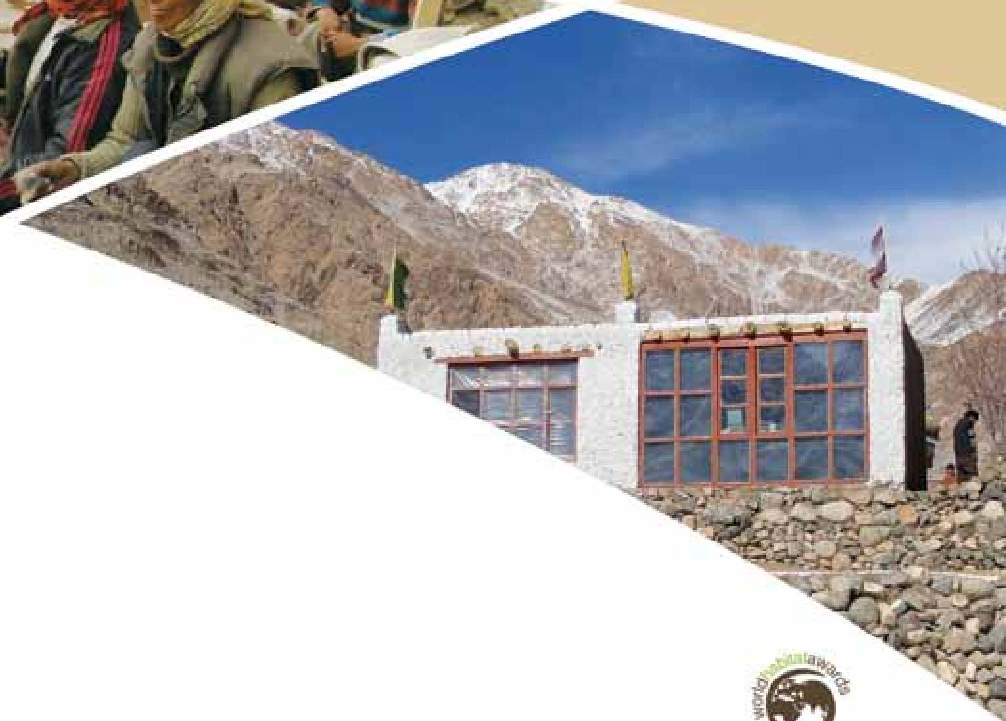
Innovative low-energy habitat solutions

Reducing pressures on rural communities and fragile eco-systems in the trans-Himalayas



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Mohammad Hasnain

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Executive summary

There is overwhelming scientific evidence that the climate is changing and the earth is warming and the causes are anthropogenic or, human induced. The life sustaining role of the biosphere is at serious risk because of an unrestrained use of natural resources. Governments around the world are waking up to the realization that unbridled use of natural resources and particularly of fossil fuel, for achieving economic growth is not sustainable.

Sustainable development cannot be achieved without the sustainable use of energy resources. Energy security is a growing concern for the rich and emerging nations alike as a peak oil crisis in the very near future looms large. Investments into alternative and renewable energy sources are finally picking up even though they still remain very small compared to fossil fuel investments.

GERES was set up following the first oil crisis in 1976 and has since been engaged in the quest for an ecologically responsible society and has focussed much of its efforts in promoting clean and efficient energy production and consumption in 12 countries where it currently works. GERES has been working in the western Himalayas with local partners for over two decades, improving rural livelihoods and promoting sustainable energy solutions.

Amidst the harsh and now unpredictable weather conditions in the western Indian Himalayas, little consideration is given to healthy, cost-effective and permanent solutions to space heating. Villages are often isolated for half a year with access passes remaining closed due to heavy snowfall. The rural population hardly has any winter income, and women and children spend a large part of their time collecting fuel wood. The conventional means of heating the rooms by keeping biomass fuel fed stoves and braziers burning throughout the day also give rise to serious health issues besides causing ecological degradation and environmental pollution.

Based on a project implemented from 2008 to 2012, efforts have been made to reduce the pressure on rural mountain communities of securing their winter heating needs as well as the pressure on the fragile ecosystem from the unsustainable harvesting of scant natural resources such as wild bushes that are needed to stabilise the loose soil on the mountain slopes or animal dung that are diverted from use as manure for field to room heating. The approach consisted of improving livelihoods of rural populations living in these remote villages of the trans-Himalayas by improving unhealthy winter conditions, supporting the development of income generation in the newly improved habitat, alleviating energy vulnerability and setting up a sustainable network for dissemination of energy efficient housing technology.

The consortium promoted energy efficient housing by helping to build over 1,000 LEC houses, 97% of which were for poor households and 3% were community or public buildings. The LEC designs were contextualised to locally available materials and architectural styles and make use of the abundantly available solar energy to heat the houses more efficiently, more healthily and without causing drudgery to women and children. Studies confirm that biomass fuel use, energy costs and pollution have all been reduced by 54 to 67% after the action while human and environmental health is being improved. Over 21,599 tCO_2 emissions are also expected to be reduced over a 10 year period.

Accronyms and abbreviations

AGH	Attached Green-House
DG	Direct Gain
EE	Energy Efficiency
GERES	Groupe Énergies Renouvelables, Environnement et Solidarités
GHG	Greenhouse Gas
GLN	Grassroots Level Network
HKH	Hindu Kush Himalayas
HP	Himachal Pradesh
IEC	Information Education & Communication
IGA	Income Generating Activities
IGH	Improved Green House
J&K	Jammu & Kashmir
KLS	Kinnaur and Lahaul & Spiti
kWh	kilo Watt hour
LAHDC	Ladakh Autonomous Hill Development Council
LEC	Low-Energy Consumption
LEDeG	Ladakh Ecological Development Group
LEHO	Ladakh Environment and Health Organisation
LNP	Leh Nutrition Project
LPG	Liquefied Petroleum Gas
LPO	Local Partner Organisation
LREDA	Ladakh Renewable Energy Development Agency
MEC	Monitoring and Evaluation Cell
MNRE	Ministry of New & Renewable Energy
NGO	Non-Governmental Organisation
PSH	Passive Solar Housing
RRC	Regional Resource Centre
Rs.	Indian Rupees
SECMOL	Student’s Educational and Cultural Movement of Ladakh
SHG	Self Help Group
SW	Solar Wall
TW	Trombe Wall

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1 The consortium

Groupe Énergies Renouvelables, Environnement et Solidarités (GERES) is the leader and nodal organisation of the initiative. It is a French NGO founded in 1976 and currently working across 12 countries. GERES India has been working in the Himalayas since 1986, supporting LPOs and institutions to promote income generation activities and eco-friendly technologies by using energy services and renewable energies. GERES India has provided in depth insight into this context over the last 25 years.

Ladakh Ecological Development Group (LEDeG) was formed in 1983 and is one of the oldest Ladakhi NGOs. It is recognised for its work in renewable energies, appropriate technologies, environment, organic agriculture, food processing and handicrafts. The organisation is based in Leh, with a sub-office in Kargil. LEDeG implements the activities in Changthang and Nubra regions in Leh as well as Zanskar, Drass and Suru regions in Kargil.

Ladakh Environment and Health Organization (LEHO) has been working since 1991 on organic agriculture, passive solar housing, handicraft, health and environment. It has expertise in greenhouse technology and pashmina fibre processing. LEHO implements the activities in Sham and central Leh areas.

Leh Nutrition Project (LNP) was set up in 1978, and focuses on child rights, rural development, education, health and passive solar architecture. LNP has developed the concept of artificial glaciers to cope with climate change. It played a role as resource organisation for the handicrafts component on account of its experience in the field. LNP carries out the activities in Rong, Nyoma and Markha valley in Leh district.

Students' Educational and Cultural Movement of Ladakh (SECMOL) has been working since 1988 in reforming the education system in Leh district. They also work in media, governance and environmental issues. They have a wing dedicated to energy efficient building construction. SECMOL is the resource NGO for awareness campaign, media and publication.

ECOSPHERE was formed as a merger of MUSE and STAG, NGOs that have been working in Spiti on community mobilization, livelihoods, cultural preservation and passive solar technologies since 1992. It has considerable experience in sea buckthorn processing and marketing. It is the partner NGO implementing the activities in Kinnaur and Lahaul & Spiti districts.

