Kingdom of Bhutan

TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY ACTION PLANS FOR CLIMATE CHANGE MITIGATION

"March 2013"

National Environment Commission
Royal Government of Bhutan

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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 is a product of the National TNA team, led by the National Environment Commission, Royal Government of Bhutan.

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FOREWORD

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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 one technology was prioritized based on a technology prioritization framework prepared through secondary research and rigorous stakeholder consultation. Part III of the TNA report, is the Technology Action Plan reports covering each adaptation and mitigation technology, in a way to reflect the prioritized measures required to enhance technology diffusion and overcome barriers identified in Part II of the TNA report. The current report brings together the key highlights of the barrier analysis and enabling framework report (Part II), in a way to present the Action Plan for technology diffusion. The Technology Action Plan is reflective of the national priorities of the Royal Government of Bhutan.

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

3Rs	Reduce, reuse and recycle
ADB	Asian Development Bank
AIT	Asian Institute of Technology
ASP	Aerated Static Pile
AVI	Automatic Vehicle Identifiers
BRT	Bus Rapid Transit
DPR	Detailed Project Report
DRE	Department of Renewable Energy
DoI	Department of Industries
EVI	Emergent Ventures India
FYP	Five-year plan
GHG	Greenhouse gases
GNH	Gross National Happiness
ICT	Information and Communication Technologies
IEA	International Energy Agency
ITS	Intelligent Transport System
INC	Initial National Communication
MoIC	Ministry of Information and Communication
MoWHS	Ministry of Works and Human Settlement
MCDA	Multi Criteria Decision Analysis
NAPA	National Adaptation Programme of Actions
NAMA	Nationally Appropriate Mitigation Action
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
RST	Road, Safety and Transport
RSTA	Road Safety and Transport Authority
SNC	Second National Communication
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UNFCCC	United Nations Framework Convention on Climate Change
VAM	Vapour Absorption Machines
WHR	Waste Heat Recovery

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Part III
Technology Action Plan Report

Executive Summary

In the Part I of the TNA report, for each prioritized sub-sector in climate change mitigation one technology was prioritized based on a technology prioritization framework prepared through secondary research and stakeholder consultation. As a precursor to developing detailed technology action plans of the identified technologies, it was imperative that key barriers be identified which the action plan should address. Thereby the Part II of the TNA report highlights the key barriers in adoption of the mitigation technologies and outlines an enabling framework for addressing these barriers.

Based on the Part I and Part II of the TNA reports, this report presents the Technology Action Plan for each mitigation technology identifying the prioritized measures required to enhance technology diffusion. The current report brings together the key highlights of the barrier analysis and enabling framework report, in a way to present action plan for technology diffusion.

The Technology Action Plan contained in the current report is reflective of the national priorities as those highlighted in the Government of Bhutan documents as well as those felt most urgent by TNA Taskforce members, Government representatives and Bhutanese experts.

A brief of the Action Plan for each sub sector in mitigation is summarized below:

Solid Waste

Composting has been selected as the appropriate technology measure in the solid waste sector for mitigation to combat climate change. The chapter outlines a brief description of the sector followed by a brief summary of the barriers to technology diffusion. In order to overcome the barriers to technology development and diffusion, streamlining of the existing institutional structure for better coordination in implementation and and management of composting plants has been highlighted to be most important and immediate step. It has also been observed that large scale commercial composting may not be viable in Bhutan's context as the amount of waste generated is quite low. Therefore, options of decentralized level composting units also need to be analyzed and if feasible detailed implementation strategy needs to be developed.

This followed by building capacity of institutions for setting up and effective management of composting plants is the need of the hour, to overcome the shortfalls in the operation of these plants. Feasibility studies to identify and prioritize potential sites for composting, assessment of financial requirements of setting up the technology, establishing support infrastructure for setting up and managing composting plants, establishing clear procedures for providing incentives or subsidies for encouraging private participation in composting ventures, dissemination of information and awareness campaigns are some of the other actions points deemed essential to for deployment and diffusion of the technology.

Transport

The primary focus of transport sector in Bhutan is the development and deployment of sustainable transport solutions such as the Intelligent Transport Systems (ITS) in order to reduce GHG emissions from the sector. For this purpose ITS, has been identified as potential technology for the sector. . The technology, although proven in developed and many developing countries, have not yet been tried in the country. There is a lack of knowledge and understanding of the technical, financial and management aspects of ITS in general among the key stakeholders. Therefore, a comprehensive feasibility study to assess the potential of ITS, suitable technology options, financing requirements and possible sources of financing has been identified as an immediate step. Among the various technology options under transport management and ITS, setting up of Automated Vehicle Fitness and Emission Testing Centres across the towns/cities of Thimphu, Phuentsholing, Gelephu, Samdrup Jongkhar and Mongar is needed to provide the infrastructure for testing of emissions from vehicles. Revising the current transport policies, and regulations to include implementation of ITS in country is crucial for diffusion of the technology. Restructuring the transport sector by addressing the overlapping mandates and improving the coordination between various departments is also critical for implementation of ITS and other transport management measures in the country. Capacity building and training programs for engineers, operators, traffic police, potential engineers and general public at large followed by preparation of a detailed project report s for ITS implementation for selected 5 cities are some of the other actions points required.

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Industries

In the industries sector, the TNA identified Waste Heat Recovery as the prioritized technology. As first step, undertaking a detailed feasibility study of available WHR potential and potential applications across iron & steel and ferro alloys industries is required to begin the process of technology deployment. This followed by conducting capacity building and awareness generation programs to build the technical capacity is required. The country currently has no policy on energy efficiency; therefore, developing a policy on energy efficiency is critical in deploying energy efficient technologies such as waste heat recovery. Providing the financial support to industries in form of financial and fiscal incentives to adopt WHR is needed. Strengthening the current institutions by, increasing the manpower of the Department of Renewable Energy and Department of Industries as well as conducting pilots to test the technology on the ground are the most vital action points.

Chapter 1 Technology Action Plan for Solid Waste

1.1 Actions at sectoral level

1.1.1 Sector Description-Solid Waste

Greenhouse gas emissions from wastes in Bhutan have been estimated from two sources; solid waste disposal on land (84% of total waste-related emissions in 2000) and domestic and commercial wastewater handling (16% of total waste-related emissions in 2000) (National Environment Commission, 2011). In 2000, GHG, emissions from solid waste were estimated to be 38.86 Gg of CO2 equivalent, from ten urban areas in Bhutan (National Environment Commission, 2011). However most of the emissions were attributed to the two cities of Thimphu and Phuentsholing. According to Bhutan's SNC, in 2000, GHG emissions from the waste sector in Bhutan accounted for 2.9% of the total national emissions. Emissions in the waste sector have steadily risen since the past decade, especially from solid waste disposal on land (Figure 1). This increase in waste generation has been primarily because of rapid growth of urbanization, rural-urban migration, changing consumption pattern and high population growth rate (National Environment commission, 2011).

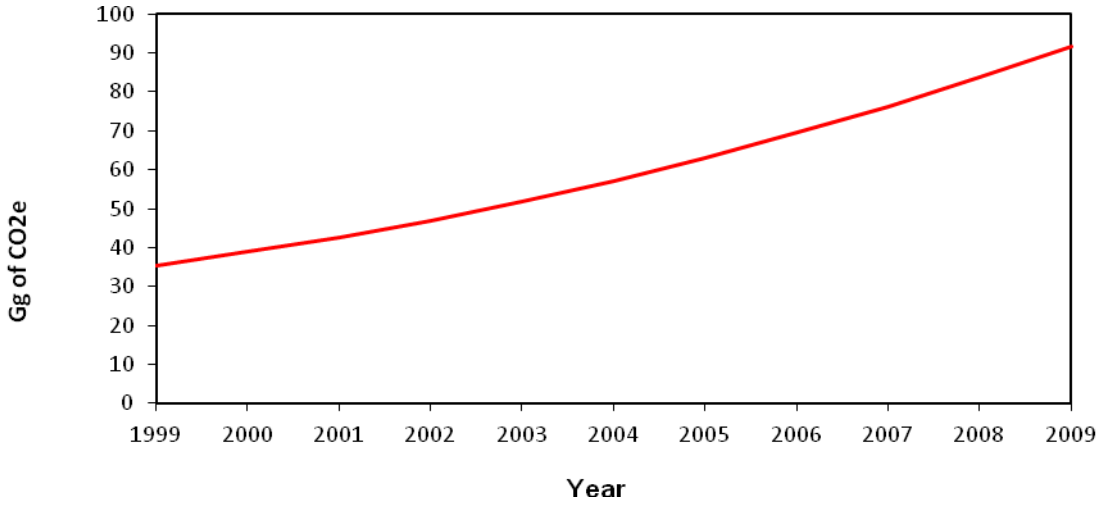

Figure 1: Emissions from solid waste disposal on land

Source: National Environment Commission, 2011

The solid waste management in the country is sluggish due to several barriers. There is a general lack of technical know-how on new technologies of waste management. The country has few engineers with limited knowledge on new technologies of waste management. There is also lack of infrastructure at the municipal level for collection and segregation of waste. 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 composting plant effectively, for example.

At present, the waste management system in Bhutan is guided by the Waste Prevention and Management Act, 2009 and is based on three guiding principles of Precautionary principle; Polluter pays principle and Principle of 3Rs (reduce, reuse, recycle) and Waste Minimization Hierarchy (Table 1). Bhutan has started exploring public-private partnership projects to improve solid waste management systems. In addition, the country has a few landfills where most of the waste is disposed. Also, a compost plant has been installed in Thimphu. 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. The NEC is in the process of drawing up a formal institutional structure for waste management in the country.

