries and attractive policy incentives could enable private players to set up waste heat recovery projects in their industries. To address non-financial barriers, establishment of an industrial energy efficiency policy and an institutional framework has been identified as the key enabling measure. Detailed market assessment and techno-economic feasibility studies for application of waste heat recovery technology has also been identified as one of the key steps in promoting this technology. Pilot projects and other initiatives that address market and information barriers are also considered potential enabling measures for diffusion of this technology in the country.

Chapter 1. Transport sub-sector

1.1 Preliminary targets for technology transfer and diffusion

Intelligent Transport System (ITS) is the prioritized technology in the transport sub-sector. The overall target for diffusion of this technology has been based on the existing national and sectoral plans, programmes and policies. Primarily, based on the Transport Policy of Bhutan and more specifically the Surface Transport Master Plan of Bhutan, 2007[1], the target is to introduce, as part of the ITS, an automated vehicle tracking system based on Global Positioning System (GPS) integrated with GPRS communication system and Geographic Information System (GIS) mapping for passenger buses. The target is also to set up IT-based information systems such as the Advanced Traveler Information Systems and e-ticketing systems for urban public transport and inter-city passenger bus services. The initial target would be to introduce these technologies in congested towns of Bhutan like Thimpu and Phuentsholing where the impact of the technology would be quite significant.

In line with the targets set for the 11th FYP for the transport sector under the TNA project as well following were targets were set to be achieved.

- The Road, Safety and Transport Division under the Ministry of Information and Communication with the objective of improving the management of public transport systems will set up Regional Transport Offices in cities of Thimphu, Phuentsholing, Gelephu and Samdrup Jongkhar during the 11th FYP period (by 2013-2018). The district of Mongar is also being proposed for the same. In addition an objective of setting up Information Display Boards on all bus terminals for inter district transport during the 11th FYP period has been set.

- Plans are also underway plans for setting up Automatic Vehicle Fitness and Emission Testing Centres at four cities, namely: Thimphu, Phuentsholing, Gelephu and Samdrup Jongkhar also during the 11th FYP plan period.

- Introduction of e-ticketing and use of smart cards for within city transport is already underway and the division targets to expand this for inter-district transport as well.

- In the longer term the division also targets to introduce Public Information System in Buses plying on cities as well as inter district routes.

1.2 Barrier analysis and possible enabling measures for Intelligent Transport System

1.2.1 General description of the technology

Intelligent Transport System (ITS) basically refers to the application of information and communication technologies to vehicles and to transport infrastructure. It is primarily an ICT based system primarily designed to improve operational and managerial efficiency of transport system in general and public transport in particular. Some examples of transport management systems include GPS based optimization of public transport, computerized traffic signaling, information systems such as e-ticketing, e-information etc. Such systems increase the reliability, safety, efficiency and quality of transport systems in general and public transport in particular. An increase in the efficiency of the public transport system also leads to a reduction in associated GHG emissions.

[1] Surface Transport Master Plan of Bhutan, 2007

ITS in Bhutan is targeted to focus on public/bus transport and overall transport system in cities. Key components could be:

- Establishing a centralized traffic control centre to handle the operational requirements of traffic. This traffic monitor system will enable effective management through a Decision Support system by collecting, collating and storing information on real time basis which can aid in decision making while formulating transport policies. The network surveillance could be done with CCTV Cameras. The traffic monitor center can facilitate timely intervention in situations of congestions and accidents and plan diversions in case of emergency. Therefore the central monitor centre could also be used for traffic surveillance and important junctions could be monitored remotely.
- § GPS based automatic vehicle tracking system.
- § Introducing LED display boards at all the bus-stops and terminals in the cities as well as districts to provide real time information about bus operations
- § Public Information System in Buses plying on cities as well as inter district routes
- § E-ticketing and smart card facilities for inter district passenger transport (already being planned for within city transport)
- § Information services for passengers through SMS
- § Setting up of automated fitness and emission testing centres (already being planned for 4 cities)

1.2.2 Identification of barriers for the technology

In order to identify barriers for technology development and diffusion, market maps were prepared for each technology. By this method, the group of experts discussed and exchanged information to build up a comprehensive picture of the entire existing system elements related to the development of new technology. The relevant factors building this market included:

- Environment that allows the introduction of new technologies (such as legal, institutional, organizational, cultural, geographical, economic and social conditions)
- The relevant object in the system (such as manufacturers, wholesalers, retail dealers, consumers, households producers)
- Supporting services (such as finance, quality management, performance, standards, etc)

In the first step, secondary research was conducted in which Bhutan's policies and other feasibility studies were referred to for the identified technologies, based on which a market map was created. In the second step, a stakeholder workshop was organized in Paro, Bhutan in which TNA Task Force members provided their inputs on key barriers and the enabling framework. Following this, focused sector specific roundtable discussions were held in Thimphu, Bhutan at NEC, with relevant experts to seek specific information on barriers and enabling measures for each technology.

However, market mapping was applied only for those technologies which are classified as consumer and capital goods. The detail of market maps for these categories of mitigation technologies are presented in the Annex 2.

Further, Logical Problem Analysis (LPA) tool has been used to identify and analyse the barriers for each technology across the sectors of mitigation, as well as for finding measures to overcome the identified barriers. The problem trees have been prepared based on discussions held with Bhutanese sector experts and TNA taskforce members.

Similarly for identifying and analyzing the enabling measures, measure result relations were discussed, to arrive at enabling measures for each technology. Annex 2 presents this methodology in detail.

The identified barriers and measures to overcome these barriers are mentioned below.

1.2.2.1 Economic and financial barriers

The main economic barrier for transport management systems is the huge investments required to set up the system in the country. Investments would be needed in setting up the infrastructure such as for traffic detectors, road-side information displays, IT- based communication systems, GPS systems etc. Subsequent investment would also be needed to continuously upgrade the systems and also for effectively operating and maintaining the systems.

For instance, the Surface Transport Master Plan of Bhutan (2007) identifies installation of communication systems integrated with tracking components for public transport as an important measure for managing the transport systems in the country. Such a system would play an important role in improved traveler advisory services, schedule adherence and could be archived to support future planning efforts that minimize GHG emissions. For such a system, the communication network available in Bhutan would have to be considerably upgraded to ensure coverage of all areas on the road corridor. It is estimated that the cost of setting up the infrastructure would be to the tune of Nu. 20 million (USD 0.36 million). The GPS unit mounted on each vehicle would cost approximately Nu. 25,000 (USD 450). Bringing in such huge investments for transport management system is a significant barrier, hindering its implementation.

These high costs are in turn due to factors such as difficulty in acquiring the needed land, limited ridership and limited investment capacity of the private players.

In Bhutan, acquisition of land is an impending issue, which leads to high land price. This is particularly true while planning for terminals. With land cost being one of the primary costs associated with development of ITS, costly land makes the entire process particularly investment heavy.