2 Introduction

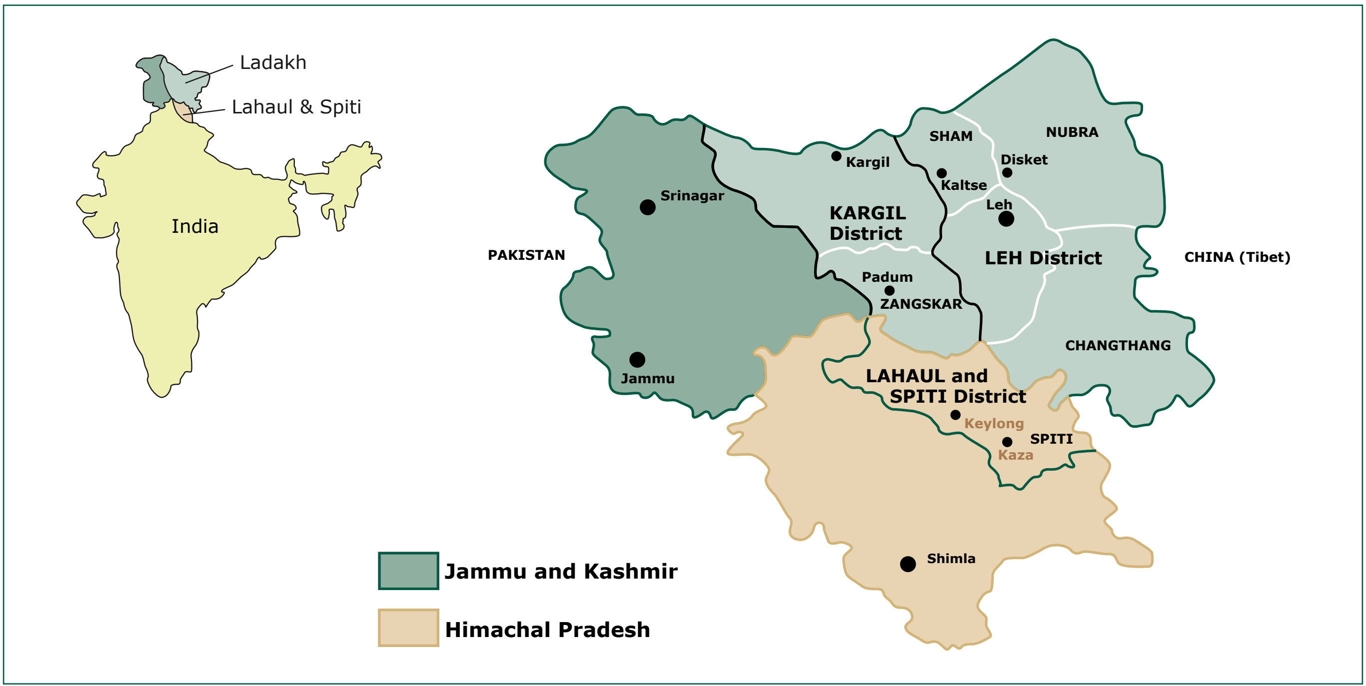
GERES has been operating in India since 1986 and has actively implemented projects in the Ladakh region on issues related to environment, renewable energy, food security and sustainable rural livelihoods. Along with its local partners LEDeG, LEHO, LNP, ECOSPHERE and SECMOL, GERES has been trying to address some of the key issues in sustaining the development of a fragile cold desert region. After successfully completing a project on improvising and popularising the technology of 'green houses' for winter vegetable production in the cold arid region who's surface connection with rest of the world gets snapped for half a year during which time people have little access to fresh vegetables raising serious issues in the balance of nutrition and resulting deficiency diseases, GERES embarked on another ambitious journey of popularising Low Energy Consumption (LEC) houses to address the issue of grave regional energy vulnerability and dependence on imported fossil fuel and the consequent environmental pollution as well as to ease the harsh life of rural seasonal marginal subsistent farming communities during the extreme winters that, besides other things, cripple economic opportunities for half a year. "*Improving the winter livelihoods of rural population and setting up sustainable network to disseminate energy efficiency in the cold desert of western Indian Himalayas*" was conceived and implemented to address these issues by improvising and popularizing innovative LEC habitat solutions in domestic, community and public buildings while organising sustainable networks for ensuring dissemination of energy efficiency. Besides the Ladakh region, this initiative also covers the cold desert region in the neighbouring state of Himachal Pradesh who share a largely similar geography, climate and ecology as Ladakh and as a consequence much of its developmental and environmental issues.

2.1 Location of the intervention

The area of the intervention is located, part of the Western Hindu-Kush Himalayas, constitutes the cold desert region in India. It comprises of Leh and Kargil districts in the state of Jammu & Kashmir, and Kinnaur and Lahaul & Spiti in Himachal Pradesh. While Kinnaur and Lahaul & Spiti districts (hereafter referred to as 'KLS') are part of the greater-Himalayas, Leh and Kargil districts (collectively known as Ladakh) are part of the Tibetan Plateau in the trans-Himalayas. KLS is spread over around 20,000 square kilometres with a population of over 115,000 people, all rural. Ladakh, on the other hand has a wider spread out at around 60,000 square kilometres and also has a much larger population of 290,000, around a quarter of whom are urban dwellers. All the four districts are amongst the most thinly populated in the whole county. Most villages have a population of only a few hundred people and are typically spread out along valleys. While a lot of infrastructure development has taken place in the last few decades and roads pass through or are close to most villages, some are still accessible only by days of trek.

The altitude of inhabited villages within the target area starts around 2,500 meters above mean sea level in Kinnaur district and goes all the way up to 5,000 meters in Leh district. The entire Ladakh region and most of the area in the other two districts fall in the rain shadow area with very little of the monsoon clouds getting past the mighty Himalayan peaks. Annual precipitation ranges between a mere 10 to 30 centimetres in much of the region. True of a desert ecosystem, temperature variations are extreme, ranging between typical summer highs of 30 0C and winter lows of -300C. The records, however, are much higher, with Kargil district alone recording a minimum of -60 0C and a maximum of 360C, peak variation nearing an incredible 100 degrees Celsius.

A region that remains cut off from rest of the world through surface transport for half a year, with clusters of villages within the region also remaining cut off from others for up to eight months a year; a difficult terrain, where many villages can be reached only after days of trek and where many of the internal roads and passes are prone to snow and landslides; besides the distinction of being one of the highest, coldest and driest place in the world, make it one of the most inhospitable inhabited regions on earth. These objectives and achievements could best be understood and appreciated within the context of these extreme challenges.



2.2 People and economy

Majority of the people inhabiting the target area are classified as belonging to various Scheduled Tribes (indigenous communities) by the Govt. of India and are largely of Tibetan descent and Mongoloid features. Buddhism is the main religion professed in Leh and Spiti while Kinnaur and Lahaul have a mix of Buddhists and Hindus and Kargil is largely Muslim. Most people in all the four districts speak various dialects of the Tibetan language while Hindi is also a significant language in Kinnaur and Lahaul.

Subsistence agriculture is the main source of livelihood in much of the region even though unproductive soil and harsh climatic conditions mean the growing season in the region is very short and the yields from a single annual crop are very low. Water resources are minimal with glacier-fed streams, declining in the wake of climate change and receding glaciers, providing the only source of irrigation. The choice of livestock varies largely according to the altitude. In the higher reaches, people generally keep Yaks for meat as well as for carrying load, horses also carry load and are used as well for ploughing the fields, while sheep and goat are raised respectively for their meat and pashmina fibre. In the lower areas, people keep *dzos* (a mixed breed of a yak and a cow) for ploughing, donkeys for agricultural loads and cows for their milk. People in the lower areas have largely stopped keeping sheep and goats and are focussed more on raising high-breed cows for their milk.

