

RENEWABLE ENERGY BASED SPACE HEATING SOLUTIONS FOR THE MOUNTAINS

TECHNOLOGIES AND POTENTIAL FOR ADOPTION

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INTRODUCTION

Renewable energy heating and cooling has been described as the “sleeping giant” of Renewable Energy (RE) potentials from the global perspective. Demand for heating accounts for a considerable portion of world total energy demand. The building sector uses 35.3% of final energy demand of which 75% is for space and domestic water heating (IEA 2007). In Europe the final energy demand for heating and cooling (48%) is more than for electricity (20%) or transport (32%).

In India, the major energy intensive sectors are Agriculture, Residential, Industry and Transport. Energy-use patterns in these sectors concentrate on changes in energy consumption, sectoral activity and structural change. Almost 40-50% of the final energy is consumed by residential sector, where the final demand for heating (36%) is higher than for lighting (31%) (Monga et al. 2006; EIA, 2014). Energy demand for space heating can be even higher in Himalayan mountain regions, where winters are long and harsh, and characterized by low ambient temperatures for most of the year. It is essential to use heat to keep the temperature of indoor spaces at acceptable levels to do normal household chores. Use of energy for heating, especially space heating becomes not only a necessity but also a requirement for survival.

Inefficient reach of on-grid electricity in remote regions, results in most of the rural inhabitants relying on wood, agricultural residue and animal waste to keep their houses warm; and in urban houses on kerosene and electric heaters. Firewood and LPG are the two main sources of fuel with per capita consumption during winters as high as 1.4 and 0.7 kgoe/person respectively (CEEW, 2014). Traditional space heating systems specific to the region also rely on wood to warm their houses. For instance, the Kashmiri Hamams is a system of construction of heating water and the floor of a stone-house room that is built of large stones. Firewood is used to heat up the Khazan, i.e., the water and the process subsequently heats up the floor of the Hamam. While efficient and cost effective, hamams do take a toll from the environmental point of view. High usage of these traditional fuels has led to environmental damage, rising indoor pollution and consequently, ill-health of the communities. Efficient and alternative non-conventional energy sources would provide sustainable heating solutions and meet the energy needs for heating space in mountain regions.

This policy brief reviews the current technological status of diverse RE technologies that can be employed in space heating. The brief highlights technologies from varied renewable sources such as solar, biomass, geothermal and examines their potential. The article spells out governmental measures to promote renewables, the barriers to adoption and concludes with recommendations for their uptake.

RE HEAT FROM SOLAR ENERGY

Harnessing solar energy for the purpose of space heating is not a nouvelle concept. While solar energy is a feasible option for space heating as most of the Himalayas gets 300 days of sunshine a year for approximately 8 hours a day; the use of solar energy has been minimal in the mountain region. Recent developments in solar technologies and strategies have shown that solar energy can now be judiciously harnessed for heating purposes. Solar energy can be captured and utilized for heating through both simple and complex strategies. These are: 1) Passive Solar Heating 2) Active Solar Heating.

PASSIVE SOLAR HEATING

Passive Solar Heating does not make use of mechanical and electrical devices; it lets the building materials collect, store and distributes solar energy through the natural heat transfer modes - convection, conduction and radiation. The building itself functions as thermal mass to store up the heat it accumulates throughout the day, which is then released during the nighttime.

Three passive solar heating systems are discussed in this brief: direct gain, indirect gain and isolated gain.

DIRECT GAIN

Direct gain is the simplest and most common passive heating system that can be used in cold regions. Radiant heat shines directly into the living space through south-facing windows and is absorbed by the thermal. The building itself acts as a storage mechanism for the heat. This keeps the temperature stable even during the night, as heat always travels from warmer materials to cooler materials. The heat is re-radiated out from the building's core (internal walls/floors) and heats the inner space (outer walls and air) during the night. Carpets and curtains should not be used while considering direct gain system as they obstruct the rate of heat flow (Nayak & Prajapati, 2006).