This coupled with limited ridership, due to low population; economies of scale are not reached, making ITS further cost intensive. Private players in Bhutan have low investment capacity which makes them unable to invest in such high cost intensive propositions as ITS. High subsidy requirements in turn further jeopardizes the sustainability of the program.

All these factors together contribute to economic and financial barriers to development of ITS in Bhutan.

1.2.2.2 Non financial barriers

In addition to economic and financial barriers several non financial barriers emerged out of the discussions held with the stakeholders as well as through the LPA process. These include:

- **Policy, legal and regulatory**

In Bhutan, the transport policies and regulations are mostly outdated having being developed in 1999. Such as the RST Act and Regulation which was developed in 1999. Thereby these do not reflect the needs of the current time, and require updating and revisions.

In addition in the current policy there is no focus particularly on development of sustainable transport systems, such as the Transport Policy 2006. The policies need to be amended to include specific portions on mass transit and ITS.

- **Institutional**

Currently, in Bhutan the transport sector is governed by different Ministries looking into varying mandates of transport. The Ministry of Information and Communication with its Road, Safety and Transport (RST) division currently looks into overall policy and planning related aspects of the sector. Ministry of Home and Cultural Affairs is responsible for looking after the Dzonkhags and traffic police whereas Ministry of Works and Human

Settlements for Thromdes. There is an ensuing proposal for re-structuring of the institutional structure, with a probability of creation of a separate ministry of transportation.

Though under the current institutional structure there are different departments looking in different aspects of transportation, there is still serious issue of limited resources which restricts the development and adoption of ITS in the country. There are few technical transport experts and professionals in RSTA at present (2-3 experts). Overall there is limited institutional capacity to plan, implement and operate new technologies. Even there is no dedicated traffic police in remote areas and traffic ends up being managed by non-transport professionals

Poor coordination between planning and implementing agencies with overlapping mandates between RSTA and City Planners poses a significant institutional barrier. In addition implementation of PPP model faces concerns regarding coordination with transport authorities and less willingness of private players in being part of such partnerships.

§ **Technical**

No specific ITS related impact assessment studies are available in order to assess the needs and benefits of such a system. Though an IFC funded study for implementation of BRT has been conducted for the city of Thimphu, no such studies exists for other cities.

In addition limited infrastructure and enforcement e.g. weigh bridges often acts as a hindrance in planning of ITS in Bhutan as well as difficult terrain and topography hinders the uptake of many new technologies.

§ **Information and awareness**

There is alot which needs to be done in terms of raising awareness of using Mass transit systems and building the related knowledge. Currently, the benefits and impacts of ITS is not known to local transport experts and general public at large.

1.2.3 Identified measures

1.2.3.1 Economic and financial measures

The constraint of huge capital costs for transport management systems and ITS could be overcome by availing international financing options in low carbon and sustainable transport. These financing opportunities can be in form of Grants, Loans and Technical Assistance. The country can utilize these opportunities in areas of creation of concepts and plans, setting of infrastructure, operations management, technology transfer and capacity building.

In order to facilitate this, it is imperative to develop a detailed project implementation plan. Following measures could be undertaken:

- A detailed technology report for ITS implementation at the selected sites in terms of equipment required, setting up Automated Vehicle Fitness and Emission Testing Centres etc, will need to be prepared.
- Next step, a detailed implementation plan assigning responsibilities across organizations within Bhutan will need to be prepared.
- Based on technology report, financial support will need to be sought. This could either be from domestic budgetary allocations, international funding etc.

MoIC and RSTA could coordinate with city authorities for preparation of such project design. Guidelines could be assigned to city authorities for designing such a programme. The project designing could focus first on cities/towns of Thimphu, Phuentsholing, Gelephu, Samdrup Jongkhar and Mongar.

1.2.3.2 Non financial measures

Various measures that could be implemented to overcome some of the impending non-financial barriers are:

§ **Overcoming technical barriers**

In wake of lack of any impact assessment studies of ITS in Bhutan, it is imperative to first conduct these studies. It is important to study the areas of implementation of ITS and potential impact on traffic, congestion, safety and environment. These could be conducted particularly for the towns of Phuentsholing, Gelephu, Samdrup Jongkhar, Mongar, Paro, Bumthang, Khuruthang (Punakha), Bajo (Wangdue), and Haa. In order to do so, as first step potential study sites would need to be identified. Case studies on similar lines of other countries could be studied. A specific agency for conducting the study along with funding options will need to be appointed.

§ **Building institutional support**

In order to strengthen the institutional structure for development and implementation of ITS, it emerged that setting up Automated Vehicle Fitness and Emission Testing Centres across the towns/cities of Thimphu, Phuentsholing, Gelephu, Samdrup Jongkhar and Mongar is needed. These centers could be established under current regional transport offices and in collaboration with similar international organizations. International funding options could be explored along with domestic budgets under FYP for setting up these centres.

Inaddition, to overcome overlapping mandates and tasks of different organizations looking into aspects of transportation in Bhutan, specific and independent mandates to different departments and ministries with regard to ITS should be assigned. What is also required is restructuring of the organizations currently looking into transport sector. This could potentially be done by bringing Roads, Safety, Transport (RSTA)and Human Settlement under a renamed Ministry called the Ministry for Transport and Human Settlement (MoTHS) thus integrating Land Use and Transport.

§ **Regulatory and policy support**

It is important for policies, regulations and acts to reflect the needed importance for developing ITS in the country and providing the required support. It is important to revise the current Bhutan's Transport policy, Act and regulations to include implementation of ITS in country. This could potentially be done by revising policies, Acts and regulations in consultation with stakeholders. A review of similar polices in other countries, which have already implemented ITS should also be undertaken. A cost benefit analysis of likely policy amendments in terms of impact assessment should also be conducted before the actual revision of policies.

§ **Information and awareness**

Awareness campaigns regarding the benefits of ITS measures in reducing congestion, reducing pollution and improving productivity to current engineers, operators, traffic police and potential engineers are required to be undertaken. Awareness campaigns for general public towards using ITS and its benefits should also be conducted.

In order to do this it is important to design a national level awareness and capacity building campaign consisting of:

- Conference, study visits and training of transport department personnel for the selected cities
- Workshops, street plays, advertisements (through print and audio/visuals) for general public for selected cities

Chapter 2. Solid waste disposal on land

2.1 Preliminary targets for technology transfer and diffusion

Composting of waste has been prioritized as the top technology option in solid waste disposal sector in Bhutan. The overall target to develop this technology has been based on the national and sectoral strategies, plans and programs such as the Waste Prevention and Management Act of Bhutan and plans of various city authorities. As per the Waste Prevention and Management Regulations, each Thomde is required to create an enabling environment for waste recycling to be a viable business opportunity to the private sector by providing technical support, leasing of land, government subsidy and through initiation of collaborative waste recycling projects with the private sector when deemed feasible. It also specifies that composting either on commercial scale or on a community level shall be the proffered method for organic waste management. Thromdes on its own initiative or through arrangement with the private sector, should provide such facilities.