The dominant crops in the region are wheat, barley, pulses and potatoes. Of late, cash crops such as apples, apricots, potatoes, peas and other vegetables have also become a very significant contributor to the family income, especially in the lower parts of the region. Pastoralists and artisans also constitute significant groups in certain pockets of the region. In the last two decades, employment with the state governments as well as the Indian army has emerged as significant alternatives to farming, and one much preferred by the educated youth. A significant number of the uneducated youth as well as the elderly add to their farm incomes by working as seasonal casual labour in the private sector as well as the military/para-military. Tourism is another sector that is fast emerging as a significant and attractive source of employment in parts of the region. Despite all elders in the family juggling through a range of seasonal and generally demanding jobs, most families in the target area subsist on less than € 0.5/capita/day.

3 The problem and its context

The United Nations Conference on Sustainable Development (Rio+20) held in Brazil in June 2012 identified energy as one of the key areas which need priority attention in implementing sustainable development. Later in September, the UN General Assembly passed a resolution on the outcomes of the conference and making a serious note on sustainable energy as a foundation of sustainable development says "*we recognize the critical role that energy plays in the development process, as access to sustainable modern energy services contributes to poverty eradication, saves lives, improves health and helps to provide for basic human needs… we recognize that improving energy efficiency, increasing the share of renewable energy and cleaner and energy-efficient technologies are important for sustainable development, including in addressing climate change… we also recognize the need for energy efficiency measures in urban planning, buildings and transportation*".

In a global economy that is growing by the leaps and bounds, fuelled largely by fossil fuels, sustainable use of energy is a prerequisite in achieving sustainable development. Fossil fuels that are scripting much of our growth story are a non-renewable resource besides being one of the main contributors of global warming. India is the third largest economy in the world and was among the lucky few that did not suffer much shock from the 2008 international financial crisis and continued to grow around 7-8% annually. But, unless India finds clean alternatives to its energy needs, this rate of growth cannot be sustained. India was likely the first country in the world to establish a separate ministry of non-conventional sources in the early 1980s but have managed only modest achievements in popularising the use of clean energy. The share of renewable energy in the energy sector currently stands at around 12%, towards the lower end amongst major economic powers.

GERES was set up following the first oil crisis in 1976 and has since been engaged in the quest for an ecologically responsible society. Much of GERES's efforts through its programmes and policy advocacy have been focussed on promoting clean and efficient energy production and utilisation across the three continents that it is currently working in. The current action in the western HKH mountains aim at popularising innovative Low-Energy Consumption (LEC) habitat solutions in the form of contextualised, community centric, Passive Solar architecture and energy efficient techniques in one of the harshest habited regions in the world with a high energy requirement for winter room heating.

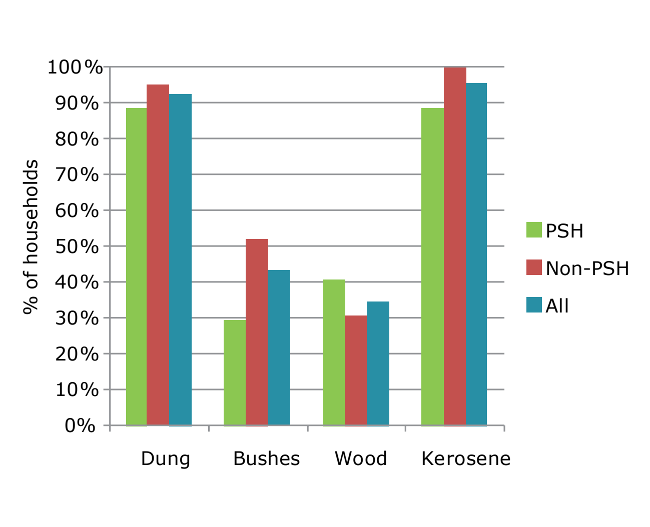
3.1 Energy vulnerability in a fragile ecosystem

The poor and tribal communities in mainland tropical India are typically found living close to the forests, as the forests have traditionally provided for much of the poor's food and energy requirements. But being a high altitude cold desert, the entire target area does not have such luck and are extremely poor in natural resource endowments. Ladakh region, which makes for three quarters of the area, has less than 0.1% area under forest cover, and that too open scrub. The situation in KLS is only a little better. When juxtaposed with an extremely harsh winter lasting 6 to 8 months when night temperatures are sub zero, the shortage of locally available fuel wood and high cost of imported conventional fuel translate to a situation of severe energy vulnerability for the region.

The energy requirement for space heating in the region makes up for more than half of the average family's total energy intake. The region is not connected to the national electric grid and local electricity production, largely through small diesel generator sets, are not able to meet even the lighting needs. A very small percentage of people in and around the towns have started to use Liquefied Petroleum Gas (LPG) based room heating devices besides kerosene oil fuelled metal braziers/furnaces, but the poor people in the villages cannot afford such expensive fossil fuel. They still depend on biomass fuel such as wood procured from the market, wild bushes collected very laboriously from the mountains and most importantly animal dung, collected from the animal sheds and the pastures. Women and children, on whom the burden of collecting the bushes and dung rest, often spend 50 to 60 days a year during the summers towards the family's survival through the winters. Surveys reveal that the average family burns around seven tons of biomass fuel every year, releasing a large amount of pollutants in the atmosphere that contribute to global warming. Additionally, wild bushes are harvested unsustainably by plucking them out from the roots causing soil erosion and land degradation while a very large amount of dung used for heating is diverted from their use as natural fertilizers in the fields, further accentuating the impact of using biomass fuel for house heating purposes.

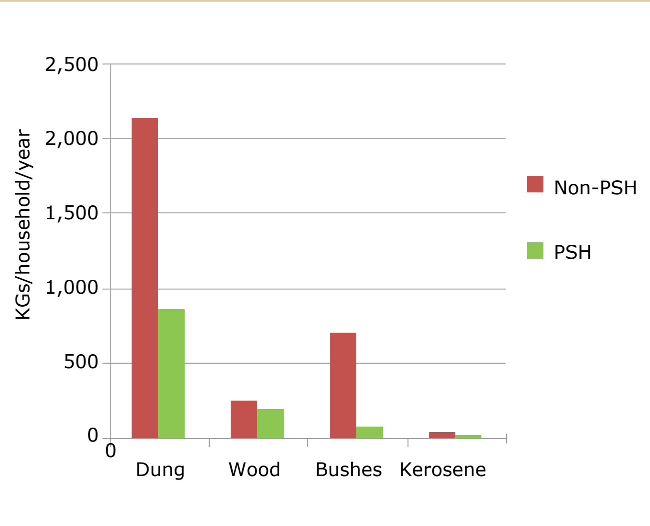
Traditional houses in the region, that are very different from ones in the mainland, have evolved over the centuries, locally available materials and the harsh climate being the two main influences. The main frames are built from sun dried mud bricks and/or rubble stone while the flat roofs are made of poplar beams and willow twigs with a thin layer of straw or shrub and a thick layer of mud/fine clay on top. The walls, floors and roof do not have any insulation and these energy inefficient rooms fail to retain much heat indoors for long. Even though trends are changing now, traditional houses had very small doors and windows with thick curtains to minimise heat loss. The rooms would thus be quite dingy and dark in the winters. During the peak winters, the entire family would live, cook, eat, study, work and sleep in a single room since most people can't afford to have heating in a second room as well.

Proportions of households using different fuels



Source: Kimberley Buss, May 2012

Reported fuel saving achieved by the PSH/LEC houses



Source: Kimberley Buss, May 2012

In much of the region people still live in joint families with even up to a dozen members living together in the same house. The living conditions are thus very unhealthy with so many people living and sleeping in a single room with very little ventilation. Tuberculosis, common cold and many other communicable diseases are easily spread from one family member to the other. Smoke from the continuously burning, and often inefficient, stoves is the main cause for a very high number of tuberculosis and other respiratory diseases that are reported in the region. Women and younger children who generally spend more time at home and close to the stoves are the biggest victims. Small scale winter livelihood opportunities are also a big casualty of the far from comfortable indoor temperatures that do not really make it possible for the people to engage in any productive work such as handicrafts that village communities are typically traditionally skilled at.