INDIRECT GAIN - HEAT COLLECTOR

Indirect gain passive heating system makes use of a dark colored heat collector positioned in front of a window directly in the sunlight. It should be dark (preferably black) because dark colored objects take in and radiate more energy than light items. Sunlight goes through the south-facing glass windows and strikes the heat collector. The collector in turn heats the air flowing within it, which creates the natural warm air convection loop.

A Trombe wall is the most widespread indirect gain approach as it can exude heat for several hours after dark. The Trombe wall is typically an 8-16" thick south-facing masonry wall with the thickness of 200-400 mm and with an air gap of 50-150 mm between the wall and the building. The Trombe wall is efficient for mountain regions as it can help in maintaining indoor temperature at about 15 °C when the corresponding outside temperature may be as low as -11 °C (Nayak & Prajapati, 2006). Besides the Trombe wall, other heat collecting insulating materials such as mineral wool, extruded/ expanded polystyrene, PUF (polyurethane foam) and vermiculite can be used.

ISOLATED GAIN – SUNSPACE

Isolated gain systems build up solar energy in a site detached from the space required to be heated. A sunspace (also called a solarium) is a room attached to the south side of a house that collects solar energy and passes on that heat into the home. Instead of solar energy directly entering the house through south-facing windows, the solar gain happens in a structure that is thermally isolated from the home. Vertical windows capture the heat just like the direct and indirect gain system and distribution is achieved through ceiling and floor vents, windows, doors and/or fans. A Sunspace can be kept warm by utilizing insulated glass and offering thermal mass by sowing beds, brick cladding on the house wall or using water-filled drums painted black to absorb solar energy. The location of the sunspace should be based on design of the building and orientation of the sun.

Box 1: Considerations in Erecting Passive Solar Buildings

While erecting a passive solar building, it should be noted that the mountains face climatic variations. Western Himalayas are placed in the cold and cloudy zone. The force of solar radiation is low in winter with a high percentage of diffuse radiation and consequently, winters are particularly cold. Himachal Pradesh, Uttarakhand and Arunachal Pradesh experience this type of weather conditions. Jammu and Kashmir is positioned in the cold and sunny climate zone. The solar radiation is in general strong with a very low percentage of diffuse radiation. Western Ghats belt is situated in the dry and humid zone with high diffusion of solar radiation. Hence conditions for transfer of passive solar strategies should be site and local microclimate-specific:

Cold (Cloudy and Sunny)

- Appropriate orientation and shape of building
- Use of trees as wind barriers
- Roof insulation, wall insulation and double glazing
- Thicker walls and weather stripping
- Sun spaces, greenhouses and Trombe walls

Dry and Humid

- Appropriate orientation and shape of building
- Roof insulation and wall insulation
- Reflective surface of roof
- Balconies and verandahs
- Pastel colors and glazed china mosaic tiles
- Walls, glass surface sheltered by over hangs and trees

Source: http://mnre.gov.in/file-manager/UserFiles/energy_efficient_solar_homes_buildings.pdf

ACTIVE SOLAR HEATING

Active solar heating is a more involved process than passive solar heating. Active solar heating can be applied almost anywhere and does not entail any energy infrastructure. It is carbon-free, has low greenhouse gas emissions and can meet 20% to 60% of the space heating and water heating requirements of a single-family house (IEA, 2011). While Passive Solar Heating makes use of methods to capture heat from the sun, it does not actively augment the process. Active Solar Heating alternatively, employs mechanical and electrical equipment to actively enhance the conversion of solar energy to heat.

Active solar systems generally require a solar collector, i.e., a device used to absorb solar energy and need to employ a substance (air or liquid) that can actively collect heat. Active solar heating systems that use air to absorb the energy are referred to as air collectors. The systems that use liquid as the substance are called liquid collectors. The quantum of heat energy captured per square meter of collector surface area varies with design and site but usually can range between 300 - 800 kWh/m²/yr (IEA, 2011).

Three active solar heating systems are discussed in this brief: Liquid-Based Active Solar Heating and Air-Based Active Solar Heating.