Table 1: List of Waste Policies, Acts and Regulation

S. No.	Name	Date Effective	Agency	Contents
1.	Waste Prevention and Management Act	2009	National Environment Commission	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
2.	Waste Prevention and Management Regulations	2012	National Environment Commission	The regulation were brought out with the purpose to: · establish procedures to implement the Waste Prevention and Management Act, 2009; · identify roles and areas of implementation of the Implementing Agencies for the purpose of establishing a sound waste management system · assign costs in proportion to the waste volume generated from the point source or by degree of their hazardousness by levying fees, charges and fines for non-compliance; and · control and prohibit illegal dumping or releasing of waste into the environment

1.1.2 Selected Technology

With the above background, together with extensive stakeholder discussions, in the Part I of the TNA report, 8 technologies for climate change mitigation in Bhutan were shortlisted for the solid waste sub sector. Out of these, 3 technologies were selected through an extensive multi-criteria decision analysis (MCDA) that was used to prioritize technologies through a process that was country-driven, participatory and involved a number of stakeholders. A three day workshop for criteria weighting and technology prioritization was held at Paro, Bhutan.

Composting, 3Rs and anaerobic digestion (biogas plants) were the three prioritized technologies for the sector. Further information on these technologies is included in the TNA report.

Out of these three technologies, composting was selected as the technology for preparation of barrier analysis, enabling framework and technology action plan in the solid waste disposal on land sub-sector. This is also the top technology as per the results of technology prioritization and offers immense scope for widespread implementation, given the government policy vision of going fully organic in agricultural production by 2020.

1.2 Action Plan for Composting

1.2.1 About Composting

The term composting is defined as biological degradation of waste under controlled aerobic conditions. The waste is decomposed into CO_2, water and the soil amendment or mulch. In addition, some carbon storage also occurs in the residual compost.

Three composting techniques that are available to compost bio solids are windrow, aerated static pile, and in-vessel composting (ClimateTechWiki)[1]. 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.

Windrow composting is the production of compost by piling organic matter or biodegradable waste, such as animal manure and crop residues, in long rows (windrows). This method is suited to producing large volumes of compost. These rows are generally turned to improve porosity and oxygen content, mix in or remove moisture, and redistribute cooler and hotter portions of the pile. Windrow composting is a commonly used farm scale composting method.

Aerated Static Pile composting, refers to any of a number of systems used to biodegrade organic material without physical manipulation during primary composting. The blended admixture is usually placed on perforated piping, providing air circulation for controlled aeration . Keeping in mind the complexity and cost, aerated systems are most commonly used by larger, professionally managed composting facilities, although the technique may range from very small, simple systems to very large, capital intensive, industrial installations. Aerated static piles offer process control for rapid biodegradation, and work well for facilities processing wet materials and large volumes of feedstock. ASP facilities can be under roof or outdoor windrow composting operations, or totally enclosed in-vessel composting, sometimes referred to tunnel composting.

In-vessel composting is an industrial form of composting biodegradable waste that occurs in enclosed reactors. These generally consist of metal tanks or concrete bunkers in which air flow and temperature can be controlled, using the principles of a "bioreactor". Generally the air circulation is metered in via buried tubes that allow fresh air to be injected under pressure, with the exhaust being extracted through a biofilter, with temperature and moisture conditions monitored using probes in the mass to allow maintenance of optimum aerobic decomposition conditions. This technique is generally used for municipal scale organic waste processing, including final treatment of sewage biosolids, to a safe stable state for reclamation as a soil amendment. In-vessel composting can also refer to aerated static pile composting with the addition of removable covers that enclose the piles. There have been other techniques and methodologies also small scale aerobic compositing such as

Further details on the technology are provided in the technology factsheet of the TNA Report.

1.2.2 Target for technology transfer and diffusion

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 2009 of Bhutan and plans of various city authorities. As per the Waste Prevention and Management Regulations, each Thromde (third level administrative division in Bhutan) is required to create an enabling environment for waste recycling to create 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 preferred method for organic waste management. Thromdes on their own or through arrangements with the private sector should provide such facilities.

As per discussions held during TNA workshop involving the NEC and City Municipalities , the preliminary target for setting up commercial scale composting systems at prominent urban centres such as Thimphu,

[1] http://climatetechwiki.org/technology/jiqweb-abt-0

Phuentsholing, Samtse, Gelephug, Samdrupjongkhar, Deothang, Trashigang, Rangjung, Yangtse, Mongar, Chamkhar, Trongsa, Bajo, Khuruthang, Paro and Haa are being set. In terms of timelines, as per the existing government plan the city of Thimphu targets to have a commercial composting system by the end of 2013 and other major cities by 2015. Currently, NEC is in the process of developing a National Strategy on Integrated Waste Management for Bhutan. It is expected to be finalized in the year 2013. In 11th Five Year Plan as well, it is expected that some budget allocations will be provided for waste management.

1.2.3 Barriers to the technology's diffusion

Given the current situation in Bhutan with regard to development and diffusion of composting as a technology for waste disposal, in the course of TNA process several barriers have been identified. These barriers have been categorized as economic barriers and non-financial barriers. While economic barriers primarily include high cost and low scale of composting plants, the non-financial barriers are mostly those associated with the limitations of the current institutional structure, the current policy and regulatory framework and those associated with information and awareness with regard to composting. Based on these identified barriers, suitable enabling measures which will assist the country in overcoming these barriers have also been identified. A brief summary of these barriers and enabling measures is presented here below. These enabling measures have further been defined and elaborated on with concrete action for each in the next section of this report.

1.2.3.1 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.

1.2.3.2 Non financial barriers

a) **Technical barriers:** 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. This poor collection and segregation of waste leads to less generation of raw material, in terms of compostable waste required 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 centres, where most spaces are available on the outskirts, and issues related to transportation of the compost then arise, often increasing costs. The other key issue is the unwillingness of people to accept composting plants around their place of stay or work which makes it even more difficult to obtain viable sites.

b) **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.

c) **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.

1.2.4 Enabling measures

Based on intensive discussions with experts, extensive secondary research as well as international experience, measures for building an enabling environment for development and diffusion of the technology in a way to overcome the above barriers have been identified. These measures include:

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. 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.

Also, since low scale is a major economic barrier, it has been identified that de-centralized composting units could be alternative option to a large scale commercial composting plant. These units can be managed through a programmatic approach in Dzonkhags and Thromdes.

Non financial measures

a. **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 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.

b. **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.

In addition, it is important to build capacity of these institutions to carry out effective waste management and also facilitate implementation of composting plants in the country.

c. **Awareness campaigns and information generation:** 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. These campaigns 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.

1.2.5 Proposed Action Plan for Composting

In order to develop a most relevant action plan for deployment and diffusion of composting technology focused sector specific roundtable discussions were held in Thimphu, Bhutan at NEC. The roundtable participants consisted of sectoral experts and representatives from National Environment Commission and Thimphu, Thromde. Through a technology specific presentation, the roundtable had intensive discussions, which focused on following aspects:

- *Overview of waste generation* - discussions were held on relevant institutions, stakeholder networks, policies, acts and regulations governing the sector and likely to facilitate deployment and diffusion of composting
- *General sector barriers and measures*- this brought forward discussions on general profile of barriers faced in the waste management sector and the kind of measures that are needed to overcome them.
- *Defining the technology domain:* special focus was given to discussion in terms of defining the technology in a most relevant way, given the national circumstances of Bhutan
- *Targets for technology transfer and diffusion*- specific targets were identified for composting technology. These were based government plans and documents, particularly the 11th FYP and any on-going or planned government programme for diffusion of the technology.
- *Barriers to diffusion of composting*- barriers as identified in Part II of the TNA report, were again revisited along with specific enabling measures to overcome them.
- *Proposed Action Plan Framework for Technology deployment and diffusion*- a draft action plan framework was presented and discussed in detail to aggregate and rationalize the measures identified to develop national capacities for acceleration of technology deployment and transfer. The discussion also prioritized and characterized measures for technology acceleration for a national action plan along with estimates of possible technology investment costs.

Based on discussions held at the roundtable, a revised national strategy/action plan was prepared and sent to roundtable participants, especially to National Environment Commission for review and comments. Based on this, a final prioritized action plan along with national strategy was prepared.

The section brings together the Action Plan which is reflective of the national priorities as those highlighted in the Government of Bhutan Plans, such as the 11th FYP as well as those felt most urgent by TNA Taskforce members and Bhutanese experts.

The Action Plan and thereby the national strategy formulation for deployment and diffusion of technology is reflective of national priorities. The budgets of each of these action points are those provided by the National Environment Commission.

a) Aggregation and rationalization of measures identified for technology acceleration

The list of measures identified for formulation of a national strategy to accelerate the development and transfer of technologies can be seen in Table 2 below.

Table 2: Measures for strategy formulation for composting

Strategic measure	Accelerating innovation RD&D	Accelerating deployment	Accelerating diffusion
Economic and Financial Measure			
Establishing clear procedures for providing incentives or subsidies for encouraging private participation in composting ventures	X	X	X
Non Financial Measures			
Institutional			
Designing of a formal institutional structure for waste management and setting up and management of composting projects		X	X
Build capacity of institutions for setting up and effective management of composting projects		X	X
Technical			
Feasibility studies to assess different composting techniques and financing models for promoting composting at decentralized and centralized level		X	X
Establishing support infrastructure for setting up and managing composting projects		XX	XX
Information and awareness			
Dissemination of information and awareness campaigns on the composting as a technology for waste management and its benefits at both municipal and household level		X	X

* Note: This table illustrates for a strategy of acceleration measures according to letters of each square, using the timescale for completion of an action, where:

- Letter "X" refers to measures which need to be started in the short term and carried out within the next five years;

- Letter "XX" refers to measures which can be completed in up to 10 years;

- Letter "XXX" refers to measures longer-term measures which can be planned for completion within 15 years from the current date and also will be used for other technologies below.

b) Prioritization and characterization of technology acceleration measures for a national plan

Based on the barriers and the enabling measures required for development and diffusion of composting technology in Bhutan, the key action points that are essential and immediate are described in Table 3. These action points are organized in priority, in order to convey the importance of action required.