3.2 The opportunity in the tragedy

The one advantage, albeit a significant one, of being a high altitude desert, is that most parts of the region keeps a clear sky and receives around 300 sunny days a year. Not just that, the high altitude and rarefied atmosphere means that the intensity of the sun rays falling on the ground is much higher than in most other places. Solar data collected by LEDeG indicate that annual average solar radiation at a 35o south facing tilt is 6360 kWh/m²/day in Leh town. Similar data recorded from some other parts of the region indicate that radiation is largely in the range of 6000 to 7000 kWh/m²/day, suggesting that the region is sitting on a virtual 'solar mine' so to say. This solar energy could be harnessed in active ways such as in photovoltaic and solar thermal electricity generation, solar cookers and water heaters, as well as in passive ways such as in heating buildings through the use of passive solar architecture. If the opportunities are tapped to the right scale, solar energies could potentially prove an important tool in attempting to break the vicious cycle of energy poverty and human underdevelopment that is one of the biggest challenges facing development agencies in much of the world's poorest countries. The opportunity GERES realised was that while most similar initiatives elsewhere in breaking this vicious cycle and propelling growth still largely fell on the use of fossil fuels that are both economically as well as environmentally unsustainable, there was a perfect opportunity to showcase how a poor and remote mountain region could set an example of implementing sustainable development by not only shifting bulk of its energy requirements to clean and renewable energy but also using the same for improving the livelihood opportunities of the poor.

4 The consortium's initiative

Passive solar concepts were promoted in Ladakh by several stakeholders at different points of time, but these were more localised and smaller initiatives that did not breed much replication. Since 1986, GERES has been working on developing solutions based on passive solar technologies to improve living conditions and livelihoods in the region. LEDeG introduced the concept in the mid 1980s and supported the construction of many passive solar houses in and around Leh town as well as in the Changthang area. LEHO also built passive solar houses in many villages in central Leh. SECMOL built its rural campus and a residential school in Durbuk using passive solar techniques and also built a few army and school buildings. From around the beginning of 2,000 many stakeholders started joining efforts and collaborate to share knowledge and experiences as well as to advocate policy changes. In 2005 this group formalised the network and worked together on another GERES led project in promoting passive solar green houses for winter vegetable cultivation in the same region, a project that won the Ashden Awards for Sustainable Energy in 2009. The current consortium is made up largely of the same partners, each of whom brings along decades of institutional experience as well as expertise along key verticals.

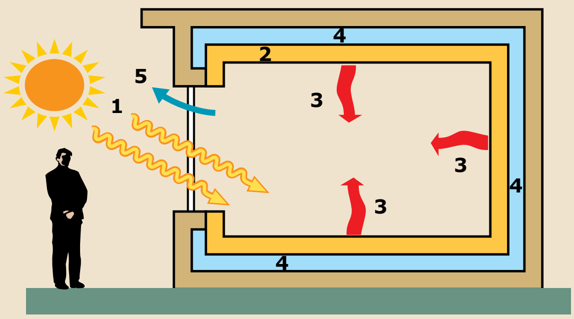
Having gained deep understanding of the sustainability issues from its presence in the region for two decades, GERES had long felt the need for demonstrating the efficacy of passive solar architecture in addressing the twin issues of energy vulnerability stemming from high winter heating needs as well as economic sterility for a large number of rural poor during the harsh winters. Its successful experience with passive solar green houses reinforced GERES and its partners' faith in the technology and approach. The ideas took the shape of a project, "Improving the winter livelihoods of rural Population and setting up sustainable networks to disseminate energy efficiency in the cold desert of western India Himalayas" in 2007, and was launched on field in 2008. The project was to conclude by the end of 2011 but because of the devastating floods in the region in August 2010, it had to be extended by a year. The project focuses on three main objectives - demonstrating the technology by integrating energy efficiency in 1,000 buildings, 970 domestic and 30 community/public owned; supporting artisans and women's groups to enhance their income generation through the winter handicraft activities; setting up networks at three levels that would sustain beyond the project to carry forward its broader goals. Besides these, the project also integrates two related focus areas into the project - environmental monitoring and climate change awareness, and, intensive capacity building of the partner organisations in technical and managerial aspects. **This case study focuses on the objective of integrating energy efficiency in 1,000 buildings.**

4.1 Technology: innovative, appropriate and scalable

Passive solar architecture has been used for centuries, for both cooling as well as heating houses, in different climate zones across the world. Simple techniques of tapping the solar energy and providing adequate thermal mass and thermal insulation to store this energy are employed to keep the house/room warm through the winters in cold regions. GERES India has been conducting R&D and testing out various models of passive solar techniques as well as green houses through pilot projects since 1998. Contextualizing the technique in a culturally appropriate architectural style as well as the use of cheap and locally available materials has been prime guiding concerns through this pilot phase.

Passive Solar Housing (PSH)
This kind of construction taps into the sun's energy for heating purposes without using a mechanical tool to transform/transport this energy. Through south-facing walls and large south-facing windows, the room collects solar energy during the day (1), stores this energy in the walls (2), releases the stored energy after sunset (3) as the walls could be used as energy banks due to the proper insulation all around (4).

Energy Efficiency (EE) in Houses
When it is not possible to collect the optimum amount of solar energy because of bad orientation of the building or obstructions, use of insulation (4) is strongly advised. This would still enable the room to retain the energy produced from heating and cooking within the house and reduce all the heat that would other be lost.



1. **Collection** and absorption
2. **Storage** of the heat
3. **Release** of this heat
4. **Insulation**
5. **Ventilation**

The principles of passive solar architecture have been used to place in front of the people three different styles or techniques of building (or retro-fitting) passive solar houses depending on their needs and preferences as well as technical feasibilities. These are:

- **Direct Gain** (DG): A big double glazed window on the south allows for maximum capture of the sun rays during the day and instant heating of the room. Insulation on the walls, floor and roof, like in the other techniques as well, insure the heat doesn't leak out quickly. This is most suitable for a room meant for day use as it warms up quickly after the sun rays start to fall on the window.

- **Solar Wall** (SW): An adaptation of the Trombe Wall technique, it comes with the big window on the south as in a DG but with a big difference, a massive wall a 12 inches inside of the window painted black on the outside absorbs the solar energy and releases it through the night towards the interior of the building. This is most suitable for rooms used during the night though they are warm in the day as well.

- **Attached Green House** (AGH): It is literally a green house attached to a south facing wall with metal or wooden frames holding up a big polythene sheet that traps the solar energy in the day and makes for an extra warm room at the same time passing on some of the heat to the adjoining room. This is a cheaper option and does not involve much structural changes.

Much thought has gone into detailing out the various contours of the project and how it would be managed on the ground. One of the key concerns was to see the energy efficiency movement surge forward even after the end of the project. The project placed its bet on three key strategies. One, as earlier mentioned, was the formation of networks at three levels that would carry forward the work at policy as well as ground levels. The second was to build a strong cadre of trained and certified LEC artisans that would form the backbone of a private sector capable of meeting the expected demand in LEC services. The third strategy was to span out the initiative in three phases with a diminishing support model.

- The 'Demonstration Phase' aims to promote the concept/technology through people who could appreciate the innovation and were willing take some 'risks'. Opinion leaders were particularly targeted since they could more effectively demonstrate the advantages to rest of the community. The support/ subsidy is the highest in this phase since people are risking on a new technology.

- The 'Extension Phase' aims at diffusing the technology to the wider public based on the hope that a single winter would suffice to demonstrate it through recommendation of promoters from the first year and visits to their houses. Socio-economically weaker sections of the society are particularly encouraged to avail the support and are also preferred where the demand outshoots the supply.

Direct Gain

Solar wall

Attached greenhouse

- The 'Exit Phase', or the third year in a particular village, as the name suggests lays ground for the project to exit from the village. Financial support as well as technical support and follow up are reduced while involvement of the local stakeholders is sought to increase to prepare for sustainability and replication beyond the initiative.

One of the main pillars on which much of the project's execution hinged is the training of professionals and artisans to supervise and monitor the technical components of LEC technologies. The coordinators and field staff from the partner organizations were the first ones to be trained in the theory and practice of those technologies. Next, a whole cadre of 237 local masons and carpenters were trained over the years that would actually build and supervise the construction of the LEC houses on the ground. These artisans, from each of the village/clusters, were selected by the village communities and were given basic, advanced and refresher courses as well as on site training and continuous guidance by the project team and technical experts. A process of testing and certifying these artisans was also developed so that service seekers could be assured of the quality of LEC service providers and at the same time the artisans, as also the profession of LEC service provision, stand to benefit from the recognition. More than 90 artisans have so far been issued certification, in the presence of top public representatives and officials.