LIQUID-BASED ACTIVE SOLAR HEATING

Solar liquid collectors are most suitable for central heating; and normally use a flat-plate collector that basically consists of an insulated metal box with a glass or plastic cover (the glazing) and a dark coloured absorber plate. Solar radiation is absorbed by the absorber plate and transmitted to a fluid (water or anti-freeze) that flows through the collector in tubes. Flat-plate collectors heat the circulating fluid to a temperature significantly less than that of the boiling point of water. Solar heat is distributed by placing a liquid-to-air heat exchanger or heating coil in the main room. Air returning from the living space is heated as it passes over the solar heated liquid in the heat exchanger. Flat collectors are best suited to applications where the requirement for temperature is 30-70°C (86-158°F) and where heat is needed during the winter months (Kaint & Sharma, 2014).

AIR-BASED ACTIVE SOLAR HEATING

Air-based systems can directly heat individual rooms or they can pre-heat the air passing into a heat recovery ventilator or through the air coil of an air-source heat pump. The "working" fluid for absorption and transfer of solar heat is air. Air collectors in comparison to liquid-based collectors, produce heat earlier and later on in the day and thereby, produce more usable energy. Solar air collectors are integrated into the walls (south-facing) or onto the roofs. For example, a tile roof could have air flow paths built into it to make use of the heat absorbed by them. Solar air collectors can be of two types: room air heaters and transpired air heaters. The choice of air collector should be site and climatic-specific.

The Government of India along with the State Governments promotes ecologically sustainable growth while addressing the country's energy security challenge. The Ministry of New and Renewable Energy (MNRE) provides Capital subsidy for Flat Plate Collectors with liquid as working fluid at Rs 3,300/sq.m. and for Collectors with air as the working fluid at Rs 2,400 / sq.m (MNRE, 2010).

Box 2 : Solar Space Heating in Ladakh

MNRE in collaboration with GIZ has adapted and disseminated solar heating concepts for buildings with active energy storage technology for the high-altitude region of Ladakh. The pilot project aims to offer sustainable energy solutions for the rising energy demand in Ladakh and in regions with cold climate by developing consistent, cost-effective and locally manufactured solar air-heating systems.

Ladakh region experiences an average solar radiation of 2022 kWh/m²/annum. The high level of radiation makes the utility of solar air heating systems favorable. These systems can bring down energy demand by 80% which would lead to savings of more than Rs.20,000 per household, thereby creating sustainable investment. The technology will increase value creation in local people through setting up of manufacturing units, generate income for local planners, engineers and material vendors and reduce outflows in payments for expensive fuel.

Source: (Shukla, 2014)

GEOHERMAL TECHNOLOGY: HEAT PUMPS

Space heating with geothermal energy is one of the most widespread and common direct uses of geothermal resources. Space heating consists of over 37% of the total direct use of geothermal energy worldwide (Bloomquist, 2003). If geothermal heat pumps are also included, space-heating accounts for more than half of all geothermal non-electric uses. Geological Survey of India reports that there are more than 300 known thermal spring localities that have been classified and grouped under geothermal provinces on the basis of their occurrence in specific geotectonic setups. However, despite the apparent geothermal potential, the resources have not been actively used for the purpose of space heating. The Himalayan region is one of the major geothermal provinces with 100+ known thermal springs; and can be actively harnessed for space heating by using existing technology and straightforward engineering.

A geothermal heat pump or ground source heat pump is a central heating and/or cooling system that transfers heat to or from the earth. It uses the earth as a heat source (in the winter) or a heat sink (in the summer). The temperature of the upper 10 feet of the earth is nearly constant between 16° to 24°C. During winter this region is warmer than the air above it, while in summer it is cooler. Geothermal heat pumps take advantage of the moderate temperatures in the shallow ground to boost efficiency and reduce the operational costs of heating and cooling the building (Sharma and Trikha 2013).