The proposed measures are aligned with the 11th Five Year Plan of Royal Government of Bhutan to ensure that these measures receive required policy and funding support of the Government. For a national level waste management strategy a robust institutional structure is essential; thereby the National Environment Commission will be the lead agency to drive all the measures and will work closely with Ministry of Works and Human Settlement and City Authorities to ensure required planning and implementation support. In this context, strengthening of these institutions in terms of required human resources and technical expertise through proper budget allocation and capacity building and training programs have been proposed.

It is also essential to undertake an assessment of different composting techniques applicable at both decentralized and centralized levels. This will help built an understanding of different techniques available and most suitable for Bhutan. What is also required is to assess different financing models for implementing these different techniques. Along with this proper support infrastructure is essential to support the composting projects including centralized composting plants. In this context, setting up the support infrastructure in terms of transportation facilities, proper waste collection and segregation units or facilities have been proposed to be constructed.

Development of composting units in the country will require significant capital support to ongoing waste management programs. This will require sourcing from both Government budget and co-funding using international technical assistance grants and loans. The funds could be utilized to provide incentives such as tax rebates, custom duty exemptions on import of related equipment, and potentially help in promoting public private partnerships in setting up composting projects. Finally, dissemination of information and awareness campaigns on the composting as a technology for waste management and its benefits at both municipal and household level is needed and has been proposed.

The importance of each action point along with the timelines and activities, agencies responsible, potential costs along with indicators of success are defined in Table 3 below.

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Table 3: Technology Action Plan based on measures identified for technology acceleration (in priority) for Composting

S.No	Measures	Why is it important? (Priority)	Who should do it?	How should they do it?	Time-scale	Indicators of Success	Estimated costs (000 USD)	Potential risks	Potential Funding sources
1.	Designing of a formal institutional structure for waste management and setting up and management of composting projects	To have a formal system of waste management in the country with specific institutions looking into waste management aspects with clearly defined responsibilities. This will greatly facilitate setting up and running of composting projects.	NEC and MoWHS	- Identify specific organizations looking into following specific aspects: - Policy, Regulation and M&E aspects of waste management (with composting being one of them) as per the Waste Prevention and Management Act - 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 (possible have a specific division looking into waste management issues) · Financial aspects- Ministry of External Affairs and Ministry	2013-2015	- A well-defined institutional structure established by 2015 - A possible strengthening of the institutional structure in the Waste Prevention and Management Act by 2018	50	New institutional structures may require changes and amendment in Acts and regulations which may be difficult. A series of approvals may be required in finalization of an institutional structure which may entail time.	Government budget appropriated for waste management sector in Bhutan

				of Finance · Implementing Agencies- Thromdes, Dzonkhags, Municipalities/Gewog/Villages					
2.	Build capacity of institutions for setting up and effective management of composting projects	To build capacity of NEC, MoWHS and Municipalities for effective waste management and composting Currently, NEC's 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	NEC and MoWHS	- Design and undertake intensive training programmes focusing for: · 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 (incl. composting) for planning, budgeting and hardware execution	2013-2018	- A number of training programmes conducted by 2018 - A separate division and created and operational under MoWHS for waste management	150	Availability of required trainers and experts for conducting training programme may be difficult.	Green Climate Fund; GEF's Least Developed Countries Fund; Carbon Funds of ADB and World Bank; Clean technology Fund; NAMA for waste management in Bhutan can be prepared in which composting could be one of the low carbon technology options. In Bhutan's context, supported NAMAs could be developed and funding could be

									obtained accordingly from developed countries.
3.	Feasibility studies to assess composting techniques and financing models for promoting composting at decentralized and centralized level	To showcase to 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. Will help assess the overall waste management potential of the	Ministry of Works and Human Settlement and City Councils,	- Identify organization to undertake such a study either domestically or hire external consultants - Prepare a list of possible composting technologies and implementation models (e.g. decentralized, centralized, hybrid). With particular focus on techniques applicable at household level. - Undertake a cost benefit analysis of each technology/model - Describe implementation mechanism for each technique, identifying roles of involved agencies. - Analyze possible financing models for different techniques of composting. Explore potential of PPP models, incentive schemes from municipalities for households to promote household level composting etc. - Document the results of such a study in form of Guidebook, to be made	6 months	A publicly available report on Composting potential in Bhutanese cities to manage waste. A list of finalized technologies for application in the country. A list of possible financing models for promotion of different techniques of composting.	50	No risk perceived. Except availability of necessary funding.	Funds allocated under Bhutan's 11th Five Year Plan; Technical assistance fund and debt fund support from ADB, World Bank and KfW. For funding policy measures and other measures Nationally Appropriate Mitigation Actions (NAMAs) can be developed

	technology and possible estimate of finances required and cost recovery period.	publically available.	for the transport sector in Bhutan. These NAMAs can then attract domestic (unilateral), bilateral and carbon finance based funding (Credited NAMAs) Green Climate Fund, Least Developed Country Fund (GEF); World Bank Clean Technology Fund; UNDP MDG Carbon Facility; ADB Climate Change Fund; International Climate

								Initiative;	
4.	Establishing support infrastructure for setting up and managing composting projects	Currently municipalities face constraints for waste collection and segregation due to lack of proper facilitating infrastructure for this. In order to ensure a proper functioning and supply of compost to	NEC and City Councils	Study successful case examples from other countries on models of support infrastructure applied.	2013-2015	- Infrastructure support set up at specific sites by 2015 - Proper transportation facilities in place for transfer of compost to composting plants	200	Getting the right manpower for undertaking the necessary work can prove to be a challenge. Along with necessary funding.	Government budget and co-funding by international funds as mentioned earlier.

		composting plants it is essential to develop this support infrastructure							
5.	Establishing clear procedures for providing incentives or subsidies for encouraging private participation in composting ventures	To encourage active private participation in setting up of composting plants.	NEC	Use of 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. 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.	2013-2015	- A number of incentives provided to equipment suppliers, plant implementers by 2015	200	Delay in getting access to funds from domestic and international sources	Government budget and co-funding using international technical assistance grants and loans.
6.	Dissemination of information and awareness campaigns on the composting as a technology for waste	To create awareness and inculcate practice of segregation of waste at source, and help accept people to have composting	NEC, MoWHS and NGOs	- 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	2013-2018	- A number of campaigns designed and conducted during the period 2013-2018 - Advertisements made and aired on radio,	100	Mindsets and breaking into old habits of households may prove to be challenging to overcome through	GEF Least Developed Countries Fund; Small Grant Program; Government Budget; Other

management and its benefits at both municipal and household level	projects around their place of stay and work	and indiscriminate disposal Use of print and electronic media, flyers, movies, etc.	television etc. during 2013-2018	awareness campaigns	international grants by UN and other multilateral and bilateral funding agencies.

c) Finalizing the national strategy

Based on priority technology action plans in the sub-sectors, a national strategy and action plan for the composting targets are presented in Table 4.

Table 4: National Strategy (technology transfer and deployment) for composting

	0-5 years	5-10 years	10-15 years
Large-scale, short to medium-term technology			
Composting for Solid Waste Management			
Designing of a formal institutional structure for waste management and setting up and management of composting projects	X		
Built capacity of institutions for setting up and effective management of composting projects	X		
Feasibility studies to assess composting techniques and financing models for promoting composting at decentralized and centralized level	X		
Establishing support infrastructure for setting up and managing composting projects	X		
Establishing clear procedures for providing incentives or subsidies for encouraging private participation in composting ventures	X	X	
Dissemination of information and awareness campaigns on the composting as a technology for waste management and its benefits at both municipal and household level	X	X	

2.1 Actions at sectoral level

2.1.1 Sector Description-Transport

The growth of Bhutan is supported by its growing electricity exports, industrial development, rural urban migration and tourism. This growth has major impact on transport sector and mobility needs of citizens and results in more private and public vehicles on roads. This has resulted in an increase in congestion and is also leading to other issues such as an increase in air pollutants, noise pollution, accidents and GHG emissions.

As shown in the **Figure 2**, the GHG emissions from the transport sector were highest (44%) in energy related GHG emissions in Bhutan followed by manufacturing industries. The emissions from the transport sector are mainly due to fuel combustion in road transport. According to the Road Safety and Transport Authority (RSTA), the number of vehicles registered in Bhutan is increasing at an average of 10% annually which will lead to further GHG emission growth from this sector in future. Emissions from transport have grown consistently from 66.81Gg CO_2 in 1995 to 118.11 Gg in 2000 and 230.36 Gg CO_2 in 2009 (National Environment Commission, 2011).

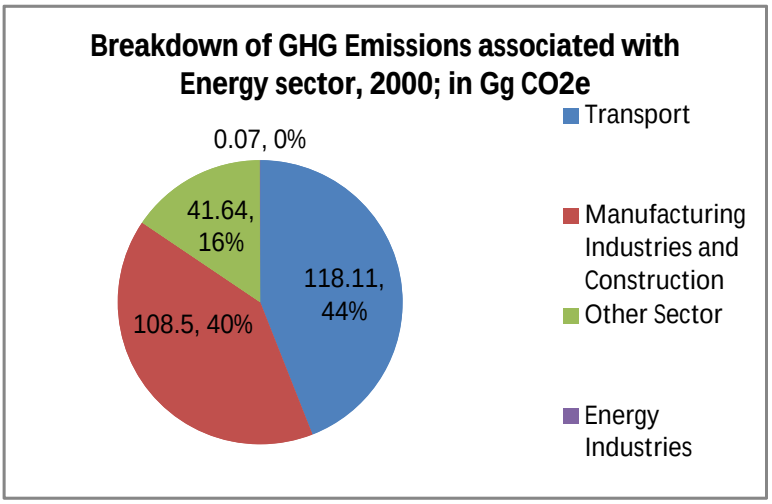

Figure 2: Bhutan's Energy Related GHG Emissions

This rapid growth has led to various issues in managing traffic. Difficult terrain and topography often hinders the expansion of roads and therefore the growing traffic needs to be better managed within the available space. Poor road engineering as well as limited knowledge on how the road infrastructure should be created leads to poor quality roads with high roughness and short life which further create issues for traffic management. Road access in remote areas is an issue with more than 42% of the population having to walk more than one hour to the nearest all-season roads. The public transport system also faces the issue of low capacity utilization in remote areas.