As per discussions with several stakeholders as part of the TNA process, it emerged that the preliminary target is to set up commercial scale composting systems at prominent urban centers such as Thimpu, Phuentsholing, Samtse, Gelephug, Samdrupjongkhar, Deothang, Trashigang, Rangjung, Yangtse, Mongar, Chamkhar, Trongsa, Bajo, Khuruthang, Paro and Haa. In terms of timelines, as per the existing government plan the city of Thimpu targets to have a commercial composting system by the end of 2013 and other major cities by 2015. Currently, the country is in the process of developing a National Strategy on Integrated Waste Management for Bhutan. It is expected to be completed by December 2012. In 11th FYP as well, it is expected some budget allocations will be provided for waste management.

2.2 Barrier analysis and possible enabling measures for composting

2.2.1 General description of the technology

The term composting is defined as biological degradation of waste under controlled aerobic conditions. The waste is decomposed into CO2, water and the soil amendment or mulch. In addition, some carbon storage also occurs in the residual compost.
Figure **1** illustrates the process of composting.

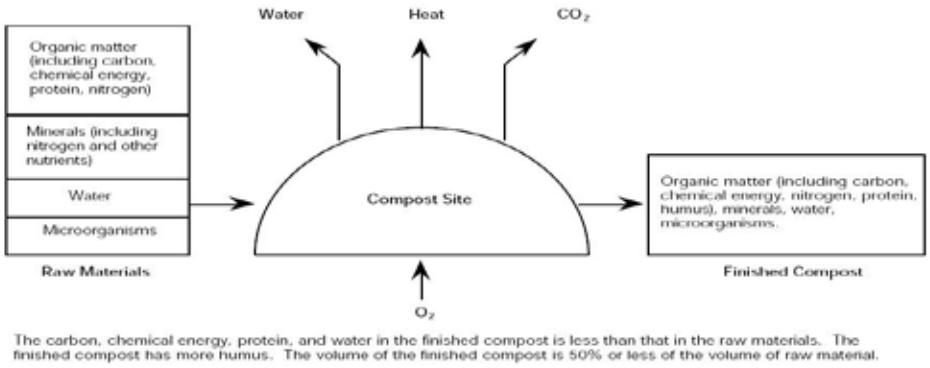

Figure 1: The composting process

Source: Rynk, et al., 1992[2]

Three composting techniques that are available to compost biosolids are windrow, aerated static pile, and in-vessel composting. Each technique varies in procedures and equipment needs. Other variations between the technologies are issues such as air supply, temperature control, mixing, and the time required for composting

2.2.2 Identification of barriers for the technology

In order to identify barriers for technology development and diffusion, market maps were prepared for each technology. By this method, the group of experts discussed and exchanged information to build up a comprehensive picture of the entire existing system elements related to the development of new technology. The relevant factors building this market included:

- Environment that allows the introduction of new technologies (such as legal, institutional, organizational, cultural, geographical, economic and social conditions ...)

- The relevant object in the system (such as manufacturers, wholesalers, retail dealers, consumers, households producers ...)

- Supporting services (such as finance, quality management, performance, standards, etc ...).

In the first step, secondary research was conducted in which Bhutan's policies and other feasibility studies were referred to for the identified technologies, based on which a market map was created. In the second step, a stakeholder workshop was organized in Paro, Bhutan in which TNA Task Force members provided their inputs on key barriers and the enabling framework. Following this, focused sector specific roundtable discussions were held in Thimphu, Bhutan at NEC, with relevant experts to seek specific information on barriers and enabling measures for each technology.

However, market mapping was applied only for those technologies which are classified as consumer and capital goods. The detail of market maps for these categories of mitigation technologies are presented in the Annex 2.

Further, Logical Problem Analysis (LPA) tool has been used to identify and analyse the barriers for each technology across the sectors of mitigation, as well as for finding measures to overcome the identified barriers. The problem trees have been prepared based on discussions held with Bhutanese sector experts and TNA taskforce members. Similarly for identifying and analyzing the enabling measures, measure result relations were discussed, to arrive at enabling measures for each technology. Annex 2 presents this methodology in detail.

The identified barriers and measures to overcome these barriers are mentioned below.

2.2.2.1 Economic and financial barriers

The key financial barrier for the creation of commercial level composting plants is the lack of financing mechanisms for such projects. Also, lack of incentives generally serves as a hindrance for private players to set up such plants.

The high cost of setting these plants is often associated with high land costs due to unavailability of land. Also, due to less population, a comparatively lesser proportion of compost is generated, economies of scale are not reached, and making these plants unattractive to investors.

2.2.2.2 Non financial barriers

The following were identified as the key non-financial barriers for setting up composting plants:

§ **Technical**

[2] In ClimateTechWiki, available at http://climatetechwiki.org/technology/jiqweb-abt-0, accessed on 6 August 2012.

There is lack of latest feasibility studies to identify and prioritize potential sites for setting up composting plants as well as the financial requirements of setting up the technology. In wake of lack of such studies no comprehensive strategy for implementation of composting has been established.

Also, there is lack of technical know-how on technology domestically thus posing issues with regard to setting up and operation of the plants. There is also lack of infrastructure at the municipal level for collection and segregation of waste. The poor collection and segregation of waste leads to less raw material generation for successful running of composting plants.

Not only sufficient availability of compostable waste is an issue but also unavailability of viable sites for setting up commercial composting plants, restricts setting up of such plants. This is particularly true for urban centers, where most spaces are available on the outskirts, and issues related to transportation of the compost then arise, often increasing costs. What is also an issue is the unwillingness of people to accept composting plants around their place of stay or work which is another barrier that makes it even more difficult to obtain viable sites.

- **Information and awareness**

There is also limited societal awareness in terms of benefits of waste management (health benefits) (financial benefits) and practice on waste segregation at source is one of the key barriers in the country. This also leads to the problem of unavailability of proper compostable raw (waste) material to operate the plant effectively. There have been no awareness or capacity building programs conducted so far in order to improve the awareness and sensitivity levels of the people towards proper waste management.

- **Lack of well defined institutional structure**

Currently, National Environment Commission is the overall coordinating agency also looking at regulatory aspects of waste management in the country. In terms of implementing agencies, there is yet no formal structure in place, it is currently informally undertaken by city corporations. There is thereby a need to develop formal institutional structure for waste management also looking at composting for the country.

2.2.3 Identified measures

2.2.3.1 Economic and financial measures

In order to overcome high financial costs associated with setting up composting plants, it is recommended to establishing clear procedures for providing incentives or subsidies for encouraging private participation in composting ventures to facilitate the availability of necessary finance. This could potentially be done by using domestic and international funding sources to provide incentives for promoting public private partnerships in setting up composting plants. These funding sources could be used to provide incentives such as tax rebates, custom duty exemptions on import of related equipment for e.g.

Such incentives are already mentioned in the Economic Development Policy and Waste Prevention and Management Act. The same could be promoted using domestic and international funding sources.