One of the best features of the LEC techniques is that they are simple, low on maintenance, use largely local material and are not expensive. Even though the costs vary according to designs and location as well as from year to year, an average cost of installing LEC features for a midsized room (±140 sq. Feet) comes to around € 700 (Rs. 47,000 as of current exchange rates), with the following distribution:

• Casual Labour	10%
• Skilled Labour	12%
• Material procured for cash (timber, glass, plastic sheet etc.)	38%
• Material available at the household level (stone, brick, straw etc.)	40%

The promoters provide casual labour and local materials and partially pay for the skilled labour and purchased materials. The total cash contribution of the families comes to around € 180 (Rs. 12,000) while the contribution in kind adds up to around € 280 (Rs. 18,500). The consortium pitches in with the remaining € 240, corresponding to around 60% of the cash component.

4.2 Social methodology

In each district, the target zones and villages were selected by the LPOs, based largely on the criteria of coldness, remoteness and economic condition. The project is concentrated in 126 villages in fifteen valleys spread across the length and breadth of the region. The methodology in brief consisted of the LPOs holding an informational meeting with the village community to present the project, explain the details of passive solar and Energy Efficiency technology and solicit interest in building LEC houses with the project's support and guidance, collect a 'long list' of initially interested families; conduct a survey of these households to establish technical feasibility (building orientation, shading, duration of sun light exposure etc.) and draw a 'short list' of potential promoters; organise an exposure visit to existing LEC houses so that the potential promoters as well as interested masons and carpenters from the village could get a 'touch and feel' of the benefits for themselves; the promoters make a choice from amongst three available designs based on their needs; and finally, an agreement is signed between the promoter, mason and the Local Partner Organisation.

Since the project sought to influence people's choices in the way they built their houses, and an LEC building from the outside can look quite different from traditional houses, the project developed a strong communication component. Awareness campaigns about LEC houses were organised across 126 villages to directly communicate with people and hold discussions. Besides villagers/promoters, exposure visits were also organised for public representatives, officials and engineers to give them a chance to assess the technology for themselves. A vigorous media campaign was also launched with five TV programmes and nine radio programmes being aired, largely in the 2nd and 3rd years of the project, reaching a large number of viewers/listeners stretching far beyond the project area in both states. Posters, leaflets and DVDs were also widely distributed in villages and schools and displayed at GLNs.

4.3 Governance

GERES is the nodal organization with the overall responsibility of successful completion of the project and took a lead in most phases of the project management cycle such as planning, monitoring, research, documentation, evaluation, advocacy, financial management and donor interface. Field implementation was carried out by partner organizations while GERES provided technical expertise and other support. A Monitoring and Evaluation Cell (MEC) comprising of project coordinators from all partner organizations and technical coordinators at GERES was constituted at the onset to meet every month to follow the progress and compile data and information. Besides the MEC meetings, biannual technical review workshops and annual general review workshops with all organizational heads were also held to take stock of the situation, share experiences and discuss critical issues. Conflicts were solved and policy decisions taken as a collective.

Besides the network of NGOs, the project also set up Steering Committees at the district (Autonomous Council) level in Leh and Kargil and at the State level in Himachal Pradesh to bring together stakeholders in energy efficiency to discuss policy issues as well as help in disseminating energy efficiency initiatives. Three policy makers' workshops with senior public representatives and officials and six practitioners' workshops with public engineers and architects were also organized. A guideline for LEC in public buildings have also been prepared by the project and approved by the LAHDC that could form the base for future policy in this sector. The LAHDCs of Leh and Kargil have also agreed on promoting LEC designs for rooms built by the government for very poor families under the centrally sponsored scheme, Indira Awas Yojna (IAY). The governments have also sought and approved many LEC designs prepared by GERES for public buildings such as medical aid centres. In congruence with the other two networks, 16 Grassroots Level Networks (GLN) have also been formed at the level of village clusters that would act as an advocacy group to influence policy and also help implementing NGOs in beneficiary selection and project implementation. Most of them have associated LEC Information Centres for further awareness, promotion and guidance to the local population.

5 Impacts

An internal system of monitoring and evaluation was set up at the beginning of the project to collect periodic data and feedback from the field. Besides, the project also commissioned various independent studies to gauge people's response to the interventions as well as to assess its impacts. This section largely draws from the below mentioned three studies carried out during the course of the project, besides thermal and fuel use monitoring data compiled by Mr. Franck Clottes, thermal engineer and Coordinators from partner organisations.

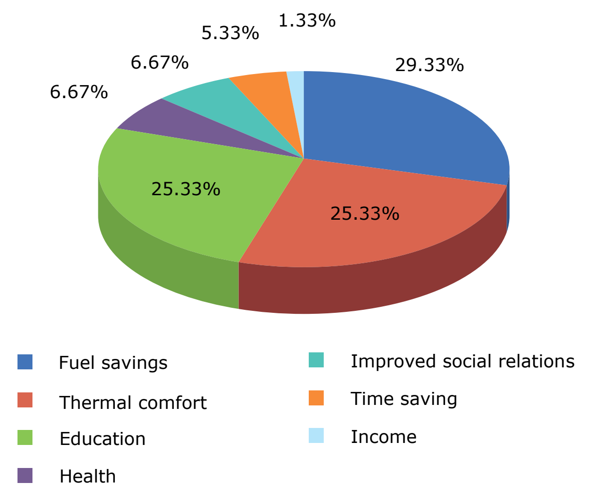
Passive Solar Housing: Mid-Term Socio-Economic Impacts Survey (March 2010), **Sylvain Koch-Mathian**

Passive Solar Housing: Impact on Human Health, Gender and Education (March 2011), **Dr. S K Srivastava**

Passive Solar Housing: Environmental Impact Assessment (May 2012), **Kimberley Buss**

There are three main benefits people attribute to the LEC houses. People are very happy with the amount of fuel they are saving from the LEC technologies, the comfort of a warm room and also, the amount of time children are able to devout to study without distracted by the cold. The two main reasons for the new found comfort are that they don't have to keep feeding the furnace/stove the whole day through and that the heat is gentle and ambient, uniform across the room. Earlier, with a stove burning in the middle of the room and no insulation around, everyone would sit circled around the stove as it would typically heat only up to a small diameter from the source and people were generally left with the front side overheated and backs cold. The new found possibilities of using the whole room and to use it till late in the night were other major contributors of their comfort.

Main benefits of LEC



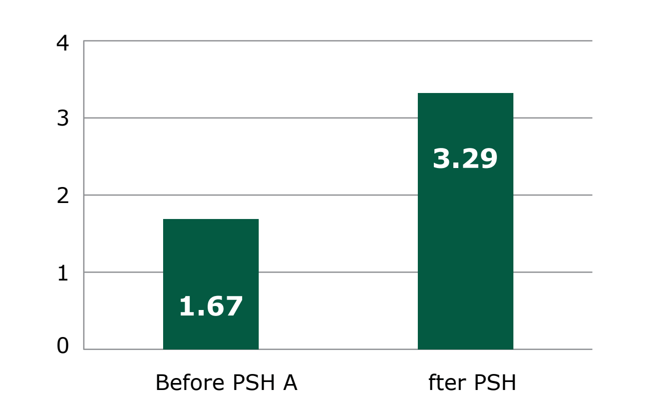
Source: Sylvain Koch-Mathian, March 2010

72% of the people report they are 'very happy' with the LEC housing and 68% feel the latter has 'considerably changed their life'. 79% felt that the expectations they had from when they signed up for a LEC house after it was explained at the village meeting were met and 17% of them even felt it delivered beyond their expectations. A resounding 78% of the promoters wish to build another LEC room in the coming years. Those who do not have any plans of doing so, largely site financial constrains.