To address these issues and promote sustainable transport growth, The Government of Bhutan has prepared its Bhutan Transport 2040 Integrated Strategic Vision[2] (Ministry of Information and Communication, 2012) which has the following key objectives:

1) Accessibility to activities and supplies as needed by people and enterprises
2) Efficient use of economic resources
3) Environmental sustainability
4) Transport safety on roads

For implementation of the vision and other programs, various transport policies and acts are in place (Table 5)

[2] http://www.moic.gov.bt/Transport/Pamphlet-traport%20vision.pdf

Table 5: List of Transport Policies, Acts and Regulations in Bhutan

S. No.	Name	Date Effective	Agency	Contents
1.	Surface Transport Master Plan	2007	Road Safety and Transport Authority (RSTA) Ministry of Information and Communications	The Plan was developed to guide the future development of transport sector with a view to: - provide equitable access to reliable, adequate, cost effective and affordable transport services and facilities in the country, - enhance transport safety, - increase the efficiency and effectiveness of government administration, regulation and service delivery system in the transport sector; and, - promote energy efficient and eco-friendly transport system.
2.	Transport Policy	2006	Road Safety and Transport Authority, Ministry of Information and Communications	The policy envisages access to safe, affordable, efficient and environment friendly transport system for accelerated socio-economic development of the country.
3.	Bhutan Transport 2040 Integrated Strategic Vision	2012		The document brings forth the unified Strategic Vision for Transport in Bhutan over the coming three decades. The transport vision incorporates all existing transport related plans, policies, initiatives, and acts in Bhutan to create a long term comprehensive strategy for the country. The vision is based on eight strategies within the overall transport sector: Road Network Management Strategy, Rural Areas Access Strategy, Urban Transport Management Strategy, Road Traffic Licensing and Transport Regulations Strategy, Transport Services and Freight Logistics Strategy, Aviation Strategy, Road Safety Strategy and Sector Management and Capacity Building.
4.	RST Act and	1999	Road Safety and	The purposes of this Act are:

Regulation	Transport Authority, Ministry of Communications	· to provide for the safe and efficient use of road system of the Kingdom of Bhutan; · to establish systems and procedures for the licensing of drivers and the registration of motor vehicles; · to provide for an efficient and safe public transport system; · to establish a Road Safety and Transport Authority to manage the delivery of objects and functions of this Act.

To address the mobility challenge in Bhutan improvement and addition of the road network and increased supply of public transport is essential. However, to ensure that these infrastructures and facilities are sustainable and effective, the importance of transport management systems has been widely recognized. Although the advanced technologies used for managing transport services have not yet been implemented in the country due to high capital cost and limited institutional capacities, the important role that it plays in improving the transport services and reducing vehicle fuel consumption makes it an important consideration in Bhutanese transport sector.

Though there is a growing realization of need for improved transport management systems in the country to improve mobility, there are, however several barriers confronting the sector that hinders the growth. These include:

- There is limited public awareness about benefits of low carbon transport options or emission testing agencies;
- The current emission testing standards are not so comprehensive
- There is limited understanding of new technology options, design engineering of roads even within RSTA
- There is also limited institutional capacity to plan, implement and operate new technologies
- Limited provisions for sustainable transport under the existing policies and regulations further hinder adoption of new technologies
- The difficult terrain and topography of the country often hinders the uptake of new technologies
- Poor road engineering and quality increase travel time thus leading to increased emissions
- There is no dedicated traffic police in remote areas and often traffic is managed by non-transport professionals

In terms of the institutional structure managing the transport sector, currently, different ministries are looking into varying mandates of transport. The Ministry of Information and Communication with its Policy and Planning 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. As recommended by the Transport 2040: Integrated Vision Strategy, a proposal on the re-structuring of the institutional structure governing the transport sector has been prepared with assistance from the Asian Development Bank. The proposal recommended bringing RSTA under the Ministry of Works and Human Settlement (MoWHS) and renaming the Ministry as the Ministry of Transport and Human Settlement. The proposal is planned to be presented to the next government for approval.

2.1.2 Selected Technology

With the above background, together with extensive stakeholder discussions, in Part I of the TNA report, 11 technologies for climate change mitigation in Bhutan were shortlisted for the transport sector. Out of these, 3 technologies were selected through an extensive multi-criteria decision analysis (MCDA) that was used to prioritize technologies through a process that was country-driven, participatory and involved a number of stakeholders. A three day workshop for criteria weighting and technology prioritization was held at Paro, Bhutan.

Intelligent Transport System, Non-Motorized Transport and Mass Transit are the prioritized technologies for transport sub-sector. Further information on these technologies is contained in the TNA report.

Out of these three technologies, Intelligent Transport System was the technology finalized by the TNA Task Force for the preparation of barrier analysis, enabling framework and technology action plan. This is also the top technology as per the results of technology prioritization. Moreover, this technology is included in the Surface Transport Master Plan of Bhutan, 2007 and is in line with Bhutan's Transport Policy that envisages safe, reliable, affordable, convenient, environment-friendly, responsible and high quality surface transport system in the country by minimizing constraints to the mobility of people, goods and services.

The other two prioritized technologies were not finalized since these are being considered under separate plans and programmes in Bhutan. Promotion of non-motorized transport is being considered (particularly for Thimphu) by the Thimphu Thromde. Further, mass transit, specifically bus rapid transit is being considered under the Bhutan Urban Transport Systems project.

2.2 Action Plan for Intelligent Transport System

2.2.1 About Intelligent Transport System

Intelligent Transport System (ITS) basically refers to the application of information and communication technologies (ICT) to vehicles and to transport infrastructure. It is primarily an ICT based system designed to improve operational and managerial efficiency of transport system in general and public transport in particular. An increase in the efficiency of the public transport system also leads to reduction in associated GHG emissions. The components of ITS systems generally includes

- Data Acquisition Systems
- Data Communication Systems
- Data Management Systems
- Display Systems

Data Acquisition Systems: This includes sensors, automatic vehicle identifiers (AVI) and GPS. Sensors are used to obtain traffic parameters such as vehicles count, occupancy and speed. AVI systems are used to specifically identify a vehicle and its speed on road. GPS systems are used to identify the vehicle location and velocity in real time. Travel time, speed, distance and delay are estimated with help of GPS systems.

Data Communication Systems: Data captured using data acquisition systems needs to be effectively communicated to its intended users such as control centres and public display systems. Wireless technology is normally used for data communication systems.

Data Management Systems: for generating short and long term trends, data gathered through acquisition systems must be clean and removed from garbage values. Once the data is clean, data can be aggregated or disaggregated and subsequent analysis is done to generate effective traffic management policies and forecast traffic status. Based on forecast status real time decisions could be taken to prevent congestion etc.

Display Systems: These display systems are used to convey information to travellers using Message Signs, Radio, SMS, etc. ITS can provide information on travel times, travel speed, delay or accidents etc.

Intelligent Transport System could be applied to various areas as highlighted below:

1) **Advanced traffic management systems:** These systems integrate various sub components such as CCTV, sensors for vehicle detection, communication and messaging into a single system for real time traffic monitoring so that traffic management is efficient, real time information to users about traffic conditions, incident detection, signal control, predict traffic trends in real time to avoid congestion.
2) **Advanced traveller information systems:** It provides travel related information to users such as estimated travel times of buses on bus stops, route selection, parking availability, so that users can take intelligent decisions as per their convenience.
3) **Advanced public transport systems** – It includes passing of real time information of public transport to passengers such as real time passenger information systems, prioritization of public transport, estimated time for bus arrival at bus stops, transit priority of public transport etc.
4) **Advanced Rural Transport Systems** – These systems provide information about remote road and weather conditions. This type of systems can be valuable for implementation in rural areas of the country to provide information for users travelling in those areas.
5) **Advanced Vehicle Control systems** – These systems enhances the driver control on the vehicles by alerting the driver of possible collision due to vehicle speed or location.
6) **Commercial Vehicles Operations** – These systems are implemented to track commercial vehicles such as trucks and taxis for enhanced safety and traceability[3].

[3] For further details on the technology please refer to the technology factsheet of the, 'Technology Needs Assessment and Technology Action Plans for Climate Change Mitigation', National Environment Commission, Royal Government of Bhutan, 2012

2.2.2 Target for technology transfer and diffusion

The overall target for diffusion of this technology has been based on the existing national and sectoral plans, programs and policies. These include the Transport Policy of Bhutan, the Surface Transport Master Plan of Bhutan, 2007[4] and the 11th Five Year Plan targets of the country.

The following specific targets have been set by TNA task force members and the Road Safety and Transport Authority (RSTA) for the period 2013-2018.

- Implement ITS technologies in the existing Regional Transport Offices (RTOs) in Thimphu, Phuentsholing, Gelephu and Samdrup Jongkhar and the proposed RTO of Mongar. The key components would include:
    - Install GPS based automatic vehicle tracking system
    - Establish a centralized traffic control centre to handle the operational requirements of traffic
- Set up LED display boards at all the bus-stops and terminals in the cities as well as districts across the country to provide real time information about bus operations
- Install Public Information System inside the buses plying on cities as well as inter district routes
- Introduce E-ticketing and smart card facilities for inter district passenger transport
- Provide information services for passengers through SMS
- Set up Automatic Vehicle Fitness and Emission Testing Centres in the existing RTOs in Thimphu, Phuentsholing, Gelephu and Samdrup Jongkhar and the proposed RTO of Mongar.

