ASIA-PACIFIC NETWORK FOR
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POLICY BRIEF LCD-06

# APN Global Change Perspectives

## Low Carbon Development

October 2015

# Towards Upscaling the Application of Low-carbon and Energy-efficient Technology in the Construction Sector — Cases of India, Nepal and Pakistan

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## Pathways to Sustainability in the Construction Sector


### SUMMARY

- The Indian construction sector has a high ecological and carbon footprint. With increasing urbanisation and growth in India, the impacts of the construction sector will only increase.
- Small cities and towns have been the primary locus of growth. Urban housing shortage in 7,935 towns is estimated to be 18.78 million as of 2012. Therefore, efforts to reduce the ecological footprint should take into account the housing requirements in urban areas.
- Low-carbon and resource-efficient technologies exist and could substantially reduce the ecological footprint of the sector were they dominant. In order to mainstream these technologies, it is essential for policy makers to streamline policies and develop guidelines that include a green mandate.
- The implementation process should also be strengthened at the same time. Technical capacity building of government officials will aid in the implementation of policies.
- Integrated and concerted efforts from different government departments are crucial for mainstreaming green construction.


**Box 1.** Summary of the India case.

## Background

The construction sector accounts for 8.2% of India's GDP and, as the second largest employer, employs an increasingly large workforce ranging from labourers to contractors and architects. Besides social and economic implications, the construction sector has critical environmental implications.

» The sector contributes to 24% of greenhouse gas (GHG) emissions, 80% of which is borne by building materials (Parikh, Panda, Ganesh-Kumar, & Singh, 2009).

» The brick sector alone generates 42 million tonnes of $CO_2$ annually, and uses 20–30 million tonnes of coal and

**Recommended Citation:**

Varsha, D., Nagrath, K., Udas, S., Acharya, S., Lotia, H., & Siddiqi, S. (2015). *Towards upscaling the application of low-carbon and energy-efficient technology in the construction sector — cases of India, Nepal and Pakistan* (APN Global Change Perspectives Policy Brief No. LCD-06). Kobe: Asia-Pacific Network for Global Change Research.



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*Potential impacts of the construction sector are rather grave, but pathways to sustainability do exist, and cleaner technologies could substantially reduce the ecological footprint of the sector.*

350 million tonnes of top soil (DA, 2012).

» The construction sector consumes 30% of national electricity, with an annual growth rate of 8% (Girija, 2011).

» Production technologies have additional implications, such as black carbon from brick kilns that further contributes to warming.

Growth in the construction sector will be further fuelled by addressing the current housing shortage of 18.78 million (MHUPA, 2012) and meeting future demand of 44–48 million by 2022 (KPMG, 2014). Adding to this is the likely need for reconstruction in the wake of numerous disasters. Considering that in India 70% of the building stock required by 2030 is yet to be constructed (NRDC & ASCI, 2012), the potential impacts of the construction sector are rather grave.

However, pathways to sustainability do exist. Cleaner technologies could substantially reduce the ecological footprint of the sector.

» The use of fly ash and vertical shaft brick kilns considerably increase resource efficiency in the brick sector.

» Cement production can be made less resource-intensive, thanks to the vertical roller mill technology, fluidised bed cement fired kiln systems and the use of fly ash in Pozzolona Portland Cement (PPC).

» Alternative building materials can reduce resource consumption by 25-30% (DA & CDKN, 2013).

» With proven commercially viable technologies, energy consumption in new and existing buildings can be cut by an estimated 30-80% with potential net profit during the building's lifespan (UNEP SBCI, 2007).

## Measures to Accelerate Adoption of Low-carbon Technologies

There are options to increase the use of low-carbon, energy-efficient and disaster resilient construction alternatives in India at national and local levels as discussed below.

### *Policy and Regulatory Norms*

India's commitment to promote alternative and low-carbon technologies in the construction sector can be visualised through several policies and initiatives. The National Housing Policy advocates the use of alternative technologies and a holistic approach to sustainability. Both the 12th Five Year Plan (2013-2017) and the National Action Plan on Climate Change have identified green buildings and construction as a focus area. However, the translation of the mandate to policies and schemes has been minimal. To remedy this, guidelines should be developed to include the aspects of green construction in policies and schemes. This includes inclusion of low-carbon building materials in the Schedule of Rates, standards and specifications of low-carbon building materials, eco-labelling systems to ensure adherence to these standards and mandatory procurement guidelines for the government. It is also crucial to allow flexibility in the design and applicability of these materials subject to local climate and cultural demands.