2.2.3.2 Non financial measures

Various measures that could be introduced in Bhutan to overcome the non-financial barriers could potentially include:

- **Overcoming technical issues**

As a first step it is crucial to undertake feasibility studies to identify and prioritize potential sites for composting as well as the financial requirements of setting up the technology. This is important to showcase to the policy developers, municipalities, financial institutions, technology suppliers and other market players regarding the market potential of composting technique in Bhutan for waste management. It will help overcome current unavailability of viable composting sites.

This will also help assess the overall waste management potential of the technology and possible estimate of finances required and cost recovery period. In order to do this, following could steps could be undertaken:

- Identify organizations to undertake such studies
- Document results of such studies and disseminate the collated knowledge
- Inspect the selected sites for application of the technology
- Preliminary identification of potential sites for setting up composting plants with the help of waste management experts within and outside the country.
- Estimate amount of waste generation from the potential sites
- Study to assess the scale and size of composting plants based on techno-economic feasibility analysis
- Assessment of financial and technical capabilities of required for setting up and operating the plants.

In addition to carrying out such studies it is also important to provide the needed support infrastructure for waste management through composting. Currently municipalities face constraints for waste collection and segregation due to lack proper facilitating infrastructure for this. In order to ensure a proper functioning and supply of compost to composting plants it is essential to develop this support infrastructure.

§ **Designing a formal institutional structure for waste management**

In wake of lack of any formal structure for waste management and also facilitate setting up of composting plants, it is important to design a formal institutional structure for management of waste in the country. It is crucial to have a formal system of waste management in the country with specific institutions looking into waste management aspects with clearly defined responsibilities. Key components of constructing such a structure would be:

To identify specific organizations looking into following specific aspects:

§ Policy, Regulation and M&E aspects of waste management (with composting being one of them)
§ Undertaking planning and technical support
§ Providing financial support
§ Implementing agencies

A possible institutional structure could consist of following bodies in hierarchy:

- For policy and regulation aspects- NEC
- Planning and technical aspects- MoWHS (potentially a specific division looking into waste management issues)
- Financial aspects- Ministry of External Affairs and Ministry of Finance
- Implementing Agencies- Thromdes, Dzonkhags, Municipalities/Gewog/Villages

In addition, it is important to built capacity of these institutions to carry out effective waste management and also facilitate implementation of composting plants in the country. Currently, NECs capacity is limited in terms of technical human resources and it requires experts in technology evaluation and its monitoring. The understanding and management potential of the municipalities is also very limited for managing. In order to ensure these following steps could be undertaken:

§ Design and undertake intensive training programmes focusing for:
  - NEC: on technology evaluation and monitoring
  - Municipality: on approaches, concepts, planning and budgeting for setting up and managing composting plants specifically

§ MoWHS to potentially have a separate dedicated division looking at integrated solid waste management (including composting) for planning, budgeting and hardware execution

§ **Awareness campaigns and information generation**

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In order to build awareness regarding composting, it is important to disseminate information and awareness through campaigns on the technology and its benefits at both municipal and household level. In order to do this, following steps could be undertaken:

- Develop content of such campaigns
- Develop campaign material, in form of brochures, pamphlets etc
- Door-step communication on segregation and storage
- Occasional clean-up campaigns on littering and indiscriminate disposal
- Use of print and electronic media, flyers, movies, etc.

These are essential to create awareness and inculcate practice of segregation of waste at source, and help accept people to have composting plants around their place of stay and work.

Chapter 3. Manufacturing industries

3.1 Preliminary targets for technology transfer and diffusion

In the manufacturing industries sector, Waste Heat Recovery (WHR) has been prioritized as the key mitigation technology option. The application of this technology has been very limited in Bhutan. However, the fast growing manufacturing industries which are hugely dependent on grid offer a huge potential of energy efficiency and emission reduction.

The long term targets to be achieved through diffusion of waste heat recovery technologies in power intensive industries in Bhutan are:

- Promote sustainable and efficient industrial growth in the country by enhancing energy efficiency
- Promote energy efficiency and reduce dependence on imported electricity during winter
- Improve specific energy consumption of industries and reduce pollution

Although there has not been any specific energy efficiency policy for industries in Bhutan, the carbon neutral strategy of the country and the second national communication to UNFCCC has clearly identified the importance of industrial energy efficiency in climate change mitigation. The Department of Renewable Energy under the Ministry of Economic Affairs has also identified the importance of energy efficiency in the manufacturing industries in Bhutan and has initiated baseline studies to develop strategies and energy efficiency policy for the country.

Based on the stakeholder consultation primarily with the Department of Renewable Energy, Department of Industries and major private manufacturers in Bhutan, the specific target for diffusion of waste to heat recovery technology has been set for the Iron and Steel industries and Ferro Alloy plants in the country. These two industries provide the maximum potential due to opportunities of trapping waste heat from boilers, stacks and by-products. In absence of any study done on energy efficiency and waste heat recovery potential in industries in Bhutan, the technology diffusion target can only be set after initial feasibility studies. Based on preliminary technology analysis, industry data and stakeholder consultation, it can be assumed that nearly 50% of the waste heat can be recovered and around 5-10% of energy efficiency can be achieved based on the actual applications.

3.2 Barrier analysis and possible enabling measures for industries

3.2.1 General description of the technology

Waste heat is heat generated in a process or operation due to fuel combustion or any chemical reaction, which is then wasted into the environment and is not used for any economic purposes. This waste heat if recovered and used for economic purpose prevents consumption of fossil fuel. Methods of waste heat recovery includes transfer of heat for cooling requirements, preheating purposes, transferring heat to load which is about to enter furnace, generating mechanical or electrical power and using heat pump for heating or cooling purpose. Various equipments such as Heat Exchangers, Vapor Absorption Machines (VAM), Recuperators, Regenerators, waste heat boilers, heat pumps are utilized for purpose of waste heat recovery. For implementation of WHR projects in industries three components are studied essentially which include i) source of waste Heat ii) a feasible technology for recovery iii) a use for recovered energy (Figure 2)[3].

[3] https://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/waste_heat_recovery.pdf last accessed on 15th October 2012

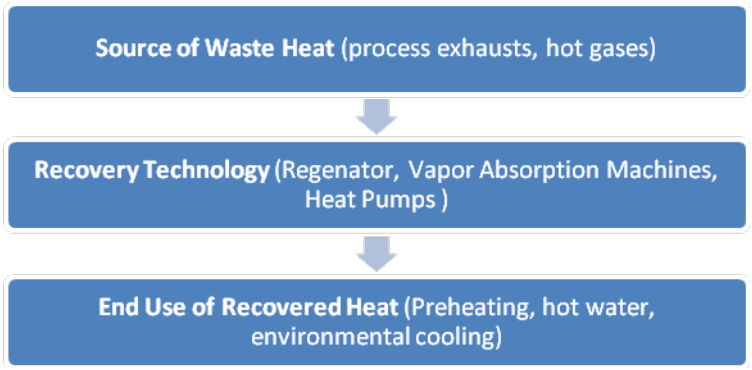

Figure 2: Key components of WHR

In Bhutan, the waste heat source is primarily available with Iron & Steel and Ferro Alloy industries. Since the size of industries is quite small, the temperatures of heat sources in the industries are comparatively low. According to the Bhutan Industry Association, the temperature of waste heat (in form of steam) in Ferro Alloy industry is nearly 300 degree Celsius. For this temperature range, the recovered heat may not be used for power generation and other conventional applications as compared to waste heat recovered from large iron and steel industries where temperature of heat sources is as high as 1000 degree centigrade.