2.2.3 Barriers to the technology's diffusion

Given the current situation in Bhutan with regard to Intelligent Transport Systems, in the course of TNA process several barriers have been identified. These barriers are both economic and non-financial barriers. Among the economic and financial barriers, as with other technologies ITS also requires high capital investments which is a major constraint to introducing this technology. The non-financial barriers are mostly those associated with the limitations of the knowledge about the technology, capacity in existing institutional structure and the current policy and regulatory framework. Based on these identified barriers, suitable enabling measures which will assist the country in overcoming these barriers have also been identified. A brief summary of these barriers and enabling measures is presented here below. These enabling measures have further been defined and elaborated on with concrete action for each in the next section of this report.

2.2.3.1 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 traveller 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

[4] Surface Transport Master Plan of Bhutan, 2007

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 number of passengers 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.

Due to low population and thereby limited number of passengers, the economies of scale are not reached for ITS measures making it 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.

2.2.3.2 Non financial barriers

a) **Policy, legal and regulatory:** In Bhutan, the transport policies and regulations are mostly outdated having being 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 in the Transport Policy 2006. The policies need to be amended to include specific portions on mass transit and ITS.

b) **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 Policy and Planning 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 human 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.

c) **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 Bus Rapid Transit System (BRTS) has been conducted for the city of Thimphu which has come components of ITS, no such studies exists for other cities. In absence of these, the knowledge about the application and operation and management of the technology in the transport departments both at central as well as local level is very limited.

In addition, limited infrastructure and enforcement measures such as weigh bridges often act as a hindrance in planning of ITS in Bhutan as well as difficult terrain and topography hinders the uptake of many new technologies

d) Information and awareness: There is a lot 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.

2.2.4 Enabling measures

Based on intensive discussions with experts and extensive secondary research, following measures for building an enabling environment for development and diffusion of the technology have been identified:

2.2.4.1 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.

2.2.4.2 Non financial measures

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

a) **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.

b) **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.

In addition, to overcome overlapping mandates and tasks of different organizations looking into aspects of transport 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.

c) **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.

d) **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.

2.2.5 Proposed Action Plan for Intelligent Transport System

In order to develop a most relevant action plan for development and diffusion of ITS in the country, focused sector specific roundtable discussions were held in Thimphu, Bhutan at NEC. The roundtable participants consisted of sectoral experts and representatives from Ministry of Information and Communications. Through a technology specific presentation, the roundtable had intensive discussions, which focused on following aspects:

- *Overview of the transport sector* - discussions were held on relevant institutions, stakeholder networks, policies, acts and regulations governing the sector and likely to facilitate deployment and diffusion of ITS

- *General sector barriers and measures*- this brought forward discussions on general profile of barriers faced in the transport sector and the kind of measures that are needed to overcome them.
- *Defining the technology domain:* special focus was given to discussion in terms of defining the technology in a most relevant way, given the national circumstances of Bhutan
- *Targets for technology development and diffusion*- specific targets were identified for ITS. These were based on government plans and documents, particularly the 11th FYP and any on-going or planned government programme for diffusion of the technology.
- *Barriers to diffusion of ITS*- barriers as identified in Part II of the TNA report, were again revisited along with specific enabling measures to overcome them.
- *Proposed Action Plan Framework for Technology development and diffusion*- a draft action plan framework was presented and discussed in detail to aggregate and rationalize the measures identified to develop national capacities for acceleration of technology deployment and transfer. The discussion also prioritized and characterized measures for technology acceleration for a national action plan along with estimates of possible technology investment costs.

Based on discussions held at the roundtable, a revised national strategy/action plan was prepared and sent to roundtable participants, especially to Ministry of Information and Communications for review and comments. Based on which a final prioritized action plan along with national strategy was prepared.

The section brings together the Action Plan which is reflective of the national priorities as those highlighted in the Government of Bhutan Plans, such as the 11th FYP as well as those felt most urgent by TNA Taskforce members and Bhutanese experts.

The Action Plan and thereby the national strategy formulation for deployment and diffusion of is reflective of national priorities. The budgets of each of these action points are those provided by the Ministry of Information and Communications

a) Aggregation and rationalization of measures identified for technology acceleration

The list of measures identified for formulation of a national strategy to accelerate the development and transfer of technologies can be seen in Table 6 below.

Table 6: Measures for strategy formulation for ITS

Strategic measure	Accelerating innovation RD&D	Accelerating deployment	Accelerating diffusion
Economic and Financial Measure			
Potential assessment of ITS implementation in the country, to approach bilateral and multilateral funding agencies		X	X
Non Financial Measures			
Institutional			
Setting up Automated Vehicle Fitness and Emission Testing Centres	X	X	
Assignment of specific targets to different departments and re-structuring the transport sector	X	X	X

Policy, Legal and regulatory			
Revise the current Transport policy, Act and regulations	X	X	X
Technical			
Prepare detailed technology report for ITS implementation for 5 cities		XX	XX
Awareness generation and information			
Training and awareness campaigns for system engineers, operators and general public on ITS		X	X

* Note: This table illustrates for a strategy of acceleration measures according to letters of each square, using the timescale for completion of an action, where:

- Letter "X" refers to measures which need to be started in the short term and carried out within the next five years;

- Letter "XX" refers to measures which can be completed in up to 10 years;

- Letter "XXX" refers to measures longer-term measures which can be planned for completion within 15 years from the current date and also will be used for other technologies below.

b) Prioritization and characterization of technology acceleration measures for a national plan

Based on the barriers and the enabling measures required for deployment and diffusion of ITS in Bhutan, the key action points that are essential and immediate are described in Table 7. These action points are organized in priority, in order to convey the importance of action required.

The proposed measures are aligned with the 11th Five Year Plan of Royal Government of Bhutan to ensure that these measures receive required policy and funding support of the Government. For implementation of these measures, RSTA along with MoIC will be the lead agencies ensuring action against each of these. Since implementation of ITS is a large scale project it is crucial to develop funding proposals and access international low carbon transportation funds based on assessment of potential of ITS implementation and its benefit in terms of GHG reduction and co-benefits in Bhutan. This has been proposed to be the most important action for implementing ITS in the country.

While key components of ITS as identified in the technology description section can be implemented based on the feasibility study, there is a clear need of the Department of Transport to set up emission testing centres for vehicles and provide necessary technical assistance to these centres. In line with this, it is proposed to set up Automated Vehicle Fitness and Emission Testing Centres across the towns/cities of Thimphu, Phuentsholing, Gelephu, Samdrup Jongkhar and Mongar. In order to implement project of this stature in the country it is essential that the policies and regulations are in support of such action. Thereby it is proposed to revise the current Transport Policy, Act and regulations to include implementation of ITS in country.

For these measures to lead to actual benefit it is important for all stakeholders to understand its benefits. 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 along with general public have been proposed.

And finally, for actual implementation of all the above measures preparation of detailed technology report for ITS implementation is essential. Utilizing the funds allocated under Bhutan's 11th Five Year Plan; Technical assistance fund and debt fund support from ADB, World Bank and KfW for preparation of detailed technology report and all of above measures will be required. It is proposed the project designing could focus first on cities/towns of Thimphu, Phuentsholing, Gelephu, Samdrup Jongkhar and Mongar. .

The importance of each action point along with the timelines and activities, agencies responsible, potential costs along with indicators of success are defined in Table 7 below.

Table 7: Technology Action Plan based on measures identified for technology acceleration (in priority) for ITS

S. No	Measure	Why is it important?	Who should do it?	How should they do it?	Time-scale	Monitoring, reporting and verification for measure	Indicators of Success	Estimated costs (*1000 USD)	Potential Risks	Potential Funding sources
1	Economic and financial measure: Develop funding proposals and access public and international low carbon transportation funds based on assessment of potential of ITS implementation and its benefit in terms of GHG reduction and co-benefits in Bhutan.	The cost of implementation of ITS system is high. However, financial assistance (technical support, grants, low rate financing) to sustainable transport measures is available through various unilateral and multilateral agencies. To avail these benefits, the project must demonstrate that it leads to less GHG	RSTA, MoIC along with transport / ITS experts	- Identify the components of ITS for implementation and how it will integrate with upcoming public sector transport systems such as BRT. - Identify total cost of implementation of ITS. - Estimate GHG emissions reduction due to implementation of ITS in the country - Estimate other benefits such as reduction in air pollution, safety improvement	2013-2014	RSTA, MoIC	- A published report on feasibility of ITS in Bhutan providing necessary information to stakeholders - Funding sources shortlisted - Funding provided by international agencies.	100	- The impact of funds in terms of GHG reduction per passenger may not be high as compared to other LDCs having higher population density. Thus it may jeopardize international fund flow.	Green Climate Fund, Least Developed Country Fund (GEF); World Bank Clean Technology Fund; UNDP MDG Carbon Facility; ADB Climate Change Fund; International Climate Initiative; Co-financing by funds allocated by Government of Bhutan under its 11th Five

		emissions than business as usual scenario and promotes sustainable transport. The study can be conducted for the towns of Phuentsholing, Gelephu, Samdrup Jongkhar, Mongar, Paro, Bumthang, Khuruthang (Punakha), Bajo (Wangdue), and Haa		and reduction in noise pollution in the country. - Develop funding proposals - Approach bilateral and multilateral agencies supporting sustainable transport development					Year Plan
2	Technical measure: Setting up Automated Vehicle Fitness and Emission Testing Centres across the towns/cities of Thimphu, Phuentsholing, Gelephu, Samdrup	While key components of ITS as identified in the technology description section can be implemented based on the feasibility study proposed above, there is a clear need of	RSTA, MoIC	- These centres could be established under current regional transport offices - Set up in collaboration with similar international organizations - International	2013-2018	RSTA, MoIC	- Centres set up across the 5 cities.		Funds allocated under Bhutan's 11th Five Year Plan; Technical assistance fund and debt fund support from ADB, World Bank

	Jongkhar and Mongar	the Department of Transport to set up emission testing centres for vehicles and provide necessary technical assistance to these centres.		funding options could be explored along with domestic budgets under FYP						and KfW.
3	Policy and regulatory measures: Revise the current Transport policy, Act and regulations to include implementation of ITS in country	The current transport policies and regulations are mostly outdated having being developed in 1999. These policies and regulations need to be updated to reflect the needs of the current time as well as increase focus on development of sustainable transport systems, particularly ITS.	RSTA and MoIC	- Revise Policies, Acts and Regulations in consultation with stakeholders. - Review similar polices in other countries , having implemented ITS - Cost benefit analysis of likely policy amendments in terms of impact assessment	2013-2018	RSTA and MoIC	- Review of similar policies in other countries conducted, along with cost benefit analysis for Bhutan - Amendments made in the current Acts and Regulations	50	Changes and amendments in Acts and Regulations may be difficult.	Modification of policies and regulations would cover all sustainable transport options. Therefore, for funding policy measures and other measures as mentioned above, Nationally Appropriate Mitigation Actions (NAMAs) can be developed

						for the transport sector in Bhutan. These NAMAs can then attract domestic (unilateral), bilateral and carbon finance based funding (Credited NAMAs). Other funding sources as mentioned in previous measures also possible.

