

POLICY BRIEF I

DECOUPLING ENERGY AND RESOURCE USE FROM GROWTH IN THE INDIAN CONSTRUCTION SECTOR

A BASELINE STUDY

By Prathiba Ruth Caleb, Sriraj Gokarakonda, Rohan Jain, Zeenat Niazi,
Vaibhav Rathi, Shritu Shrestha, Stefan Thomas, Kilian Topp

IMPRINT

PUBLISHED BY

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Environmental Policy Programme
Köthener Straße 2
10963 Berlin, Germany
T +49 30 33 8424-272
F +49 30 33 842422-272

detlef.schreiber@giz.de
www.giz.de

DESIGN AND LAYOUT

SCHUMACHER – Design und digitale Medien
www.schumacher-visuell.de

AS OF

April 2017

The analysis, results and recommendations in this paper represent the opinion of the author(s) and are not necessarily representative of the position of Deutschen Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Responsibility for the content of external websites linked in this publication always lies with their respective publishers.

POLICY BRIEF I

DECOUPLING ENERGY AND RESOURCE USE FROM GROWTH IN THE INDIAN CONSTRUCTION SECTOR

A BASELINE STUDY

TABLE OF CONTENTS

TABLE OF CONTENTS	2
LIST OF FIGURES	4
LIST OF TABLES	4
LIST OF ABBREVIATIONS	5
THE POLICY BRIEFS	8
KEY MESSAGES	9
1 DECOUPLING IN INDIA	10
1.1 TYPES OF DECOUPLING	10
1.2 THE INDIAN CONTEXT	12
2 NEED FOR DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR	13
2.1 INDIA'S GROWING CONSTRUCTION SECTOR	13
2.2 RESOURCE SCARCITY IN THE CONSTRUCTION SECTOR	14
2.3 UNDERSTANDING CRITICALITY OF RESOURCES	16
2.3.1 SOIL	16
2.3.2 SAND	17
2.4 ENERGY CONSUMPTION IN THE CONSTRUCTION SECTOR	18
2.4.1 RESIDENTIAL BUILDINGS	18
2.4.2 COMMERCIAL BUILDINGS	19
3 EXISTING RESEARCH AND DEVELOPMENT CONNECTED WITH DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR	20
3.1 R&D CENTRES WORKING TOWARDS DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR	20
3.2 FUNDING FOR RESEARCH, DEVELOPMENT AND DEMONSTRATION (RD&D) PROJECTS	21

4	EXISTING POLICIES THAT ADDRESS DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR	24
4.1	EXISTING POLICIES FOR FOSTERING ENERGY EFFICIENCY IN BUILDINGS	24
4.1.1	POLICY ROADMAP AND TARGETS	25
4.1.2	ENERGY EFFICIENCY COMPLIANCE SERVICES FOR BUILDING DESIGN AND CONSTRUCTION	26
4.2	EXISTING POLICIES FOR RESOURCE EFFICIENCY IN BUILDINGS	27
4.2.1	REGULATORY FRAMEWORKS FOR DECOUPLING	29
4.2.2	INTERNATIONAL COOPERATION AND CAPACITY BUILDING	31
4.3	INCENTIVES AND FINANCE	32
4.4	GAP ANALYSIS	34
5	EXISTING INSTITUTIONS INVOLVED WITH DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR	35
5.1	ENERGY INSTITUTIONS	35
5.2	ENERGY EFFICIENCY CLUSTERS/NETWORKS	36
5.3	ENERGY EFFICIENCY FUNDS	36
5.4	MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS) AND APPLIANCE LABELLING	37
5.5	INSTITUTIONS FOR BUILDING MATERIALS	37
5.6	GREEN RATINGS AND CERTIFICATION SCHEMES	38
5.7	CAPACITY BUILDING AND NETWORKING	40
5.8	GAP ANALYSIS	40
6	THE WAY FORWARD	41
	BIBLIOGRAPHY	42
	RESEARCH TEAM	44