However, through use of Vapor Absorption Machines (VAM) using waste steam at 300 degree Celsius environmental cooling and chilled water production is feasible. VAM could be used with steam pressure as low as 0.5 KG/cm^2. In addition, heat pump can also be used to extract heat from cooling water (used in chillers) and reduce energy consumption required for water heating in industries. Absorbption Heat Pump generates the hot water based on 75% heat from heat source (e.g. diesel, steam, gas). Hence 25% Heat source (diesel, gas, steam) is saved. The concept is shown in the below figure.

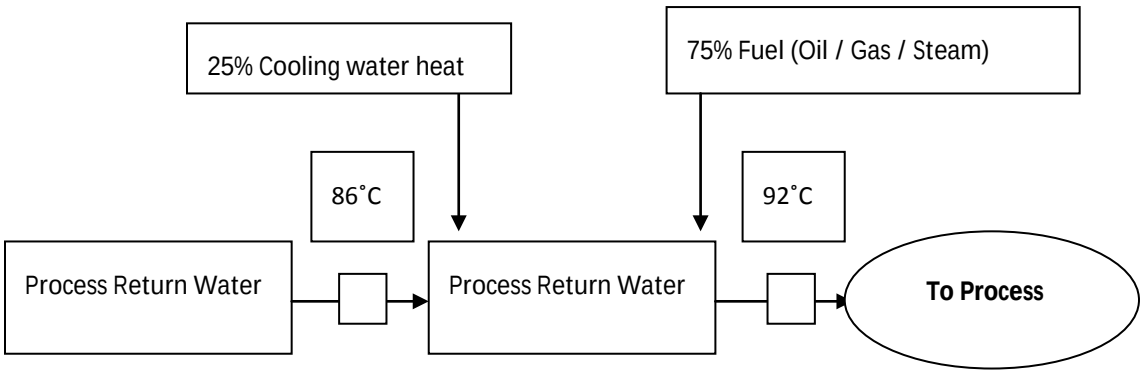

Figure 3: Illustration of energy efficiency through use of Heat Pump

Therefore, the recovered waste heat in Bhutan's industries can be best utilized for water heating, room heating/cooling and other process heat requirements. In addition, since the industries in Bhutan are located in close vicinity, waste heat recovery can be done in cluster basis and the heat utilized from one industry can be used in other industry as process input.

3.2.2 Identification of barriers for the technology

3.2.2.1 Economic and financial barriers

High capital cost due to unavailability of technology domestically is one of the key barriers to deployment of waste heat recovery technologies in Bhutan. Due to small scale of the industries in Bhutan, their capacity to invest equity is also limited.

The high capital cost is supplemented by the low economic return due to cheap grid electricity prices in Bhutan. In absence of financial and fiscal incentives for energy efficiency projects in industries in Bhutan, the energy efficiency sector in general is economically unattractive for investors and financial institutions.

3.2.2.2 Non financial barriers

The following were identified as the key non-financial barriers:

a. Policy, legal and regulatory

There is no specific policy of government to promote energy efficiency in manufacturing industries in Bhutan. Also, there are no specific industry energy efficiency standards and regulations that act as driver for energy efficiency in industries in Bhutan.

b. Technical

The size of Iron and Steel and Ferro alloy industries in Bhutan is relatively small for typical waste heat recovery technology implementation. The temperature of heat sources from these industries is in range of 300 degree or less as compared to 500 to 1000 degree Celsius in large industries[4] which limits the application of recovered energy from the waste heat stream for useful purposes. Also there is limited knowledge about the application, operation and maintenance of the WHR technologies in Bhutan both in the industries as well as in government departments.

c. Institutional

Currently, the Department of Renewable Energy has a mandate to promote energy efficiency in industries with limited involvement of the Department of Industries. However, there is no specific division in these departments which purely focuses on industrial energy efficiency. Also, currently there are no specific institutions which have mandates to support technical standards, promote technical knowhow, conduct research and development and promote markets. In addition, there is also limited availability of service providers such as energy auditors in the country. Within the industries also, there are no energy management cells to assess energy efficiency opportunities.

d. Market

Industries, financial institutions, technology suppliers and policy makers have limited information about the market size and potential of suitable WHR technologies in manufacturing industries of Bhutan. Also, there are no demonstration projects implemented in the country which can provide relevant information to the market players regarding technology application and deployment.

[4] http://www.beeindia.in/energy_managers_auditors/documents/question_bank/2.8_Waste_Heat.pdf last accessed on 15th October 2012.

3.2.3 Identified measures

3.2.3.1 Economic and financial measures

- Capital subsidies for purchase of equipments, energy audit and detailed project report preparation. International climate finance can be utilized in this regard.
- Fiscal incentives such as accelerated depreciation and reduced import duty of WHR project equipments
- Easy access to capital through dedicated low interest credit lines from international development banks
- Creation of credit risk guarantee and venture funds to enhance finance flow using public fund and international funds. These funds could be created under the Renewable Energy Development Fund as proposed under the draft renewable energy policy of Bhutan.

3.2.3.2 Non financial measures

Policy and regulatory measures

- Develop a national level energy efficiency policy for promoting energy efficiency in industries in Bhutan. The Department of Renewable Energy of Bhutan has initiated this process recently with an energy efficiency baseline study of the entire country with support from the UNDP, Bhutan.
- Create an energy efficiency fund as a part of the Renewable Energy Development Fund proposed under the draft renewable energy policy. Such funds can also be created under the economic development policy of Bhutan. This can be done by the Ministry of Economic Affairs, Bhutan through its Department of Renewable Energy and Department of Industries.
- Develop specific energy consumption guidelines for industries. This can be done by the Bhutan Standards Bureau in consultation with Department of Renewable Energy and Department of Industries.

Institutional framework development

- Strengthen existing institutions to promote energy efficiency in industries and application of waste heat recovery technologies. In this context, the research and development division under the Department of Renewable Energy and Department of Industry can be strengthened by enhancing their knowledge base and providing them with adequate resources. In addition, the College of Science and Technology, Bhutan can also be promoted as the lead academic institution to carry out relevant research and development work in energy efficiency.
- Enhance coordination among various departments as there are certain overlaps in mandates regarding promoting energy efficiency in industries. Currently, the Department of Renewable Energy has an energy efficiency division which interacts with department of industries for developing strategies for promoting energy efficiency and renewable energy in Bhutan. In long term, a separate energy efficiency department can also be formed under the Ministry of Economic Affairs.
- Collaboration with reputed international technology providers and research institutions

Market support and technical measures

- Conduct potential assessment and benefit cost analysis studies of WHR technologies using preliminary walk through audits and detailed investment grade audits of industries.
- Generate awareness by facilitating technology supplier and industry interactions through technology exhibitions, trade shows, workshops and conferences.
- Set up demonstration projects of waste to heat recovery technologies to provide relevant information to market players and policy makers.