### *Technology and Capacity*

Currently, the Indian construction sector suffers from a lack of appropriate technologies and support in efficient technology transfer. Innovation of low-carbon and resource-efficient technologies is essential for the transformation of this sector. Several aspects need to be addressed for the successful adoption of these technologies. Technologies that include collaborative research, technology demonstrations, access to information and capacity building of workforce.

The lack of technical capacity is one of the largest barriers facing the sector. Policies should focus on addressing this by organising technical training of masons and engineers on a regular basis. Capacity building of officials for the proper implementation of these policies should be promoted (TARA, 2014).

### *Market and Finance*

The disaggregated nature of this sector throws up challenges with respect to strengthening the supply chain of materials and services. Continuous supply

## HOW POLICY TOOLS PROMOTE ADOPTION OF LOW-CARBON TECHNOLOGIES: USING FLY ASH AND BAMBOO AS BUILDING MATERIALS

Fly ash is a waste stream from thermal power plants. As a secondary material, it has successfully been mainstreamed in brick and cement production replacing scarce primary raw materials. Due to these efforts, fly ash bricks now occupy close to 10% of the brick market while Portland Pozzolana cement (PPC) occupies 75% of the cement market share. Some of the tools that have helped this transition are explained below:

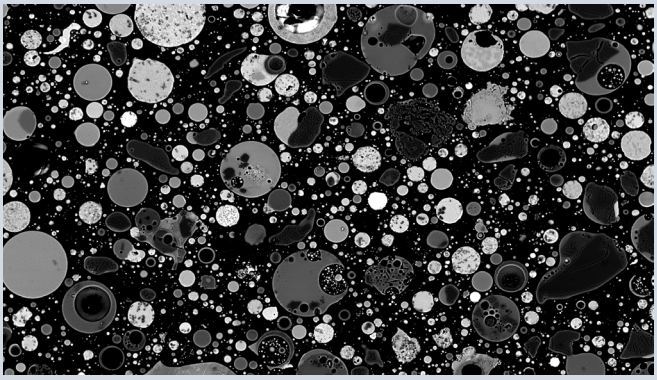

**Image:** Cross section of fly ash particles at 750x magnification. Source: Wabeggs/Wikemedia (CC BY-SA 3.0)

- The Bureau of Indian Standards (BIS) has issued production and performance standards for fly ash bricks and PPC. The use of these materials earns green building credits in the voluntary national green building certification programme (GRIHA). Inclusion in the Central and State Schedule of Rates and a mention in tender documents ensure that it can be procured preferentially for public construction projects.
- There is a ban on red bricks within 100 km around power plants, where fly ash is readily available thus promoting fly ash products. Capital subsidies are offered to new brick entrepreneurs in many states to eliminate the liquidity barrier. Workshops and awareness drives organised for users and entrepreneurs have helped disseminate the benefits of the technology.

On the other hand, use of bamboo for interior structural systems has not become popular despite the scientific validation of the technology. One of the major reasons for this is the restriction on bamboo development by several policies and acts. The perception of bamboo as 'poor man's timber' adversely affects its mainstream use. Also, restrictions on harvesting on both private and public land dissuade plantation efforts.

**Box 2.** Examples of policy tools promoting/discouraging the adoption of low-carbon technologies.

of construction materials can be ensured by setting up micro enterprises. Fiscal incentives and priority financing for Small and Medium Enterprises (SMEs) should also be initiated to facilitate setting up green building material production facilities.

Quality is a key component in the aggregation of green construction services. Standardised curriculum and a system for certified skills for masons and artisans will go a long way in monitoring and assuring quality.

Common interest groups and guilds can be leveraged to strengthen this cadre of skilled personnel.

### *Partnerships*

It is vital to promote public-private partnerships (PPP). In such partnerships, the services are delivered by the private sector, while the responsibility of providing service rests with the government. PPP would not only help in commercialisation of low-carbon technologies, it would also aid stricter implementation of these policies.

User acceptance of these technologies is the key to its acceptance. Limited information about the benefits of these technologies, its viability in the local context, and the operation processes hinder its growth. Awareness generation that targets users needed.