5.1 Education

Numerous studies in the region confirm that people here place a high priority on their children's education; despite the fact that most of the elder generation has had none or very little formal education themselves. Enrolment up to middle school (class 8, age 14) is over 90% and close to 100% in most parts of the region. The cold and dark of most conventional houses in the winters, however, do not provide the ideal setting for these children to follow up on their school work. Children often have to choose between studying near the windows where there is light but not enough heat or near the stove in the centre of the room where there is enough heat but not light. The LEC housing changes all of that and now children can study near the windows with the ambient heat being spread equally across the room. They also don't have to go to bed early to beat the cold and are able to study till late. Another important contributor in longer study times is that owing to the amount of fuel saved by LEC houses, children, along with their mothers, are now able to cut down on weeks of time every year spent in gathering fuel. As the graph below shows, children have doubled the amount of time they spent on studies post an LEC house.

Average of hours of studies per day

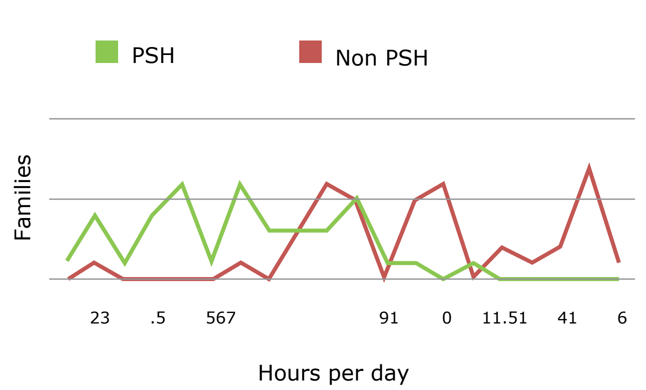


Source: Sylvain Koch-Mathian, March 2010

5.2 Improved health and hygiene

The health impacts of a LEC house in terms of health largely relate to a warm and smoke-free environment compared to the conventional rooms. Non-LEC houses typically keep a wood and dung based *thap* (local metallic stove) or *bukhari* (a small metal barrel used as a room heater), and often both, burning through most of the day, from the time they get up till the time everyone goes to sleep. Even though these come with a pipe to vent the smoke out of the room, most of these devices let a lot of the smoke into the room which then stays trapped indoor as the doors and windows stay shut, leading to a high rate of respiratory diseases, including tuberculosis. Besides making it possible to have a warm room without a fuel fed heating device, the passive solar heating uniformly raises the ambient heat of the whole room such that you could sit anywhere in the room and your whole body would be uniformly warm. Those suffering from joint pains and respiratory problems benefit hugely from the clean and warm indoor air. The elderly, infants and expectant or nursing mothers particularly benefit from the protection an LEC house gives from the unclean and inadequate heating of a *bukhari*. Accidents involving children such as burns and scalds from the *bukhari* are also avoided. Unlike conventional rooms where inside temperatures could fall below zero in the night, a LEC room always maintains a minimum of 50C and thus keeps water and eatables from freezing. The sample survey below shows that most non-LEC houses keep burning a *thap* or *bukhari* round the clock, while LEC households use it for only 4-6 hours, while cooking in the morning and evening.

Bukhari / *thap* usage



	PSH (LEC)	Non-PSH (Non-LEC)
Mean (Hrs)	6.1	10.9
Median (Hrs)	6.00	10
Mode (Hrs)	5.00	16

Source: S K Srivastava, March 2011

A Non-LEC family near BodhKharbu.

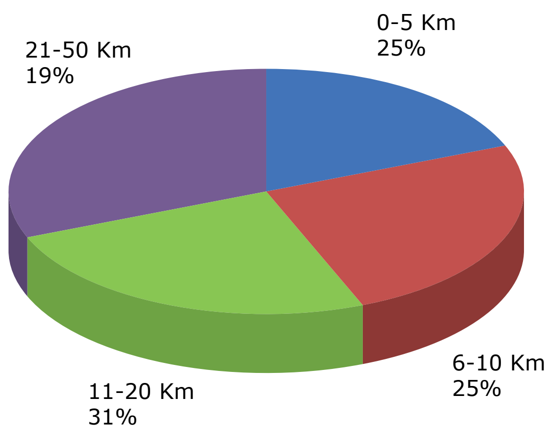
Bukhari (left) is used primarily for heating; *Thap* (Right) is used for cooking. While both can heat and cook to some extent the design is optimized for one of the two purposes.

Non-LEC households are often forced to use both during winters.

5.3 Reduced gender burdens

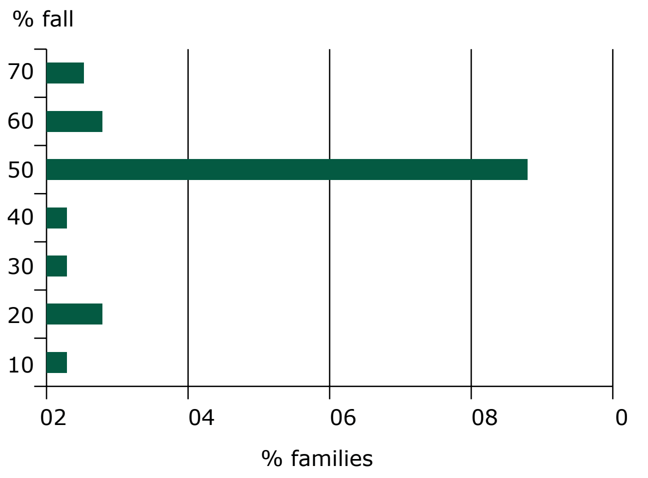
Until a few decades back, in an overwhelmingly subsistence farming based society, men and women worked together on the farm and shared much of the other work. Things have changed with the village communities integrating into the formal monetized economy. Now, a large number of men have to take up work outside the village, at least during the summer months, to substantiate their farm based income. This period coincides with the farming season as also the time to collect fuel-wood and dung from the mountains to be stored and used during the winters. All of this work now falls on the women, and children, and substantially increases a woman's work burden. In many parts, women have to travel great distances from home to collect fuel, 50% of them having to travel more than 10 kms. With 80% of the sample reporting a decrease in fuel consumption by 50% or more after PSH, the corresponding reduction in time women have to spend collecting fuel is very substantial. Women can now devote the saved time to income generating activities or to leisure.

Distance covered to collect fuel



Source: S K Srivastava, March 2011

Fall in fuel consumption after PSH

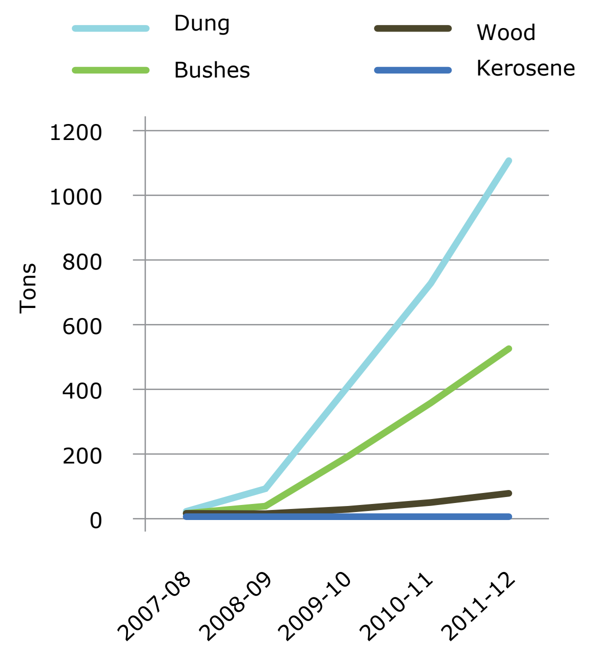


Source: S K Srivastava, March 2011

5.4 Reduced economic burden

Heating accounts for more than 50% of annual energy intake in a rural household in the region. In the winters, monthly heating costs typically stand next only to a family's food costs. Cooking also requires more fuel as water boils at around 850C at these heights because of the reduced air pressure and it takes more time to cook the food. Many studies and surveys undertaken have shown a huge dip in the amount of fuel used during the winters. Usage of stoves in LEC rooms and fuel consumption has gone down by more than 60% on an average. Dung available from one's own cowshed or from the fields or pastures nearby suffices the needs of most families. Most families burn around 750 to 900 Kgs. of dung through the winters, which last from November to April. With each sack costing Rs. 70-80 in the local market, a 50-60% drop in consumption means a saving/earning of more than Rs. 2000 over the winters. Families in Kargil and Lahaul who are more dependent on wood purchased from the market now use 2-4 quintals of wood less, which translates to a saving of around Rs. 2500-4000 every winter.