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- Capacity building and training programs for industries, operators and energy auditors for proper assessments, implementation and operation and maintenance of WHR technologies.

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Annex I. Market Maps and Problem Trees

A proposed method for technology innovators to find barriers and problems is by mapping market. By this method, the group of experts discuss and exchange information to build up a comprehensive picture of the entire existing system elements related to the development of new technologies. The relevant factors that are mainly considered include:

- Environment that allows the introduction of new technologies (such as legal, institutional, organizational, cultural, geographical, economic and social conditions ...)
- The relevant object in the system (such as manufacturers, wholesalers, retail dealers, consumers, households producers ...)
- Supporting services (such as finance, quality management, performance, standards, etc ...).

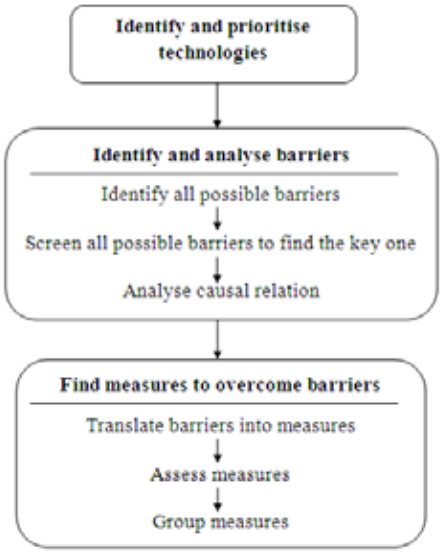
Based on this picture, Bhutan TNA Taskforce members and other stakeholders identified existing problems in the system, from which barriers were found for each technology.

The market mapping is only applied for technologies which are classified by consumer and capital goods. For mitigation technologies, there are no technologies of capital goods categories, but only one of consumer goods category such as the waste heat recovery.

For example, for technology of drought waste heat recovery, the market chain includes import, distribution, dealers and industries.

Next, the main related-market chain factors in the transfer and diffusion process of new technology are defined as: geographical conditions, cost, production cycle, infrastructure etc. On the basis of identified barrier, we can also provide some solutions to overcome the barrier such as identifying possible areas of conversion, pilot demonstration or researching to develop technology that can suitable for many localities. Or for cost factor, whether technology needs high investment or not and if the investment is high, this will be an obstacle for industries for adopting the technology. Therefore, cost is also considered as a barrier. Accordingly, one of the solutions given is: setting up of the funds ... Similarly other barriers are determined and the solutions overcoming barriers are also given in parallel in the transfer and diffusion of this new technology.

The Figure below presents the process used for arriving at the final list of barriers and enabling measures.



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Identifying and analysing barriers and finding measures to overcoming barriers

Logical Problem Analysis (LPA) tool has been used to identify and analyse the barriers for each technology across the sectors of mitigation, as well as for finding measures to overcome the identified barriers. The LPA enabled to arrange the observed problems into a hierarchy of causes and effects, with each problem being linked to causes and effects and creating a multi-level cause and effect pathways to form a problem tree. The problem trees have been prepared based on discussions held with Bhutanese sector experts and TNA taskforce members. Similarly for identifying and analyzing the enabling measures, measure result relations were discussed, to arrive at enabling measures for each technology.

Problem trees for the three technologies under mitigation are presented below.

Annex II

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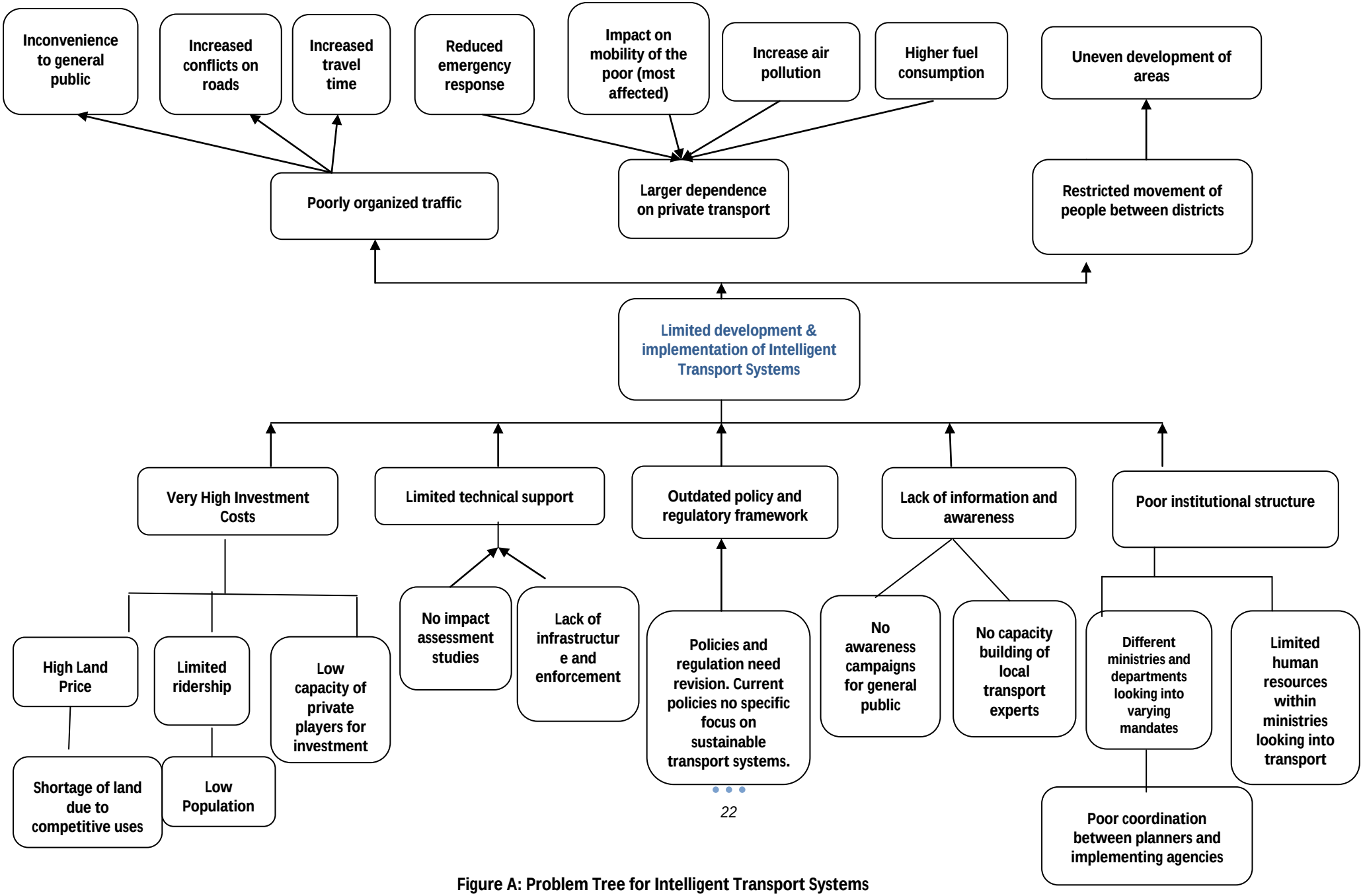