## Recommendations

### *National Level*

» Guidelines, codes and standards should be developed by the government to include aspects of green construction in policies and schemes and to accommodate green building materials. The scope of the schedule of rates (SoR) should be expanded to accommodate green building materials.
» A quality control system in the form of eco-labelling/ rating systems for materials and products should be set in place to ensure standardisation of materials.
» Collaborative research for technology innovation and demonstrations should be promoted.
» Large-scale awareness programmes targeting both entrepreneurs and users should be organised.

### *Local Level*

» Capacity building of officials for the proper implementation of these policies should be promoted.
» Technical training and certification of masons and engineers should be organised on a regular basis. Green aspects need to be included in the curricula for engineers and architects.
» Fiscal incentives and priority financing for small and medium enterprises (SMEs) should be initiated.
» Public-private partnership should be promoted.

# Nepal

## From Gray to Green: Driving Low-carbon and Energy-efficient Housing in Nepal

### SUMMARY

- Adoption and upscaling of low-carbon and energy-efficient construction technology for housing is emerging as an important policy and implementation agenda in Nepal both in consideration of rapid urbanisation and climate change.
- With an annual urban growth rate of 3.62%, Nepal will require an additional one million urban houses from 2011 to 2021 (UN-Habitat, 2011).
- Using conventional practices will exploit depletable resources, incur high costs and increase $CO_2$ emissions.
- It is essential to enable the policy environment to promote sustainable construction materials and housing, to strengthen the supply chain for sustainable construction materials, and to stimulate the demand for sustainable housing as an economical, environmentally sound and aesthetically pleasing solution.

**Box 3.** Summary of the Nepal case.

*Policy makers must decide on strategies to promote practices of designing, constructing and operating sustainable buildings.*

### Recommendations

Mainstreaming low-carbon construction materials (LCCM) requires action on enhancing awareness and knowledge on LCCM and alternative structural materials and systems, codes and standards, as well as labelling of construction materials. Thus, decision makers should consider the following:

» Providing subsidies on building design approval for the adoption of LCCM. To this end, Lalitpur Sub-metropolitan City is planning to categorise houses into A, B and C classes on the basis of five major aspects—use of eco-friendly construction materials, passive solar design, energy efficiency, water conservation and sustainable management of solid and liquid waste.

» A voluntary green building certification system can be an effective tool for promoting low-carbon construction. Internationally, voluntary building rating and certification systems have been instrumental in raising awareness and popularising sustainable building and most of the rating systems devised have been tailored to suit the building industry of the country where they were developed. There are various rating systems around the world such as Leadership in Energy and Environmental Design (LEED) in the USA, the DGNB system of the German Sustainable Building Council in Germany, the Building Research Establishment Environmental Assessment (BREEAM) in the UK, and the Green Rating for Integrated Habitat Assessment (GRIHA) in India, etc.

» The increased usage of low-carbon construction material can be made possible by improving awareness and knowledge of these materials, encouraging construction practitioners to invest in a long-term low-carbon construction future, and providing code and regulation compliance for the materials.

» The increased adoption of alternative building materials through increased awareness, knowledge and stringent building codes and regulations will attract more investment into the market. There is also a need for norms, guides and regulations from the government to assure the quality of alternative building materials in the market.

## Policy Implications

The adoption of low-carbon construction materials as an alternative to conventional materials is essential for the construction sector to reduce GHG emissions. For this, the following policy needs have been identified.

- Incorporate sustainable building components and provisions for sustainable housing into National Building Codes.
- Develop more specific policies and detailed guidelines related to sustainable housing.
- Encourage research to mainstream LCCM in the local context.
- Incorporate adaptation and mitigation measures into local municipal planning and service delivery to promote low-carbon construction practices.

Under a business-as-usual scenario, 55 billion bricks (117 million per year) and a 10% increase in cement use is required to meet the housing demand. The suggested policy measures above will help mainstream LCCM as viable alternatives for sustainable housing in Nepal and curtail the use of brick and cement.

The application of policy measures to mainstream LCCM will also benefit the national economy by cutting imports and lowering the cost of construction. The constraints for mainstreaming alternative construction materials in Nepal based on the finding of a survey conducted by the research team is presented in Box 4 below.