4	Capacity building and awareness generation measures: 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 Undertake awareness campaigns for general public towards using ITS and its benefits	The measure is crucial to raise 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. In order to ensure, effective implementation of these systems, and ensure economies of scale are achieved, it is important to build confidence of general public, and increasing their comfort of depending on these systems.	MoIC and RSTA	- Design a national level awareness and capacity building program 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	2013-2018	MoIC and RSTA	- Awareness campaign conducted for general public - Training conducted for engineers, operators and traffic police. - Workshops and exposure visits for transport department personnel	150	No perceived risks	Funds allocated under Bhutan's 11th Five Year Plan; Technical assistance fund and debt fund support from ADB, World Bank and KfW.

5	Technical and market enabling measure: Prepare detailed project report for ITS implementation Focus on cities/towns of Thimphu, Phuentsholing, Gelephu, Samdrup Jongkhar and Mongar Set up pilot project in Thimphu for demonstration of ITS.	It is important to prepare such detailed reports to arrive at estimates for equipment required for e.g. for setting up Automated Vehicle Fitness and Emission Testing Centres etc. and also to assign responsibilities across organizations within Bhutan.	MoIC and RSTA	- MoIC and RSTA to coordinate with city authorities for preparation of such project design. - Assign guidelines to city authorities for designing such a programme.	2013-2018	MoIC and RSTA	- Reports prepared for all five cities.	400 (Detailed Project Reports) 2000 (pilot project)	No perceived risk apart from availing the required funding support for the measure.	Funds allocated under Bhutan's 11th Five Year Plan; Technical assistance fund and debt fund support from ADB, World Bank and KfW.

c) Finalizing national strategy

Based on priority technology action plans in the sub-sectors, a national strategy and action plan for the ITS implementation targets are presented in Table 8.

Table 8: National Strategy (technology transfer and deployment) for ITS

	0-5 years	5-10 years	10-15 years
Large-scale, short to medium term technology			
Intelligent Transport Systems			
Potential assessment of ITS implementation in the country, to approach bilateral and multilateral funding agencies	X		
Setting up Automated Vehicle Fitness and Emission Testing Centres across the towns/cities of Thimphu, Phuentsholing, Gelephu, Samdrup Jongkhar and Mongar	X		
Revise the current Transport policy, Act and regulations to include implementation of ITS in country	X	X	
Assigning specific independent mandates to different departments and ministries with regard to ITS	X		
Awareness campaigns and training programs for engineers, operators, traffic police, potential engineers and general public at large	X	X	
Prepare detailed technology report for ITS implementation to start with 5 cities and set up pilot projects	X		

Chapter 3 Technology Action Plan for Industries

1.1 Actions at sectoral level

3.1.1 Sector Description-Industries

Bhutan has many small and medium scale industries; however energy consumption in the sector is dominated by few large energy-intensive industries. These energy intensive industries are primarily the Iron & Steel, Ferro-Alloy and Cement manufacturing units.

In 2005, six major energy intensive industries consumed close to 90% of the total sectoral energy consumption and 62% of the country's electricity consumption (National Environment Commission, 2011). Most of the energy requirements of the sector are met through electricity and coal. Other fuels that are used in the sector include furnace oil, kerosene, light diesel oil, and fuel wood (National Environment Commission, 2011).

According to Bhutan's Second National Communication (SNC), emissions from energy use in manufacturing industries have grown from 81.42 Gg CO_2 in 1995 to 228.10 GgCO_2e in 2009, an increase of almost 2.8 times (Figure 3). The growing trend of emissions from the sector is consistent with the rapid economic development in Bhutan

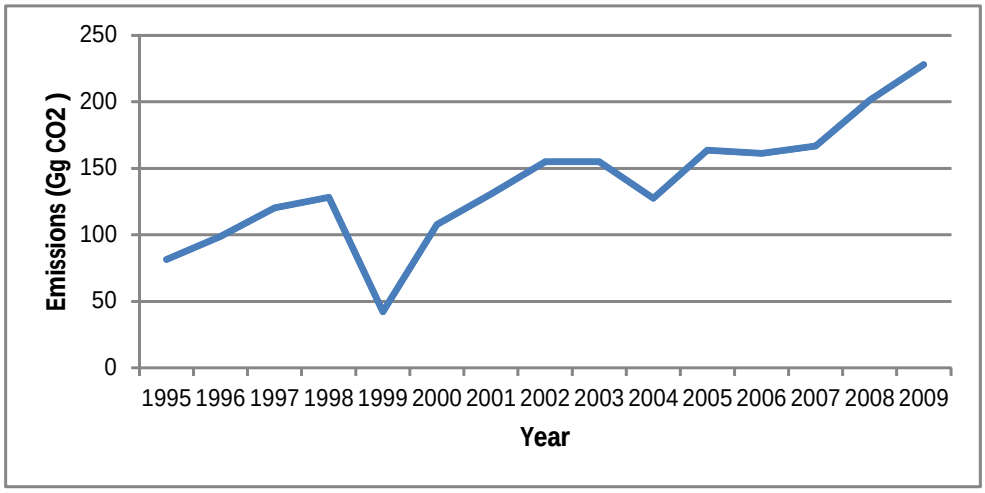

Figure 3: GHG emissions from energy consumption in manufacturing industries

Source: National Environment Commission, 2011

The GHG emissions and trends from major industries in the sector are listed below.

- In 2000, 17237.02 tons of Ferro Alloys production emitted 67.22 Gg CO2, accounting for more than one-third of the domestic electricity consumption (National Environment Commission, 2011).
- Cement industry is heavy user of electricity and one of the biggest consumers of coal in Bhutan. In 2000, 293994.67 tons of clinkers production emitted 152.07 Gg CO2 (National Environment Commission, 2011).

Emissions from iron and steel industry along with Ferro Alloys have increased significantly since 2006 and surpassed emissions from cement industry (National Environment Commission, 2011).

As per the SNC, demand side management in industries can effectively reduce emissions by adopting energy efficiency measures and promoting energy-efficient technologies. In the manufacturing industries sector, the Department of Renewable Energy under the Ministry of Economic Affairs, Bhutan had conducted preliminary energy audits of few industries recently, covering Cement, Ferro Silicon and Bhutan fruits. The energy saving potential in these industries is documented in the Bhutan Energy Directory 2005. However, in absence of any energy efficiency policy which could have pushed these industries to adopt energy saving measures, no

concrete action took place that time. After that, the most notable initiative has been the energy baseline study of the country which has been initiated by the Department of Renewable Energy in October 2012. Besides this, the industries sector has been guided by the Economic Development Policy, 2010. The Department of Renewable Energy, Ministry of Economic Affairs is soon to finalize a Renewable Energy Policy for the country. Table 9 provides a brief overview of these polices.

Table 9: List of Policies for Industries Sector- Bhutan

S. No.	Name	Date Effective	Agency	Contents
1.	Economic Development Policy of the Royal Government of Bhutan	2010	Gross National Happiness Commission	The document is an apex policy document for economic development of the country and is the guiding document for all ministries and agencies to stimulate the economy growth and more importantly, to ensure that growth takes place in consonance with the principles of GNH. Among other sectors and areas of focus, the policy also emphasizes on industrial growth. It highlights a strategic plan for industrial development that will allow the nation to clearly set the path for the desired industrial outcome. The availability of competitively priced energy will be the initial drivers for industry and mentions that industries shall be encouraged to move up the industrial value chain over the long-term.
2.	Draft Renewable Energy Policy	Yet to be effective	Department of Renewable Energy (DRE) under the Ministry of Economic Affairs (MoEA)	The policy sets long and short term objectives for achieving targets, set for generating energy from renewable sources.

As per the major industry players, though they strive for efficiency in production, the low energy prices in the country acts as a major detriment in adoption of energy efficiency measures by them. However, it was widely felt amongst the industry representatives that there does exist a scope and need for energy efficiency measures. The increasing trend of energy consumption in industries and erratic availability of power during lean power supply season along with national goals of reducing dependence on fossil fuel including coal and achieving industrial energy efficiency has been identified as the key imperatives for adopting energy efficient technologies in the manufacturing industries in Bhutan.

3.1.2 Selected Technology

With the above background, together with extensive stakeholder discussions described in the Part I of the TNA report, 8 technologies for climate change mitigation in Bhutan were shortlisted for industries. Out of these, 3 technologies were selected through an extensive multi-criteria decision analysis (MCDA) that was used to prioritize technologies through a process that was country-driven, participatory and involved a number of stakeholders. A three day workshop for criteria weighting and technology prioritization was held at Paro, Bhutan.

Construction of energy efficient infrastructure (Energy efficiency in construction), improvement in process-related energy efficiency (iron and steel, ferroalloys and cement industry) and High efficiency electric motors (iron and steel, ferroalloys and cement industry) are the prioritized technologies for manufacturing industries and construction sub- sector. Further information on these technologies is contained in the TNA report.