Geothermal heat pump systems consist of 3 components: the ground heat exchanger, the heat pump unit and the air delivery system (ductwork). The pumps use a heat exchanger that is in essence a system of pipes called a loop, buried in the shallow ground close to the building to move heat from one space to another. In summer, the

Box 3: Puga Geothermal Spring

Puga is sited at a distance of about 180km from Leh in the Ladakh Region of J&K across the Great Himalayan Range. Puga thermal spring situated at the intersection of the Indian and Tibetan plates in Ladakh, has the maximum geothermal energy potential on the Indian subcontinent. It is estimated that a 30 MW geothermal plant at Puga can save approx 3 million liters of diesel burnt in the region in a year. This can effectively eliminate the need for gas-operated heaters and traditional kerosene stoves and bring down carbon emissions up to 28000 tonnes.

Experimental space heating has been successfully tried using the geothermal fluids at Puga from the shallow wells drilled to date. A prefabricated hut (5m X 5m X 2.5m) was heated with thermal fluids and an excess temperature of 20C over the ambient temperature could be maintained within the hut.

Source: mnre.gov.in/file-manager/akshay-urja/july-august-2013/.../14-18.pdf

geothermal heat pump extracts heat from the building and transfers it to the ground for cooling. In winter, the pump acquires natural heat from the earth and transfers it to the house for heating.

Geothermal heat pumps come in 4 types of loop systems that loop the heat to or from the ground to the house:

- Horizontal: Is best suited for residential construction, particularly for a new building where there is availability of adequate land. It needs trenches of minimum 4 feet deep.
- Vertical: Is used for larger geothermal systems for example in commercial buildings where land is less or the soil is too shallow to bury the horizontal loops in the trenches. Drilling into the bedrock may be required and hence can be more costly.
- Pond/Lake: If the site has a sufficient water body, this system may be the least expensive choice. A supply line pipe runs underground from the building to the water body and coils into circles at least 8 feet beneath the surface to prevent freezing. The coils must be sited in a water source that meets minimum volume, depth and quality criteria.
- Open-Loop: This system uses well or surface body water as the heat exchange fluid that circulates directly through the geothermal heat pump. Once it has circulated through the system, the water returns to the ground through the well, or surface discharge. Open-Loop is effective when there is adequate supply of comparatively clean water, and meets all local rules and directives on groundwater discharge.

Choosing the loop system that is best suited for a specific location depends on the weather, soil conditions, obtainable land and local installation expenditure at the site.

Geothermal heat pumps reach high efficiencies (300% to 600%) on the coldest of winter nights. Furthermore, they have low operating costs as they gain from the relatively stable ground or water temperatures. They are independent of weather and seasonal fluctuations, and of variation in external supply/ demand effects and exchange rates of fuels.

RENEWABLE HEAT FROM BIOMASS ENERGY

The Ministry of Statistics and Program Implementation reports that the Himalayan region is rich in biomass resource with an accumulative bio-power potential of approximately 850 MW (MOSPI, 2014). In Eastern Himalayan Region alone, 37 million tonnes of biomass is produced yearly from agriculture and forestry. The dominant use of biomass fuels as firewood, dung and agricultural residues is for the basic energy need of heating for most households. Extensive use of biomass for heating purposes by direct burning leads to emission of pollutants including respirable particles which cause health hazards and increase greenhouse gas emissions. Excessive and injudicious use of biomass resources has also contributed to deforestation, de-vegetation and soil degradation. Nevertheless, biomass resources when used judiciously using appropriate technologies, can contribute to space heating without adding to environmental and health risks in mountainous regions. These technologies are: 1) Bio-Briquetting 2) Biogas Space Heating.

BIO-BRIQUETTING

Briquetting is the, "process of densification of biomass to produce homogeneous, uniformly-sized solid pieces of high bulk density which can be conveniently used as a fuel" (Kathuria & Grover, 2012). Densifying waste crop residues can provide a better household fuel, especially in remote mountain regions. In addition, briquettes can be manufactured using a simple hand-process, thereby making them feasible for poor communities.

There are several technologies for briquetting and the most conventional and viable is beehive briquetting that carbonizes the biomass waste partially by mixing char with binder followed by the densification process. This form of briquette is circular in shape with a diameter of 150 mm and height of 85 mm, having circular holes. 'Beehive Briquette' gets its name from the presence of the holes, which makes it appear as a beehive.