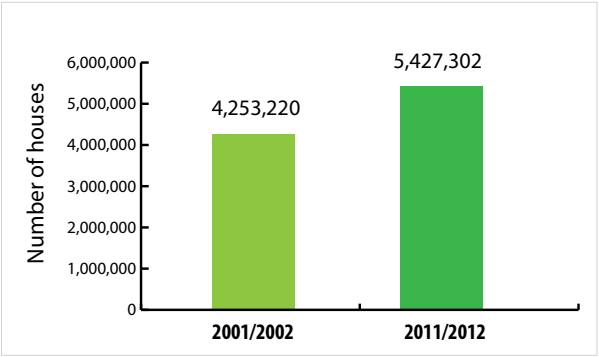


**Figure 1.** Existing housing scenario in Nepal.

### CONSTRAINTS FOR MAINSTREAMING ALTERNATIVE CONSTRUCTION MATERIALS IN NEPAL

With increasing urbanisation, the number of traditional buildings has decreased dramatically in the past six decades. They were gradually replaced by modern buildings made of contemporary building materials such as brick, cement, concrete, steel and aluminium. Traditional mud-and-stone houses were common in the past and designed to suit the local climate using traditional knowledge. The materials used, such as soil, stone, timber, bamboo and wood, were mostly available locally. The National Housing Policy 2012 mentions that 57% of the houses in Nepal are constructed with cement mortar, 27% with mud and stone and the remaining 8% with wood, bamboo and other temporary materials.

There are existing practices of using low-carbon construction technologies such as hollow concrete brick (HCB), compressed stabilised earth block (CSEB), bamboo housing, earth rammed housing and traditional mud stone houses, which are comparably low-cost technologies. However, the popular public perception is that low cost means low grade. These technologies are further sidelined by the absence of an enabling policy environment.

Construction practitioners tend to focus on conventional building practices and are less aware of LCCM as an alternative to contemporary materials and their importance in protecting the environment and reducing GHG emissions. The relatively low

cost of LCCM gives consumers a perception that they are structurally weak and designed for people with low income.

The absence of guidelines, codes and regulations for encouraging the adoption of LCCM is one of the major barriers in mainstreaming these materials.

Due to an imbalance between supply and demand, there is limited availability of LCCM in the market. There is also a lack of readily accessible and reliable information that compares alternative structural materials and systems.

Further, there is a lack of quality assurance for LCCM available in the market. No norms or guidelines exist for manufacturing these alternative materials, and monitoring mechanisms are lacking to ensure the quality and strength of these alternative, sustainable materials. This poses barriers in public acceptance. (SBCI, 2007).

**Box 4.** Findings of a survey regarding the constraints for mainstreaming alternative construction materials in Nepal.

# Pakistan

## Low-carbon, Energy-efficient and Disaster-resilient Construction Alternatives

### RECOMMENDATIONS

- The government should encourage research and implementation of greener technologies.
- Efforts should be taken to educate the population in the technology and skills involved in low-carbon construction.
- The government should break the monopoly of cement industries in the market.
- Good quality alternative materials should be made available in the market to increase their usage.
- The government needs to recognise brick making as an industry requiring dedicated regulations, policies and standards.
- The government needs to raise awareness of local manufacturers and kiln workers about low-carbon options and support the transition to such technologies.
- The government should take significant efforts to introduce environmentally friendly and energy-efficient brick production technology, such as vertical shaft brick kilns.
- The government should develop partnerships with donor institutions, agencies or banks to ensure access to financing for entrepreneurs.
- The government should encourage synergies between local investors and entrepreneurs to increase ownership and acceptability of alternative technology.
- There is a need for wider dissemination via print and electronic media before the establishment of kilns.
- More pilot VSBKs should be established in areas like Lahore, Sialkot, Sargodha and Faisalabad.
- The government should protect bamboo resources and incentivise its production.
- Targeted advocacy efforts are needed to overcome the barrier of social and cultural associations with bamboo as a less-preferred material.
- The government needs to update policies and building codes to reflect new research and ideas.

**Box 5.** Recommendations from the Pakistan study.

### Background

The construction sector in Pakistan is consistently growing. With an average growth rate of 1.2% during 2000–2004, it experienced a great boom during 2004–2007 when it grew at an average rate of 18% per annum (Neilsen, 2010). Expansion in the construction sector is a result of the progress in socio-economic indicators of the country, as well as reconstruction efforts in the wake of numerous disasters. Floods alone have led to the collapse of over two million homes since 2010. Disaster-resilient and low-carbon reconstruction has been given very little consideration in Pakistan as disaster response is unplanned, urgent and makeshift.