Improvement in process related energy efficiency particularly Waste Heat Recovery (WHR) in Ferro Alloy and Iron and Steel industries in Bhutan has been prioritized by the TNA Task Force based on the technology prioritization framework. The application of WHR technologies has been very limited in Bhutan. The maturity of the technology, proven successful applications in the region and high potential of energy efficiency as identified in SNC and Carbon Neutral Strategy of Bhutan are the key factors in prioritizing WHR over other technology options.

3.2 Action Plan for Waste Heat Recovery Technology

3.2.1 About Waste Heat Recovery

Waste heat is the 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 and improves production efficiency. 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.

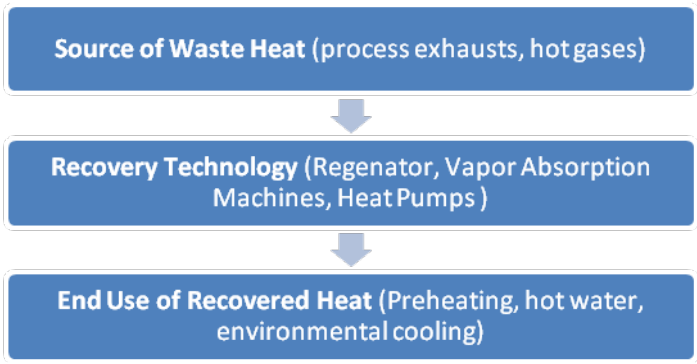

Figure 4: Key components of WHR

Various equipment such as Heat Exchangers, Vapour Absorption Machines (VAM), Recuperators, Regenerators, Waste Heat Boilers and Heat Pumps are utilized for purpose of WHR. For implementation of WHR projects in industries three components are studied essentially which include (Figure 4) i) source of waste heat ii) feasible technology for recovery iii) use for recovered energy[5].

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 Vapour 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. Absorption Heat Pump generates the hot water based on 75% heat from heat source (e.g. diesel, steam, gas). Hence 25% heat from existing sources (diesel, gas, steam) can be saved. The concept is shown in the below Figure 5.

[5] https://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/waste_heat_recovery.pdf page 10

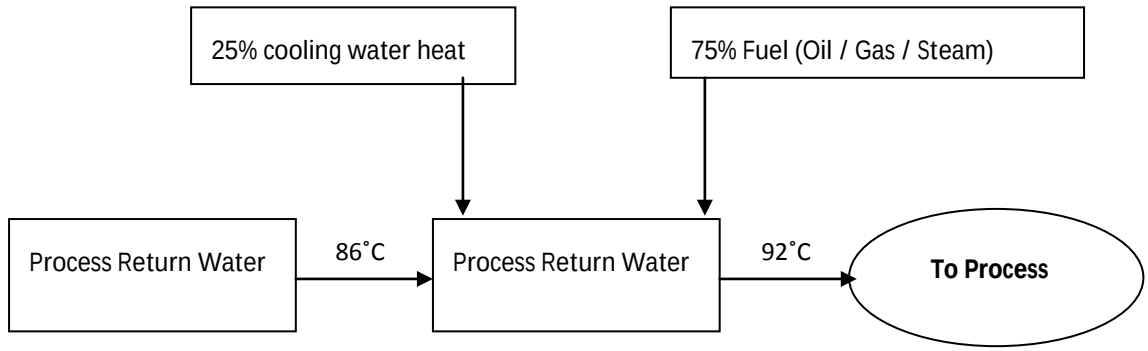

Figure 5: Illustration of energy efficiency through use of Heat Pump

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.

Further details on the technology are provided in the technology factsheet of the TNA Report.

3.2.2 Target for technology transfer and diffusion

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 WHR 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 if conducive implementation environment is developed.

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. There is currently no specific policy on energy conservation / efficiency, however, a renewable energy policy is being drafted, which is to be finalized soon. This draft "Renewable Energy" policy also covers some provisions on waste Heat Recovery (WHR) technology.

3.2.3 Barriers to the technology's diffusion

Given the current situation in Bhutan with regard to the technology, in the course of TNA process several barriers have been identified. These barriers are either economic barriers or non-financial barriers. The non-financial barriers are mostly those associated with the limitations of the current institutional structure, the current policy and regulatory framework or those associated with information and awareness. Based on these

identified barriers, suitable enabling measures which will assist the country in overcoming these barriers have also been identified. A brief summary of these barriers and enabling measures is presented here below. These enabling measures have further been defined and elaborated on with concrete action for each in the next section of this report.

3.2.3.1 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.

3.2.3.2 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[6] (Bureau of Energy Efficiency, India) 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.

3.2.4 Enabling measures

Based on intensive discussions with experts, extensive secondary research as well as international experience, measures for building an enabling environment for development and diffusion of the technology in a way to overcome the above barriers have been identified. These measures include:

3.2.4.1 Economic and financial measures

- Capital subsidies for purchase of equipment, 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 equipment

[6] http://www.beeindia.in/energy_managers_auditors/documents/question_bank/2.8_Waste_Heat.pdf

- 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.

3.2.4.2 Non financial measures

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

a) 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.

b) Institutional measures

- 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

c) 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.

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

3.2.5 Proposed Action Plan for Waste Heat Recovery

In order to develop a most relevant action plan for deployment and diffusion of waste heat recovery technology in Bhutanese industries focused sector specific roundtable discussions were held in Thimphu, Bhutan at NEC. The roundtable participants consisted of sectoral experts and representatives from Association of Bhutanese Industries and Department of Renewable Energy, Ministry of Economic Affairs, Bhutan. Through a technology specific presentation, the roundtable had intensive discussions, which focused on following aspects:

- *Overview of industrial sector*- discussions were held on relevant institutions, stakeholder networks, policies, acts and regulations governing the sector and likely to facilitate diffusion of waste heat recovery
- *General sector barriers and measures*- this brought forward discussions on general profile of barriers faced in the industries sector and the kind of measures that are needed to overcome them.
- *Defining the technology domain:* special focus was given to discussion in terms of defining the technology in a most relevant way given the national circumstances of Bhutan
- *Targets for technology transfer and diffusion*- specific targets were identified for diffusion of waste heat recovery technology. These were based on government plans and documents, particularly the 11th FYP and any on-going or planned government programme for diffusion of these varieties.
- *Barriers to diffusion of waste heat recovery technology*- barriers as identified in Part II of the TNA report, were again revisited along with specific enabling measures to overcome them.
- *Proposed Action Plan Framework for Technology diffusion*- a draft action plan framework was presented and discussed in detail to aggregate and rationalize the measures identified to develop national capacities for acceleration of technology diffusion. The discussion also prioritized and characterized measures for technology diffusion for a national action plan along with estimates of possible technology investment costs.

Based on discussions held at the roundtable, a revised national strategy/action plan was prepared and sent to roundtable participants, especially to the Ministry, for review and comments. Based on which a final prioritized action plan along with national strategy was prepared.

The section brings together the Action Plan which is reflective of the national priorities as those highlighted in the Government of Bhutan Plans, such as the 11th FYP as well as those felt most urgent by TNA Taskforce members and Bhutanese experts.

The Action Plan and thereby the national strategy formulation for the diffusion of waste heat recovery is reflective of national priorities. The budgets of each of these action points are those provided by the Ministries.

To promote energy efficiency through the WHR in manufacturing industries, it is essential to incorporate policies and measures that take industries through path of energy efficient development. The key measures required for diffusion of WHR technologies in Bhutan include the following:

- **Detailed Feasibility Studies** of available WHR potential across iron & steel and Ferro alloys industries - This is a market support measure which will enable various stakeholders including industries, government, financial institutions, and technology providers to develop necessary strategies for WHR implementation.

- **Financial and Fiscal Incentives** – This financial measure will make the projects economically attractive for industries, investors and technology suppliers to invest and promote sustainable development.

- **Capacity Building and Awareness Generation** – This measure is needed to demonstrate the potential and successful application of WHR technologies in Industries. This action will promote accelerated diffusion of the technology in the country.

- **Develop Energy Efficiency Policy** – This measure is required to enhance industry focus and inform market players regarding the strategy of government to promote waste heat recovery as a means for industrial energy efficiency.

- **Strengthen Institutions** – The Government need to create enabling institutions for setting up WHR projects in Bhutan. By strengthening institutions, government will create a single window of all information required for long term support.

- **Set-up Pilot Projects** - For demonstrating financial and non-financial benefits to industry participants and uncover any barriers in large scale implementation

a) Aggregation and rationalization of measures identified for technology acceleration

The list of measures identified for formulation of a national strategy to accelerate the development and transfer of technologies can be seen in Table 10 below.

Table 10: Measures for strategy formulation for Waste Heat Recovery

Strategic measure	Accelerating innovation RD&D	Accelerating deployment	Accelerating diffusion
Economic and Financial Measure			
Designing Financial and fiscal incentives for promotion of waste heat recovery technology in industries	X	X	X
Non Financial Measures			
Institutional			
Strengthen institutions for promotion of WHR technology in Bhutan	X	X	X
Policy, Legal and regulatory			
Develop Energy Efficiency Policy	X	X	X
Market			
Set up Pilot Projects		XX	XX
Technical			
Detailed Feasibility Study of available WHR potential across iron & steel and ferro alloys industries	X	X	X
Awareness and information generation			
Capacity building and awareness generation		XX	XX

* Note: This table illustrates for a strategy of acceleration measures according to letters of each square, using the timescale for completion of an action, where:

- Letter "X" refers to measures which need to be started in the short term and carried out within the next five years;

- Letter "XX" refers to measures which can be completed in up to 10 years;

- Letter "XXX" refers to measures longer-term measures which can be planned for completion within 15 years from the current date and also will be used for other technologies below.

b) Prioritization and characterization of technology acceleration measures for a national plan

Based on the barriers and the enabling measures required for deployment and diffusion of WHR in Bhutanese industries, the key action points that are essential and immediate are described in Table 11. These action points are organized in priority, in order to convey the importance of actions required.