Beehive Briquettes counter the adverse effects of direct burning as they burn in a controlled, slow and efficient manner because of lower moisture content, higher bulk density and lower ash content. Briquettes are found to be an eco-friendly, clean and economic alternative source of household fuel with temperatures attained ranging from 437°C to 572 °C., with an average equilibrium of 433hr (Mandal et al, 2014). Bio-Briquetting assists in the reduction of fuel wood and deforestation, and its purchase price is less than natural gas, propane and fuel oil, making it viable for space heating. The potential for biomass briquetting in India is estimated at 61,000 MW, while the projected employment generation is about 15.52 million. Farmers have an earning potential of \$ 6 per ton of farm residues (Kathuria & Grover, 2012).

BIOGAS SPACE HEATING

Biogas, the metabolic creation of anaerobic digestion, is a clean, efficient and renewable source of energy, which can be applied as an alternative for other fuels such as firewood; cattle dung cake, kerosene oil, natural gas and LPG. Biogas can be combusted directly as a source of heat for cooking, space cooling and as fuel in gas lamps for lighting; apart from its use for industrial processes and agriculture. Generally, biogas is produced via digesters, which are simple designs that produce gas through decomposition of organic material. Digesters can be of several types, most common being fixed dome digesters and floating drum digesters, which are fixed and cannot be moved. In contrast, tubular digesters are easily movable.

Biogas driven micro-turbines electric capacity is typically less than 200 kWe but their price tag is quite high. The approximate net calorific value of biogas (which depends on the efficiency of the burners or appliances), is about 21.6 MJ/m³ which is about half a liter of diesel oil. The annual biogas generation potential of India is about 17,340 million m³, which could sustain the setting up of up to 12 million family-size biogas plants (Minde et al, 2013).

RENEWABLE HEAT FROM HYBRID SYSTEMS

Hybrid Renewable energy systems are highly energy efficient as their heating Coefficient of Performance (COP) is 3 to 4, meaning they are 300 to 400 times more efficient than using just electric heat.

Solar-Geothermal Hybrid System: A hybrid solar-geothermal pump system (HSGS) can be optimal for space heating in the Himalayas where there is huge potential for geothermal energy and adequate solar radiation. The HSGS consists of solar heat unit and heat pump unit, and acquires heat by an evacuated heat collector that is then transferred to a thermal heat storage tank that is controlled to maintain the designed temperature (Samantaray & Rout, 2013). As solar radiation is variable, the HSGS can absorb solar energy by solar collection. Alternatively, when the solar radiation is not enough to operate, the required energy can be filled by using heat pump, thereby maintaining a constant temperature throughout the year. In addition to space heating, HSGS can be used to supply many different types of heating and cooling loads such as snowmelt, radiant floor systems and domestic hot water up to 115°F.

RENEWABLE HEAT FROM OTHER ENABLING TECHNOLOGIES

Other Enabling Technologies for space heating include the Inter-seasonal heat transfer, Underfloor heating and Radiant heating.

Inter-Seasonal Heat Transfers: Inter-seasonal heat transfer (IHT) is a process by which heat energy is collected and balanced between periods of demand and excess supply. It uses simple underground energy stores to turn solar energy collected by appropriate surfaces, such as asphalt into useable energy (Gordon, 2005). The heat is stored in thermal store underground which raises the ground temperature from 10°C to 25°C. Excess heat energy from the sun is accumulated during the summer and stored in the earth for use in winter. Cooling energy is collected during winter and stored for summertime use. Several variants of IHT can be envisaged, the most popular are:

- i. *Borehole Thermal Energy Storage*, where no fluid is actually exchanged with the ground, but where the volumetric heat capacity of the rock alone is used to store heat
- ii. *Aquifer Thermal Energy Storage*, where heat transfer and storage is by warm or cold groundwater (Midttømme et al, 2008)

IHT provides onsite renewable heat for space heating by re-cycling solar energy; and has less carbon emissions when compared to using gas boilers for heating (50 per cent) and low maintenance costs.