Figure A: Problem Tree for Intelligent Transport Systems

Annex II

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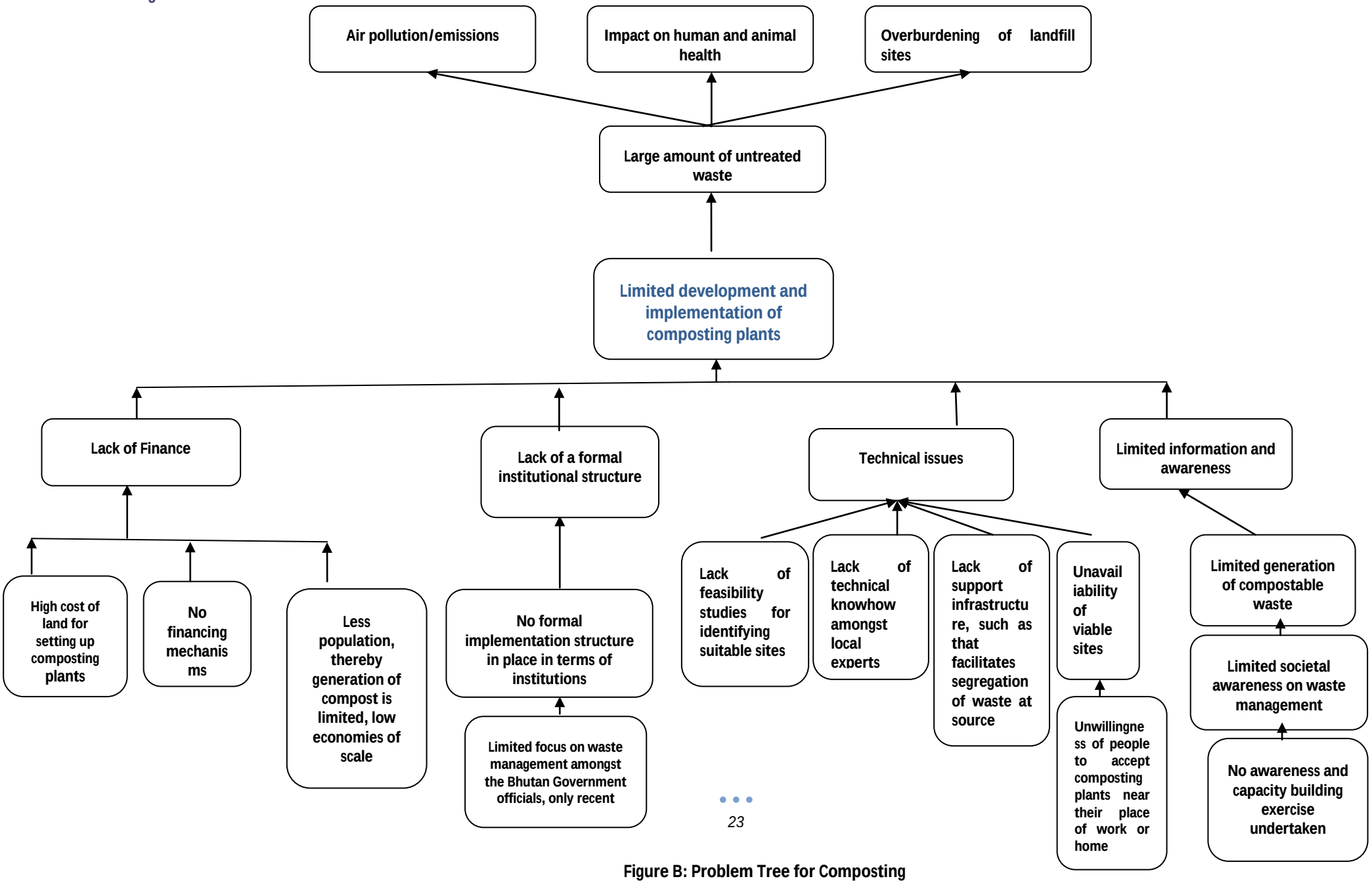

Figure B: Problem Tree for Composting

Annex II

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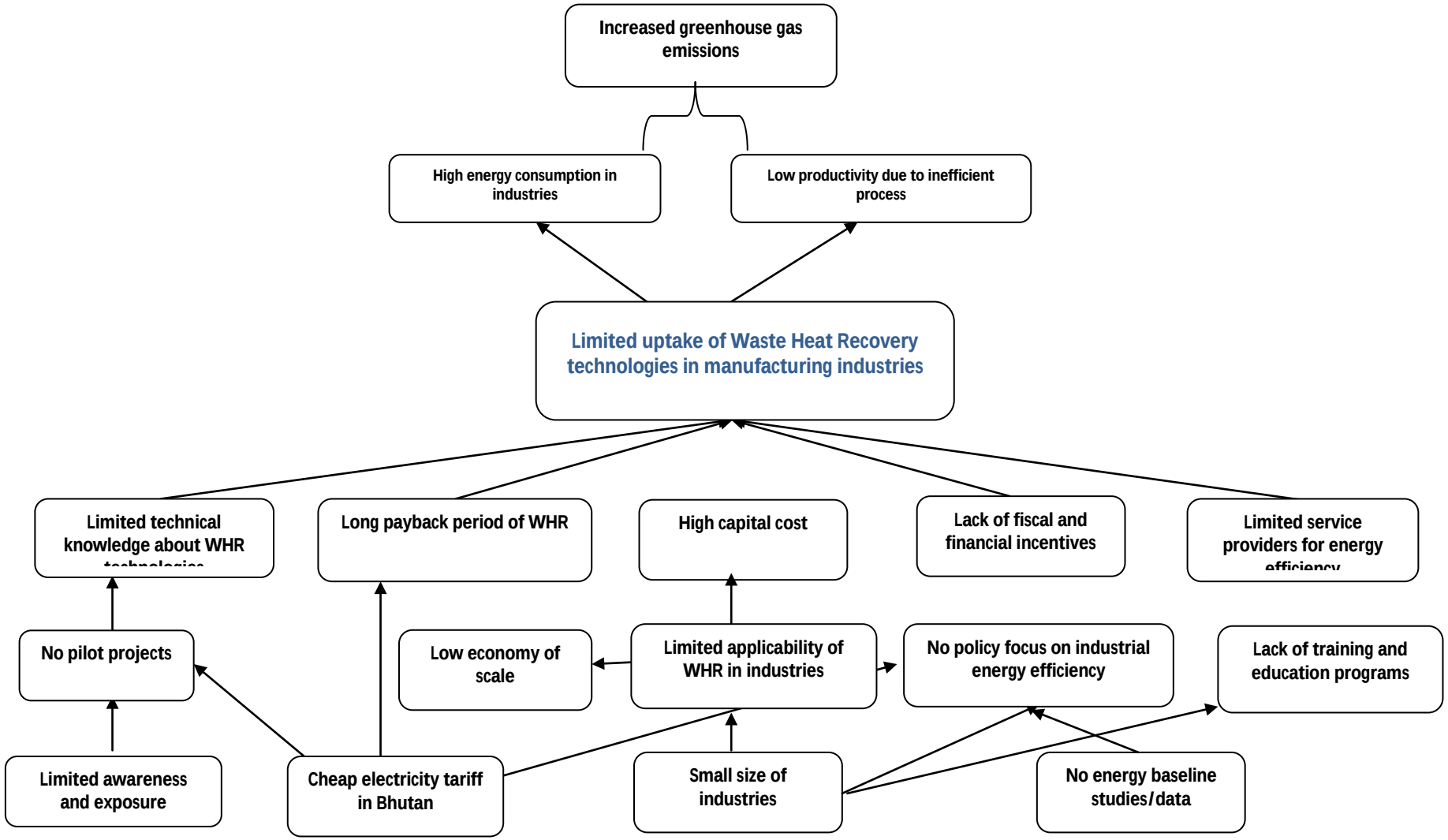