The proposed measures are aligned with the 11th Five Year Plan of Royal Government of Bhutan to ensure that these measures receive required policy and funding support of the Government.

For implementation of these measures, Department of Industries and Department of Renewable Energy under the Ministry of Economic Affairs will be the lead agencies ensuring action against each of these.

Currently there is lack of understanding amongst the Bhutanese industries on the potential of the WHR technology and its applicability in Bhutan. Thus, as a first step it is crucial to undertake a detailed feasibility study of available WHR potential across iron & steel and ferro alloys industries. Along with this, in order to build the market for the technology it is important to undertake the needed capacity building and awareness generation of the industries. For this, related workshops, seminars, exposure visits to other countries are proposed for the industries in Bhutan. In order to introduce a new technology in the current system of industries in Bhutan, it is essential that the policies and regulations are in support of such action. Thereby it is proposed to develop an energy efficiency policy for Bhutan, to enhance focus and inform market players regarding the strategy of government to promote waste heat recovery as a means for industrial energy efficiency. Along with an enabling policy environment, in order to make the projects economically attractive for industries, investors and technology suppliers it is important to make provisions for suitable financial and fiscal incentives. In order to take advantage of a favourable policy and implement the financial and fiscal incentives it is also important to strengthen existing institutions. The R&D Division in the Department of Renewable Energy, Energy efficiency cell in Department of Industries and College of Science and Technology, Bhutan are some of the institutions for which capacity building and increasing their manpower are essential for effective diffusion of WHR in the country. And finally, in order to built the confidence of the industries in the technology it has been proposed to undertake suitable pilot projects to demonstrate the technology. This will help demonstrate financial and non-financial benefits to industry participants and uncover any barriers in large scale implementation.

The importance of each action point along with the timelines and activities, agencies responsible, potential costs along with indicators of success are defined in Table 11 below.

Table 11: Technology Action Plan based on measures identified for technology acceleration (in priority) for Waste Heat Recovery

S.No	Measure (grouped under core elements)	Why is it important?	Who should do it?	How should they do it?	Time-scale	Monitoring, reporting and verification for measure	Indicators of Success	Estimated costs (*1000 USD)	Potential Risks	Potential funding sources
1	**Market support and technical measure:** **Detailed Feasibility Study of available WHR potential across iron & steel and ferro alloys industries**	To inform policy developers, industries, financial institutions, technology suppliers and other market players regarding the market potential of WHR technologies in Bhutan. To assess the overall energy savings and emission reduction potential using WHR technologies in industries.	Department of Renewable Energy	- Preliminary investment grade audits with help of certified industrial energy auditors having audit experience in Iron and Steel industry to assess o Energy consumption baseline in industries across the country o Existing technology use o Assessment of waste heat generated - Studies to assess suitable technology options for the scale relevant to Bhutanese industries based on techno-economic	2013-2014	Department of Renewable Energy and Department of Industries	A publicly available report on Waste Heat Recovery potential in Bhutanese Industries. A list of industries where potential projects on WHR can be implemented	100	Due to limited local capacity, international experts may be required which could result in higher cost for the study.	Green Climate Fund; GEF Least Developed Country Fund; International Climate Initiative; Fast Start Finance; Global Energy Efficiency and Renewable Energy Fund; Nordic Climate Facility; World Bank Clean Technology Fund; NAMA for energy efficiency sector can be

				feasibility analysis - Assessment of financial and technical capabilities of industries						prepared which can include WHR as a key clean technology option and access finance under unilateral, bilateral and credited NAMAs.
2	**Market support and technical measure:** **Capacity building and awareness generation**	To demonstrate viability and successful application of WHR technologies in Industries.	Department of Renewable Energy, Department of Industries	- The DRE and DoI organize various events and programs with support from industry bodies such as Bhutan Industry Association and Bhutan Chamber of Commerce and Industries - 2-3 Exposure visit to industries where WHR has been implemented. The potential sites could be in India and South East Asian countries including Indonesia, Thailand and Philippines - One Technology Exhibition and Trade	2013-2015	Department of Industries and Department of Renewable Energy	Department of Industry and Department of Renewable Energy publishes proceedings and learning from events in their websites. Relevant information also published in Bhutan Chamber of Commerce and Industries and Bhutan Industry Association's websites	100	Low participation of industries as energy efficiency is not directly linked to financials. Policy support is essential to generate the overall importance of energy efficiency for the sector and country.	Same as above

				Show in Bhutan inviting regional technology suppliers and manufacturers - Workshops and conferences in Bhutan and other countries on application and importance of WHR in Industries						
3	**Policy and regulatory measure:** **Develop Energy Efficiency Policy**	To enhance focus and inform market players regarding the strategy of government to promote waste heat recovery as a means for industrial energy efficiency Develop guidelines on specific energy consumption for energy intensive industries	Department of Renewable Energy	- Analysis of existing policies and regulation in Bhutan - Analysis of policies in other countries targeted towards promoting WHR - Develop draft policy and guidelines and request for public comments - Seek approval by Cabinet	2013-2015	National Environment Commission, Ministry of Economic Affairs	Strategies to promote WHR in industries included in Energy Efficiency Policy of Bhutan. Guidelines for specific energy consumption for industries developed and published in Department of Renewable Energy' website.	100	The policy may not be ready within the stipulated time period due to limited institutional capacity and slow process of policy formulation	UNDP is already supporting an energy efficiency baseline study in Bhutan. More funds can be budgeted along with some co-financing from government budget. In addition, international funds providing technical assistance grant to LDCs

										can also be approached for funding.
4	**Economic and financial measure:** **Design Financial and fiscal incentives**	To make the projects economically attractive for industries, investors and technology suppliers	Department of Industries and Department of Renewable Energy	· Under the economic development policy create a renewable energy fund having a defined outlay for promoting WHR projects. The fund could be used for providing various financial incentives. · Using the domestic fund and international funds following incentives could be provided: o Capital subsidies for DPR preparation, energy audit and equipment cost o Fiscal incentives such as accelerated depreciation and reduced import duty for procurement of WHR project equipment o Easy access to capital through dedicated low	2014-2016	Ministry of Economic Affairs	Incentives included in energy efficiency policy of Bhutan and schemes to promote WHR announced by DRE and DoI.	100	Financial support required for WHR projects may be very high and government may not approve all the fiscal and financial incentives. Accessing necessary international funding may take more time than envisaged.	Credit lines for energy efficiency are currently being provided by KfW, World Bank and ADB among others in developing countries. In addition, agencies which finance private sector can also be potential source of funding. These may include IFC, DEG and other private equity firms in the region primarily in India.

				interest credit lines o Creation of credit risk guarantee and venture funds to enhance finance flow · Incentives and schemes designed based on detailed techno-economic feasibility study and investment grade audits					
5	**Institutional measure:** **Strengthen institutions**	To create enabling institutional framework for setting up WHR projects in Bhutan	Ministry of Economic Affairs	· Strengthen existing institutions by increasing resources and building their capacity. Targeted institutions could be o R&D Division in the Department of Renewable Energy and o Energy efficiency cell in Department of Industries o College of Science and Technology, Bhutan · Enhance coordination between various departments by	2013-2015	Ministry of Economic Affairs	An expert core committee focusing on promoting energy efficiency in industries created under the Ministry of Economic Affairs having members from DoI, DRE and other technology and finance experts. The committee would develop programs and schemes to promote WHR in industries. It will also develop	100	This measure depends heavily on policy environment for promoting energy efficiency in Bhutanese industries	This could be funded under government's appropriated budget with support from UNDP's fund for promoting energy efficiency and other international technical assistance grants as mentioned above.

		creating an inter-departmental expert committee promoting industrial energy efficiency in the country · Establish collaboration with international technology providers and technology research/academic institutions · Develop programs for training individuals for becoming energy auditors/managers. In order to build domestic capacity to undertake energy audits/management.	resource plans for strengthening the existing institutions. In long run, this committee could form the basis for creating a separate energy efficiency department under Ministry of Economic Affairs. Currently, energy efficiency is mandate of Department of Renewable Energy. A special cell in College of Science and Technology created with support from a reputed international research/academic institute. The cell would work on industrial energy efficiency and provide

							technology research support to government and private sector. A pool of energy auditors developed in the country			
6	**Market support and technical measure:** **Set up Pilot Projects**	For demonstrating financial and non-financial benefits to industry participants and uncover any barriers in large scale implementation	Department of Energy	· Identify suitable industry and technology provider · Develop detailed project report and implementation plan · Access international finance for setting up the projects · Develop communication and outreach program	2014-2015	Department of Renewable Energy	One pilot project successfully implemented	300	Pilot projects may be associated with technology performance and financial risks	The pilot project can be funded by funding sources as mentioned above. Additionally, there are many WHR technology manufacturers and ESCOs which can provide partial funding. Funding opportunities under NAMA also exist for this measure.

c) Finalizing national strategy

Based on priority technology action plans in the sub-sectors, a national strategy and action plan for the Waste Heat Recovery targets are presented in Table 12.

Table 12: National Strategy (technology transfer and deployment) for Waste Heat Recovery

	0-5 years	5-10 years	10-15 years
Medium-scale, short to medium term technology			
Waste Heat Recovery			
Detailed Feasibility Study of available WHR potential across iron & steel and ferro alloys industries	X		
Capacity building and awareness generation	X	X	
Develop Energy Efficiency Policy	X		
Design Financial and fiscal incentives	X	X	
Strengthen institutions	X	X	
Set up Pilot Projects	X		

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Annex I. List of Stakeholders consulted

Several stakeholders were consulted in the process of preparation of the current Technology Action Plan Report. The list of stakeholders consulted along with their details 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	Water, Agriculture

			interactions	
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 Environment 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, Assistant 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	

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