Underfloor Heating: Underfloor heating can effectively distribute heat into a building that can be utilized for space heating, irrespective of whether one uses IHT. Lower temperatures (around 40°C) can be distributed over a bigger area than the higher temperatures (around 70°C) required for wall-mounted radiators. Underfloor heating systems are not visible and can radiate ground level heat to avoid the convection losses and draughts generated by wall-mounted radiators. These heating systems work in sync with ground source heat pumps that can also reduce the annual cost of heating. Ground source heat pumps will deliver a higher coefficient of performance when a lower delivery temperature can be used.

Radiant Heating: Radiant heating systems supply heat directly to the ground or to panels in the wall. These heating systems depend mainly on radiant heat transfer -- the release of heat directly from the hot surface to the populace and objects in the room via infrared radiation. When radiant heating is placed in the flooring, it is frequently named radiant floor heating.

RE TECHNOLOGIES FOR SPACE HEATING AND POTENTIAL FOR ADOPTION

There is a range of well-developed technologies for space heating through renewable sources such as solar, biomass, geothermal, hybrid and other resources. The International Energy Agency (IEA) recommends that multiple criteria should be adopted for selecting the appropriate space heating technologies, from the point of view of deployment. Criteria for selection and deployment should comprise the annual heating profile for space heating, emission regulations and cost comparatives such as utility prices of various fuels, initial expenditure and cost of financing. Operational factors such as the seasonal efficiency of equipment, complexity of installation and operation, reputation of manufacturer and architect/engineer/builder/installer's knowledge of available technologies and model should also be considered (IEA, 2011). The potential for RE technologies in space heating is examined by looking at some of these criteria such as: economic variability, in terms of maturity of the technology, estimated life, levelised cost and capital cost of equipment; GHG emissions and their limitations (Table 1).

GOVERNMENT EFFORTS TOWARDS PROMOTING SPACE HEATING TECHNOLOGIES

India does not have an integrated RE policy towards space heating but an array of different policies that provide incentives and benefits for renewables. Most noteworthy are the Electricity Act 2003 and National Tariff Policy 2005. The landmark act and subsequent policy has had a significant role in recognition of RE projects by providing a framework for preferential feed-in tariffs and quotas for renewables. A number of RE committed institutions such as the Ministry of New and Renewable Energy (MNRE) and India Renewable Energy Development Agency (IREDA) have been set up to promote RE technologies. MNRE plays a key role in facilitating RE development ranging from resource mapping, to technology development and promotional projects; MNRE also gives incentives to individuals for installing RE utilities (TERI, 2011). IREDA is a public financial institution established in 1987 and has played a pioneering role in supporting and financing the policies and programs of MNRE.

The Government of India also has various policies for promoting energy efficient or green buildings. Primarily amongst these are The Integrated Energy Policy 2006 (Planning Commission) and the National Housing and Habitat Policy 2007 (Ministry of Housing and Urban Poverty Alleviation, 2007). Energy efficiency measures in buildings are also being encouraged by state electricity companies, municipalities and banks, through rebates in electricity charges for those using solar technologies, introducing voluntary codes and low interest loans for green buildings (GBPN, 2014).

Table 1: RE Technologies and Potential for Adoption.

	Bio-Briquettes	Biogas Space Heating	Solar	Geothermal (Heat Pumps)
Maturity	Mature	Mature	Mature	Mature
Estimated Life	10 Years	25–35 Years	20-25 Years	20+ years for the heat pump and 25-50 years for the underground infrastructure.
Levelised cost (Estimated)	Rs 4 / unit	Average economic cost of generation is Rs 4.6/kWh for biomass (Ranges between Rs 3.9–Rs 5.7/kWh).	Rs 12 /kWh.	Average economic cost of generation is between Rs 3.11-Rs 4.08 Kwh. The cost may further decline once the capital cost has been recovered (EAI, 2012).
Capital cost of equipment (Rs)	Maximum of Rs 40, 000	Cost of bio digester technology is USD 200-400 i.e. between Rs 13000 – Rs 24000 (Rajendran et al. 2012).	5,000/m ² (Bhatt, 2011) for Active Solar Heating Technologies	Rs 1,487,960/-
Fuel Availability	Regional, dependent on harvest and forestry		- Availability across mountainous regions - Seasonal Variation	Constant availability due to presence of Geothermal Springs
Concerns	<ul style="list-style-type: none"> - High investment cost and energy consumption to the input process. - Can lead to air pollution in the form of char if the biomass is not completely combusted 		<ul style="list-style-type: none"> - Battery replacement every 3 to 4 years - Continuous power production not possible 	Despite its huge potential, geothermal energy has been inadequately explored due to its high up-front capital demand.