Figure C: Problem Tree for Waste Heat Recovery

Annex II. List of Stakeholders involved and their contacts

Several stakeholders were consulted in the process of preparation of the current Barrier Analysis Report. The list of stakeholders consulted along with their contacts is provided below.

S. No.	Name	Organization	Type of Consultation	Topics consulted for
1.	Birkha B. Chhetri, General Secretary	Association of Bhutanese Industries	Roundtable discussions and one on one interview	Industries
2.	Chhimi Dorji, Deputy Executive Engineer	Department of Hydro Meteorology Services	Roundtable discussions and one on one interview	Water, Agriculture
3.	Chhimi Rinzin, Chief Agriculture Officer	Department of Agriculture	Roundtable discussions	Agriculture
4.	Dawa Chogyel, Deputy Chief Environment Officer (EU-DOI),	Ministry of Economic Affairs	Roundtable discussions	
5.	G K Chhopel, Chief, Water Resources Division	National Environment Commission Secretariat	Roundtable discussions and one to one interview	Water
6.	Tek Nath Kararia, Civil Engineer	Thimphu Thromde	Roundtable discussions	Waste
7.	Gyembo Tenzin, Deputy Executive Engineer	Department of Agriculture	Roundtable discussions	Agriculture
8.	Jigme Nidup, Senior Environment Officer	National Environment Commission Secretariat	Roundtable discussions	Farmroads
9.	K. P Bhandari, DGM (plant)	SKW Tashi Metals	Roundtable discussions	Industries
10.	Karma Pemba, Chief Transport Officer	Road Surface and Transport Authority	Roundtable discussions and one to one interview	Transport
11.	Karma Tshethar	Department of Agriculture	Roundtable discussions	Agriculture
12.	Kunzang Choden, Senior Research Officer	Council of RNR Research in Bhutan	Roundtable discussions and one to one interactions	Water, Agriculture

13.	Nima Dorji, Engineer	Department of Agriculture	Roundtable discussion	Water, Agriculture
14.	Namgay Thinley, Deputy Chief Horticulture Officer	Department of Agriculture	Roundtable discussion	Agriculture
15.	Prem P. Adhikari, Senior Transport Officer	Road Safety and Transport Authority	Roundtable discussion	Transport
16.	Sherab Jamtsho, Deputy Executive Engineer	Department of Renewable Energy	Roundtable discussion	Industries
17.	Subarna Sharma, General Manager	Ugen Ferro Alloy Pvt Ltd	Roundtable discussion	Industries
18.	Tashi Dorji, Head of Administration	SKW Tashi Metals	Roundtable discussion	Industries
19.	Tashi Wangdi, Senior Manager	Bhutan Ferro Alloys Ltd	Roundtable discussion	Industries
20.	Tenzin Khorlo, Chief Environment Officer	National Envrionment Commission Secretariat	Roundtable discussion	Waste
21.	Thinley Dorji, Chief, Compliance Monitoring Division	National Environment Commission Secretariat	Roundtable discussion	
22.	Trashi Namgyel, Hydromet Officer	Department of Hydro Meteorology Services	Roundtable discussion	Water
23.	Tshering Yangchen, Assitant Environment Officer	Thimphu Thromde	Roundtable discussion	Waste
24.	Yeshey Penjor	Independent consultant	Roundtable discussion and one to one interview	Waste
25.	Tshering Wangchuk, Program Officer		Roundtable discussion	
26.	Tshewang Lhamo, Environment Officer		Roundtable discussion	

Annex III. Policy Factsheets

POLICY: Name of Policy	Transport Policy
Date Effective:	2006
Date Ended:	-
Unit:	**CC**
Country:	Bhutan
Year:	2006
Policy Status:	**In force**
Agency:	Road Safety and Transport Authority, Ministry of Information and Communications.
Policy Type:	-
Policy Target:	-
URL:	http://www.moic.gov.bt/pdf/tpolicy.pdf (accessed on 3 August 2012)
Description:	The policy envisages access to safe, affordable, efficient and environment friendly transport system for accelerated socio-economic development of the country. Specific objectives of the policy for surface transport are: Specific objectives are to: § Improve accessibility, equity and affordability of passenger transport services; § Promote urban transport; § Provide choice of passenger and freight transport; § Develop, upgrade and maintain transport infrastructure and facilities; § Promote road safety to minimize road traffic accidents; § Enhance efficiency of administration and improve public service delivery system; § Initiate transport research; § Develop institutional capacity; § Promote private sector participation; § Promote efficient, reliable and responsible freight transport industry providing services at minimum cost; § Protect environment and promote the use of energy efficient and less

	polluting vehicles.

POLICY: Name of Policy	Waste Prevention and Management Act
Date Effective:	
Date Ended:	-
Unit:	**CC**
Country:	Bhutan
Year:	2009
Policy Status:	**In force**
Agency:	National Environment Commission
Policy Type:	-
Policy Target:	-
URL:	http://www.nec.gov.bt/waste%20prevention%20and%20management%20act%202009.pdf (accessed on 6 August 2012)
Description:	The Act aims to prevent and reduce volumes of waste generation, promote segregation, reuse, recycling and management of waste in an environmentally sound manner. The ACT is based on the guiding Principles of the Middle Path and Gross National Happiness, Precautionary Principle and the Principle of 3 Rs and Waste Minimization Hierarchy.

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