Raw materials used in construction are infamous for utilising inefficient technologies that consume large amounts of coal and release high carbon emissions. The production of every tonne of cement results in an emission of at least one tonne of carbon dioxide ($CO_2$); the production of every tonne of steel releases over two tonnes of $CO_2$ into the atmosphere (Mahzuz, Ahmed, Ashrafuzzaman, Karim, & Ahmed, 2011). Due to these environmental hazards, the status of public health and the quality of urban life are degrading day by day in Pakistan.

### Policy Implications

Customised construction guidelines are not available and instruments like the Housing Policy (2001), planning standards, and building codes are outdated, not addressing the issue of low-carbon construction. Taking carbon considerations into account in risk reduction, relief and reconstruction would contribute to the potential "greening" of the disaster risk management industry. This is an important dimension for recognising the benefits that a low-carbon economy can bring to developing countries. (Urban, Mitchell, & Villanueva, 2010)

There is a desperate need for the concerned authorities to push the need for low-carbon construction in housing policies, reconstruction guidelines, agendas for NGOs and international donors, as well as encourage academic research on the issue.

There is a dire need to launch campaigns generating awareness among regulatory agencies, builders/architects, end users and the general public. Furthermore, these campaigns need the endorsement and support of the Pakistan Environment Protection Agency (Neilsen, 2010). The involvement of the authorities is for eradicating institutional barriers.

By encouraging the streamlining of indigenous, locally produced material, there will be a significant economic regeneration within the select communities. Some projects have assigned duties and responsibilities to specific trained members of the community, who are then given an adequate compensation. This aids individuals in earning their livelihoods, along with promoting green construction and building shelters.

There is an urgent need for authorities to recognise the environmentally destructive monopoly of cement and brick in the construction industry, and actively work towards breaking this hold. Foundations are making their own contribution in introducing these indigenous technologies to communities, making them aware of their advantages and using development forums to discuss these issues. However, there needs to be an institutionalised, collective effort made to mainstream these materials and technology into housing policies, instructional guidelines etc., for widespread usage.

There is a glaring lack of any kind of academic and research work on low-carbon construction in Pakistan. There needs to be a provision for instructional courses at different levels of university studies and technical schools about the use of prospective indigenous and traditional building materials and technology. This will give a genuine motivation to students and can lead to the enhancement of local conditions of living and a greener construction industry. (Adhikary, Ervin, & Chand, 2012)

Studies are being carried out to establish the durability of bamboo reinforcement with improved bonding capability of bamboo reinforcing bars. Results from around the world show that bamboo can satisfactorily substitute steel structures. With reference to these types of studies there is also a need for updating national building codes especially in the case of developing countries. (Adhikary, Ervin, & Chand, 2012)

## Research Findings

Three case studies in the construction and infrastructure sectors were evaluated for this brief. In the first, the Department For International Development (DFID) and HANDS used lime as a stabilising agent to reconstruct damaged or destroyed houses in the most affordable, resilient and energy efficient manner, thus synergising disaster risk management and low-carbon construction. However, there was lack of widespread acceptance and implementation due to lack of awareness, absence of research, dearth of good quality limestone, social taboos and lack of government bodies and institutions backing the cause.

The second case study explored VSBK as an energy efficient technology used for fired clay brick production. After running