LIST OF FIGURES

FIGURE 1: DRIVERS OF DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR 10

FIGURE 2: DECOUPLING RESOURCE USE FROM GROWTH 10

FIGURE 3: PROJECTED GROWTH IN RESIDENTIAL CONSTRUCTION DEMAND 13

FIGURE 4: PROJECTED GROWTH IN THE URBAN POPULATION IN INDIA 14

FIGURE 5: RESOURCES USED IN AN URBAN HOUSE 15

FIGURE 6: PROJECTED DEMAND FOR AGGREGATES IN CONSTRUCTION 17

FIGURE 7: DISTRIBUTION OF END USE ENERGY CONSUMPTION 18

FIGURE 8: ENERGY CONSUMPTION IN COMMERCIAL BUILDINGS 19

LIST OF TABLES

TABLE 1: BUILDING-RELATED RESEARCH AND DEVELOPMENT INSTITUTIONS IN INDIA 21

TABLE 2: KEY INTERVENTIONS MADE BY THE BRICK-MAKING INDUSTRY 30

TABLE 3: IS CODES TO PROMOTE RESOURCE DECOUPLING IN INDIA 38

LIST OF ABBREVIATIONS

ABBREVIATION	FULL FORM
AAC	Autoclaved aerated cement
ACEEE	American Council for an Energy-Efficient Economy
AEEE	Alliance for an Energy Efficient Economy
ASCI	Administrative Staff College of India
BAI	Builders' Association of India
BEE	Bureau of Energy Efficiency
BEPL	Building Energy Performance Laboratory
BIS	Bureau of Indian Standards
BMTPC	Building Materials and Technology Promotion Council
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
CAG	Comptroller and Auditor General
CBERD	Center for Building Energy Research and Development
CBRI	Central Building Research Institute
CEPT	Centre for Environmental Planning and Technology
CERI	Clean Energy Research Initiative
CFI	Construction Federation of India
CFL	Compact fluorescent lamp
CIPET	Central Institute of Plastics Engineering and Technology
CMVP	Certified Measurement and Verification Professional
ComSolar	Commercialisation of solar energy in urban and industrial areas
COP	Conference of the Parties
CPWD	Central Public Works Department
CREDAI	Confederation of Real Estate Developers' Associations of India
CRRI	Central Road Research Institute
CSEE	Centre for Sustainable Environment and Energy
CSO	Central Statistics Office
DAC	Department of Agriculture, Cooperation & Farmers Welfare
DELP	Domestic Efficient Lighting Programme
DISCOM	Distribution company
DMG events	Subsidiary of the Daily Mail and General Trust plc
DST	Department of Science and Technology
ECBC	Energy Conservation Building Code

LIST OF ABBREVIATIONS

ECO	Energy Conservation and Commercialization
EEFP	Energy Efficiency Financing Platform
EIA	Environmental impact assessment
ESCO	Energy service company
EWS	Economically weaker sections
FAUP	Fly Ash Utilization Programme
FDFA	Federal Department of Foreign Affairs
GDP	Gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
GOI	Government of India
GRIHA	Green Rating for Integrated Habitat Assessment
HVAC	Heating, ventilation and air conditioning
IEA	International Energy Agency
IESS	Indian Energy Security Scenarios
IGBC	Indian Green Building Council
IGEF	Indo-German Energy Forum
INDCs	Intended Nationally Determined Contributions
INSDAG	Institute for Steel Development and Growth
IREDA	Indian Renewable Energy Development Agency Ltd.
IRP	International Resource Panel
ISES	International Solar Energy Society
ISHRAE	Indian Society of Heating, Refrigerating and Air Conditioning Engineers
IST	Institute of Solar Technology
LBNL	Lawrence Berkeley National Laboratory
LEED	Leadership in Energy and Environmental Design
LIG	Low-income groups
MEPS	Minimum energy performance standard
MNRE	Ministry of New and Renewable Energy
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoP	Ministry of Power
MTEE	Market Transformation for Energy Efficiency
NAPCC	National Action Plan on Climate Change

NBC	National Building Code
NCCBM	National Council for Cement and Building Materials
NGT	National Green Tribunal
NHBF	National Highways Builders Federation
NISE	National Institute on Solar Energy
NITI	National Institution for Transforming India
NMEEE	National Mission for Enhanced Energy Efficiency
NRDC	National Research Development Corporation
OECD	Organisation for Economic Co-operation and Development
OPC	Ordinary Portland cement
PACE	Partnership to Advance Clean Energy
PPC	Pozzolana Portland Cement
PRGF	Partial Risk Guarantee Fund
RCC	Reinforced cement concrete
RDSO	Research Designs and Standards Organisation
REC	Renewable Energy Certificate Regulation
REEC	Regional Energy Efficiency Centre
SDA	State Designated Agency
SDC	Swiss Agency for Development and Cooperation
SECF	State Energy Conservation Fund
SERI	Sustainable Europe Research Institute
SESI	Solar Energy Society of India
SIDBI	Small Industries Development Bank of India
SoR	Schedule of Rates
SVAGRIHA	Small Versatile Affordable GRIHA
tcs	Tonne of crude steel
TIFAC	Technology Information, Forecasting and Assessment Council
ULB	Urban local body
UNDP-GEF	United Nations Development Programme - Global Environment Facility
UNEP	United Nations Environment Programme
VCFEE	Venture Capital Fund for Energy Efficiency
VSBK	Vertical shaft brick kiln
WBRDEA	West Bengal Renewable Energy Agency