BARRIERS TO ADOPTION

There is a range of well developed RE technologies for space heating which are a viable option for competing with fossil fuel derived sources of heat. However, the uptake of RE for space heating is slow and has received limited attention from policy makers. Several barriers hamper the uptake for renewable heat. Heat is less open to regulations as compared to conventional fuels and electricity sector that can be regulated through grids and production, transmission and distributed processes (IEA, 2014). Further, there is lack of reliable and specific data on heat production, its utilization pattern and cost of production across mountain regions in India. This gets compounded with the unavailability of skilled personnel who can install and maintain RE technologies. For instance, heating engineers might not be familiar with solar or geothermal systems. There is a general lack of awareness amongst stakeholders in mountain regions vis-à-vis the potential and suitability of diverse renewables (Enviros, 2008).

Overriding these multiple barriers is the skewed prioritizing of subsidies right at the policy level. Policies targeting the cost of fossil fuels through subsidies and other mechanisms pose a significant challenge for the cost-competitiveness of RE for space heating. India ranks fourth amongst the countries with the highest quantum of subsidies spent (IEA, 2014), and this severely affects the growth of the RE sector. Hence, primarily the barriers are economic~ RE technologies are not generally cost-effective with conventional technologies under existing pricing mechanisms; and structural including regulatory and policy uncertainties and institutional frameworks.

Box 4: Barriers to Adoption

- Lack of regulation in space heating sector
- Lack of data on heat production and utilization
- Unavailability of skilled personnel to install and maintain RE technologies
- Lack of awareness amongst stakeholders
- Lack of active players in the market
- Prioritizing skewed subsidies
- Lack of replicable models

Source: USAID, 2013

RECOMMENDATIONS FOR RE TECHNOLOGIES

The role of RE has been relatively negligible in space heating sector in remote mountainous regions, with the exception of traditional and inefficient use of biomass. The deployment of cost-effective renewable space heating technologies, adjoined with energy efficiency measures can reflect a broader positive change in the space heating energy scenario. The following recommendations would encourage effective deployment of RE technologies in mountain regions.

DEPLOYMENT OF REGULATORY POLICIES

- Introduce a holistic, integrated regulatory framework together with policies and programs that assimilate the mountain perspective and their energy needs.
- Embed energy policies in the local economic development plan to reflect local potentials and needs.
- Integrate RE technologies in space heating within supply chains in rural mountain economies such as agriculture, forestry and green tourism.
- Limit subsidies in both span and duration and only utilize them to promote RE projects that are close to viability in market scope (OECD, 2012). If there are too many subsidies and incentives, they can lead to “high cost-energy that is viable as long as high levels of subsidies are sustained” (ibid).
- Introduce efficiency-labelling schemes for heating sector in mountain regions.

IMPROVE INFORMATION AVAILABILITY

- Develop uniform information/metric packages of life-cycle costs and benefits for heating technologies (IEA, 2011).
- Ensure that stakeholders in building sector and consumers are aware of information offered and are well informed in the use of the information.

MARKET TRANSFORMATION

- Expand quality assurance schemes to encompass the entire sector and provide investors with confidence to invest (IEA, 2011).
- Promote market investment in RE by instilling Energy Service Orientation that makes a change from delivery of energy products to providing energy services.

OTHERS

- Encourage localized plans for space heating. Include factors such as efficiency and affordability as the guiding principles while introducing any new technology.
- Promote international technology development along with transfer mechanisms, to aid increase in technological efficiency and further cost reductions.

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