Fuel savings by the project so far



Women and children are also saving 4-6 weeks of time because of the reduced burden of collecting fuel. With a huge drop in the fuel requirement, many women have stopped collecting bushes at all after a slight change in the mix of fuel used and are now devoting the saved time for income generating activities. 72% of the promoters report that their handicraft production has increased after building LEC room, 16% of who have more than doubled it. 16% families have started selling the extra production and are earning an average Rs. 2700 per winter from that. 40% of the families report they are saving an average of Rs. 1700 per winter by buying less handicraft items like socks, sweaters, gloves and caps etc. for themselves or for giving as gifts.

5.5 Reduced pressure on the local and global environment

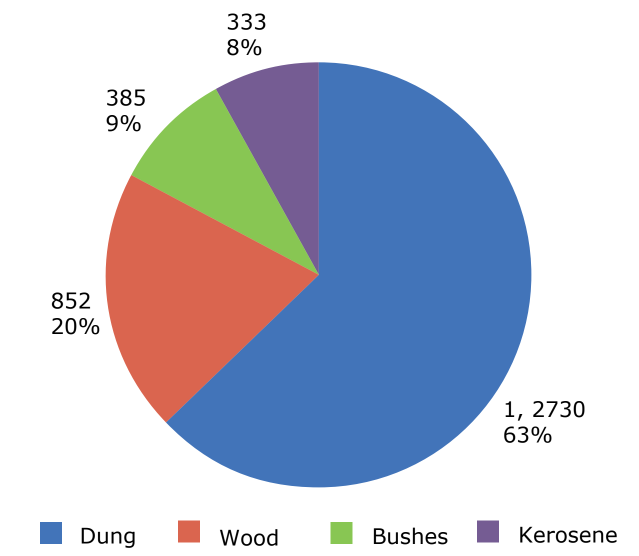
The key environmental impacts of the actions are also associated with the LEC technologies reducing the household's fuel consumption. As seen in the graphs below, the overall fuel consumption for LEC houses has reduced by around 60%. Bushes were reduced by the largest proportion (87%), followed by dung (60%) and wood (20%). The types of fuel used in the area, which are largely biomass-based, dictate that the majority of impacts associated with the reduction in fuel use relate to local improvements in general soil condition and land stabilisation, as well as contributions to biodiversity preservation, watershed improvement and greenhouse gas emissions mitigation on a broader scale.

The largest resource savings generated by the intervention is dung, over 2200 tons of it between 2009 and 2012. Henceforth these savings are expected to be over 1300 tons per winter. A large portion of the dung saved is likely to be used as farm manure and result in a decrease in the use of chemical fertilisers. This increase in the ratio of farm manure to fertilisers would have a positive impact on the soil quality and fertility as also the sustainability of the agriculture system. Similarly, since a large number of people have stopped collecting dung from the pastures, a lot of it is left on the pastures and nourish the pastureland. It is estimated that each ton of dung left on the grounds would help in retaining an additional 750 litres of water besides increasing the organic matter in the soil, ultimately resulting in improved pastures over the long run, something the pastoralist communities are particularly in need of following the current degradation of pastures in the wake of disturbed climate patterns and falling precipitation. Collection of bushes for fuel has also gone down in a huge way. Collecting bushes are pretty labour intensive and many find it the most logical fuel source to reduce. Since bushes are collected by uprooting them from the roots, a substantial reduction in their collection would mean significant increase in the environmental services they provide in the form of stabilising the steep slopes, arresting soil erosion and fixing nitrogen in the soil. In some parts of the region, uprooting of sea buckthorn bushes, whose berries are sold and fetches good money, has also come down.

Since the fuels used in the region are overwhelmingly biomass based, the high reduction in the use of these resources are quite likely to translate into an improvement in the local environment. In an extremely fragile ecosystem, where changes in any constituent part of the ecosystem can trigger quick changes in the others, what might come across as small differences in terms of sheer numbers could actually go a long way in conserving biodiversity and ecological balance in the region. It is also estimated that the reduced fuel consumption adds up to around 2.5 tons of CO_2 saved by each LEC building. In a ten year period the project expects to save 21,599 tCO_2 of pollution from 1000 LEC Houses from getting in to the global environment.

Fuel mix in LEC household

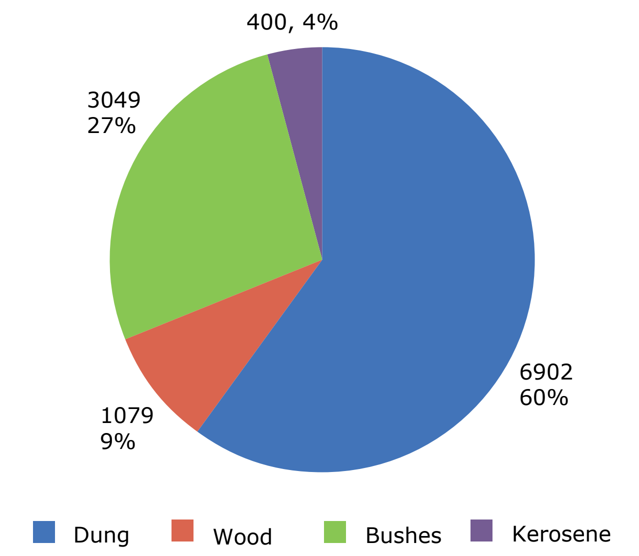
(kWh/household/winter)



Source: Kimberley Buss, May 2012

Fuel mix in non-LEC household

(kWh/household/winter)



Source: Kimberley Buss, May 2012

6 Challenges and lessons

The initiative was in many ways quite different from much of the other development interventions implemented by the partners in the region and was thus a constant source of learning for all. It was also an ambitious initiative ensuring constant challenges along the way.

• Even though the objective was the promotion of energy efficient housing, as opposed to being a housing project for the poor, the social methodology had a strong preferential bias towards the poor and needy. The team also selected people who were quick to understand the benefits and more likely to enthuse replication from others in the community, thus balancing the need to demonstrate the technology and ensure replication and at the same time reach out to the poor who bore a heavier burden of energy costs.

• The twin priorities of reaching out to the remotest villages with little access to clean fuels as also to the poorest families reeling under heavy energy costs to some extend come at the cost of selecting more 'visible' villages closer to the town or block headquarters and within them better off families who could build more 'impressive' LEC houses that could have had a more effective demonstration effect of the LEC designs and possibly ensued a faster replication from the larger population. Picking a small number of families from the latter category is an option that could possibly be exercised.

• Trained and certified artisans were one of the main building blocks of the intervention. To maintain the transparent and community centric approaches, the team invited village communities to recommend masons and carpenters from their own villages who, once trained, would always be available to the community. On the other hand, a trend to employ 'better skilled' seasonal workers coming from outside the region has also been noticed. While all the masons trained were locals, a significant number of the ones employed in the villages were outsiders who were not trained in LEC concepts and techniques. The team responded to this situation by advising promoters to engage certified masons on an advisory basis for the LEC aspects of the building. The non-local masons also generally responded well to on-site technical guidance given by field staff from partner organisations.

• It is extremely important to monitor and ensure quality of every single LEC house construction. People are generally hesitant to try out a new technology and if a new construction fails to deliver on what was promised, more often than not it is efficacy of the technology to deliver that gets questioned rather than a host of other factors that could possibly have gone wrong. This could result in negative publicity and damper replication.

• To a people who were 'subsidy spoilt' as a result of many government projects with a heavy subsidy component and did not have much experience of development support weaning out in phases, the intervention's strategy of incremental reduction in financial support through the demonstration, extension and exit phases did not sit well with many promoters who joined in the 2nd and 3rd years and consequently received lesser support than their neighbours who joined a year before them. Many made a strong case for getting as much subsidy in the 2nd and 3rd years as well. The project coordinators however managed to explain the phasing out support design to the people and also to point out how they would get an even lesser support or no support at all year in the following year. They also impressed upon the promoters how many people are adopting the LEC designs without any financial support at all.