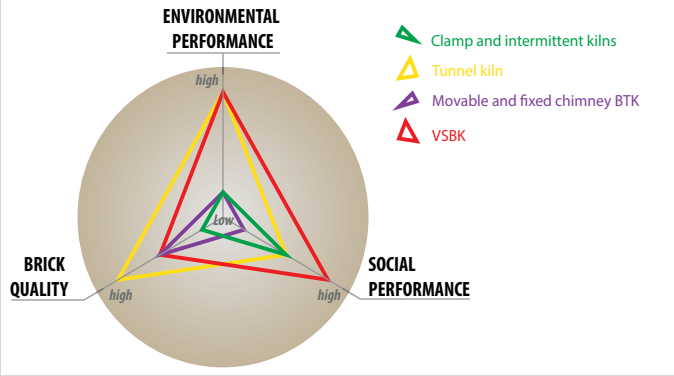


**Figure 2.** Comparison of VSBK with other technologies.

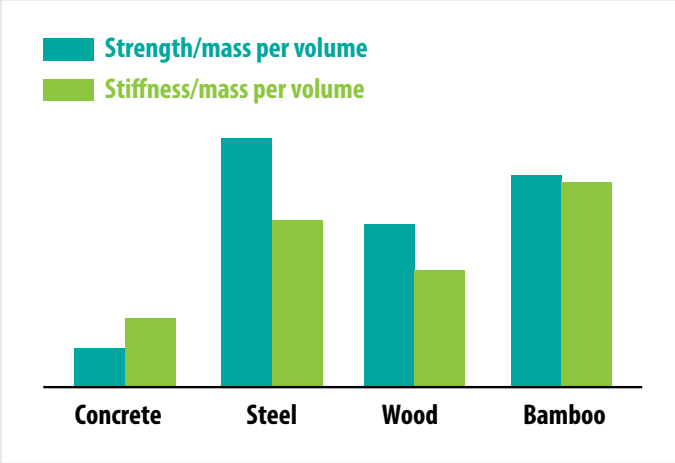


**Figure 3.** Comparison of strength and stiffness of construction materials.

VSBK kilns running on full capacity for a year in their project called Energy Efficient Brick Production (EEBP), the Swiss Resource Center and Consultancies for Development (SKAT) and Swiss Agency for Development and Cooperation (SDC) found that:

- High quality VSBKs can be established with local material supply, within the expected price level.
- VSBK bricks can compete with the upper brick quality segment of the Pakistani brick market.
- A correctly operated VSBK reduces energy consumption (and $CO_2$ emissions) by 30–50%.
- First production cost assessments have confirmed that a full scale VSBK will generate considerably higher profits than a traditional brick kiln and that its comparative advantage will further increase with the rising coal price. (SKAT EEBP, 2010)
- VSBKs considerably improve working conditions, in particular by reducing exposure to toxic gases and heat, and will offer alternatives to bonded- and child-labour exploitation.

The kiln industry in Pakistan, as in other Asian/South Asian countries is conservative in nature. Most of the investors and technical personnel are not trained at any institution and are more concerned about a quick return on investment, thereby depending upon traditionally available technical knowhow and manpower. New and innovative technology is negatively perceived. While introducing the VSBK concept, these factors play an extremely important role in the lack of acceptability and ownership of the technology.

The third case study illustrated the architectural, structural, environmental and technical performance of bamboo as a low-carbon and disaster resilient alternative to conventionally used material such as steel, cement and brick. The study looked at work done by the Heritage Foundation – an organisation pioneering the work on bamboo construction in Pakistan via their Green Karavan Ghar initiative. This technique of construction was tried out when the 2010 floods struck Pakistan. The first project undertaken was in Swat where 300 Green Karavan Ghar were constructed in remote mountainous areas from October

2010 to February 2011. Also, over 100 Green Karavan Ghar were built in a perennially flooded area in Khairpur. The Heritage Foundation also constructed floating bamboo structures on stilts as women centres, schools and health facilities. These structures endured the 2011 floods, providing refuge to the community on the upper level while the waters flowed through the stilts — proving that such green structures are not only environmentally friendly, but disaster resilient as well.

With the use of mud and bamboo, people are able to construct their own houses and produce the material that is used, incurring little or no labour cost considerably bringing down the cost of construction. Also, such low-carbon construction employing indigenous material actively involves the people and ensures that women are able to continue to contribute in home-making. Other than the ownership and pride that this system flourishes, it also trains the community and makes them aware of the different ways various materials are employed in construction, and teaches them the best methods for achieving low-carbon, green construction. This is probably the most long term benefit that comes out of such an endeavour — the education of the people with regard to low-cost, low-carbon construction.

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**About this publication:** This policy brief is developed for APN project "Identification of Policy and Institutional Gaps, Drivers and Strategies to Scale-up Low Carbon and Energy Efficient Technology Application in the Construction and Infrastructure Sectors in South Asia" (LCI2012-01NMY(R)- Vashist; LCI2013-01CMY(R)-Vashist) under APN's Low Carbon Initiatives Framework. For full details of this project, including technical reports and other outputs, please visit the project metadata page at http://www.apn-gcr.org/resources/items/show/1915.



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Development Alternatives

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