• The extensive geographic spread, in a difficult terrain and climate with a limited 'working season' also proved a big challenge. Productive activities involving water, such as farming and construction, can be carried out only for around half a year while the water still doesn't freeze. On the other hand, being a technical intervention, continuous monitoring was essential to ensure quality. Despite these challenges, the team chose not to confine the intervention to a few clusters and rather take it far and wide across the region to maximise the technology demonstration and impact.

• A lot of initiatives were taken to rope in the Government on the intervention's vision and keeping them abreast of its progress. While the political leadership showed a lot of support, lower level bureaucracy often did not share the same enthusiasm. Trainings were organized for government engineers with the hope that they would integrate LEC techniques in their building designs as well but the response was less than enthusiastic. While some in the team feel the engineers are reluctant to work with 'simple' technologies and local materials such as mud and hay, others feel the senior bureaucracy is hesitant to support such alternate technologies. The team also realises the need to have identified the key stakeholders in the initial phase itself and to have relied more on an institutional approach in its networking and advocacy efforts. This is however not to say there wasn't any adoption from the Government. 13 LEC designs have been approved by the latter for public buildings of which one has already been constructed. The LAHDCs in both Leh and Kargil are also very enthusiastic about introducing LEC designs for a Government-aided housing project for the ultra poor.

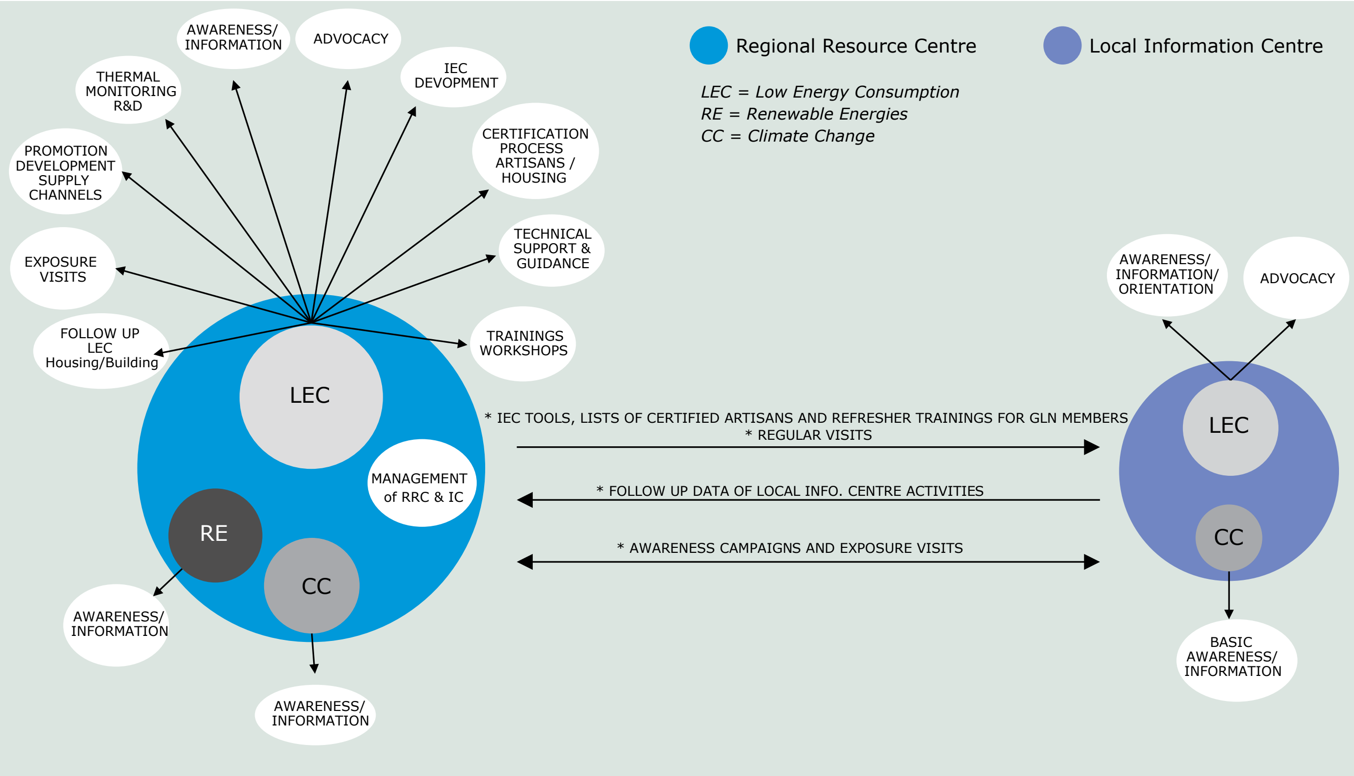
7 Way forward

A lot of thought has gone into ensuring sustainability of the initiative. Transfer of knowledge to local stakeholders have been insured, policy networks have been set up to influence policy at the various levels of the government. Besides the state and local governments, the central Ministry of New and Renewable Energy (MNRE) as well as the Indian Army stationed in large numbers in the region have also shown keen interest in the LEC approach and have expressed possibilities of working with passive solar techniques in the future. A document on how energy efficiency could be integrated in a proposed 'building code' has also been produced and submitted to the LAHDC and approved by the public experts and decision-makers in Ladakh.

The project also received a lot of interest from international agencies working in similar conditions, especially from central Asian countries. Many groups from Afghanistan, Tajikistan, Kyrgyzstan and Nepal visited the project to learn the techniques and experience. Most of them have already started initiatives in their own regions. A technical training was conducted in Afghanistan to help organisations there initiate work on domestic houses to integrate energy efficiency. GERES has also initiated replication with local partners in Tajikistan. Many technical manuals, booklets, case studies and DVDs have also been produced and are available for free download. It is hoped that these would be used by groups working in similar contexts who are interested in implementing sustainable energy solutions to mitigate the devastating impacts of climate change while we still have a chance to do so. The project also got nominated as one of the eight finalists for the prestigious World Habitat Awards (2011) for innovative housing solutions, among around 200 projects from around the world.

Even though building over a thousand LEC houses in such harsh conditions was quite a challenging task, the entire consortium team took upon themselves the challenge with great enthusiasm and commitment. The real impact of the intervention could however be seen more in the coming years as the benefits of an LEC house become more visible and the technique gradually gets more accepted and mainstreamed and people start to adopt such bioclimatic habitat on their own without further promotion or support from the consortium. For an intervening period of few years from the project's conclusion at the end of 2012, the consortium has decided to work together in setting up a Regional Resource Centre (RRC) on LEC technologies, new & renewable energies and environmental conservation.

The Centre will especially help and guide interested individuals and public or private parties in the why and how of passive solar architecture and energy saving. It will be run by experienced professionals from the consortium that can provide services such as preparing building designs and construction supervision for a fee. It will also maintain a database of trained and certified masons, carpenters as well as suppliers of insulation materials etc. and provide a single window clearance centre for all needs related to passive solar buildings. The RRC would also continue the work on research and development, technical trainings and policy advocacy. The main goal of setting up the RRC, along with 15 local Information Centres at village/cluster level in Ladakh is to build up on the project's actions and achievements in favour of promotion and diffusion at a large scale of energy efficient, eco friendly and sustainable technologies and practices. This RRC would be based at the project's demonstration building on the outskirts of Leh town. Some of the key activities undertaken by the RRC would be promoting LEC technologies developed by the network, organizing awareness campaigns and workshops, providing technical advices and support in constructing LEC houses, promote R&D, stimulating the private sector for LEC materials and continuing the certification process and technical support to certified artisans. The Centre would also manage and support the 15 Information Centres spread across Leh and Kargil districts through follow up activities, refresher trainings and supply of IEC materials. These ICs would be directly managed by the respective Grassroots Level Networks and, with support from RRC, promote LECs and generate demand at the local level by organising awareness campaigns and events, providing information on various techniques and connecting people to certified artisans and suppliers. It is also envisaged that the RRC would gradually extend its sphere to include work on Renewable Energies, Climate Change and Rural Livelihoods.



Source: RRC Concept Note, September 2012

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GERES India email: info.india@geres.eu
GERES. 2 cours Foch, 13400 Aubagne, France
Email: contact@geres.eu - www.geres.eu