THE POLICY BRIEFS

CONTEXT OF THE POLICY BRIEF SERIES

India is currently at a crucial juncture where it is aiming for economic growth to meet the basic needs of its 1.2 billion people. However, so far this growth has resulted in energy shortages and the increasing use of limited resources. This policy brief series is about decoupling, i.e. improving efficiency to reduce the resources and energy needed for this growth and meet the country's increasing development needs.

The construction sector is highly resource and energy intensive; it is therefore imperative that it moves towards a path of environmental sustainability. This transition is likely to be achieved by decoupling both resource and energy use from the sector's growth. Decision-makers in the sector will play a crucial role in achieving this. The aim of this policy brief series is to inform decision-makers in India at central government and state level about the current status of research, policy and institutions in the Indian construction sector and to identify key drivers and barriers. Finally, practical recommendations will be made for decision-makers about how to promote decoupling of resource and energy use from growth in the construction sector.

The series comprises three policy briefs:

Policy brief 1 focuses on the baseline for decoupling in the Indian construction sector. The study draws attention to the existing scenario in terms of key policies, research and institutions linked to resources and energy in the sector.

Policy brief 2 focuses on analysing the potential for decoupling in the Indian buildings and construction sector. Primary and secondary research was conducted to identify the factors that influence decoupling. Subsequently, a framework was established to make it possible to measure the nature and extent of decoupling that is possible within the existing policy environment. Furthermore, gaps, drivers and barriers have been identified which could enable a potential analysis study on decoupling to be carried out. In addition, examples of good practice from Germany and other European countries have been studied with a view to learning lessons that can help to bridge the current gaps in India.

Policy brief 3 focuses on recommendations both at national and state level on the possible interventions that could result in resource and energy use being decoupled from growth in the Indian construction sector. Lack of a comprehensive policy on resource efficiency and the possibility of using secondary raw materials to obtain resource and impact decoupling continue to be the key issues that India will have to grapple with in the years to come.

The policy briefs are a follow-up of the Policy Paper "Decoupling Economic Growth from Resource Consumption. A Transformation Strategy with Manifold Socio-Economic Benefits for India and Germany" by Peter Hennicke and Ashok Khosla with contributions from Chitrangna Dewan, Kriti Negrath, Zeenat Niazi, Meghan O'Brien, Mandira Singh Thakur, Henning Witts, published in November

2014. The Policy Paper was elaborated by members of the Indo-German Expert Group on Green and Inclusive Economy. The group is supported by the German Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and facilitated by the GIZ Environmental Policy Programme in Berlin and the Indo-German Environment Partnership in Delhi.

KEY MESSAGES

POLICY BRIEF 1 – A BASELINE STUDY



DECOUPLING ENERGY AND RESOURCE USE FROM GROWTH IN THE INDIAN CONSTRUCTION SECTOR

- An increasing population, burgeoning middle class and rapid urbanisation is fuelling the growth of India's resource and energy-intensive construction sector.
- By 2007, construction had become the second largest sector with regard to material consumption, accounting for around 20 % of total demand. Soil, sand and limestone form the bulk of materials used for construction.
- Commercial and residential buildings accounted for 31 % of total energy consumption in India in 2013–14.
- Pressure on limited stocks of material and energy resources will rise due to the anticipated increase in India's built-up area. The built-up area of housing is projected to increase fourfold by 2030 from the base year of 2005 and built-up area occupied by commercial buildings is projected to increase sevenfold.
- Decoupling resource use from economic growth is a key strategy to reduce pressure on resources.
- There are a number of options for and approaches to improving resource and energy efficiency in the sector. They include the use of fly-ash bricks, energy-efficient appliances, green building design, building-integrated solar PV etc. These options have the potential to be scaled up by multi-stakeholder action. A good example of decoupling is fly ash based Pozzolana Portland Cement (PPC), which uses fewer resources than conventional Ordinary Portland Cement (OPC) and has already been accepted and scaled up in the Indian cement market.

1 DECOUPLING IN INDIA

1.1 TYPES OF DECOUPLING

Decoupling – i.e. increasing resource and energy efficiency as a key strategy for creating a green economy – has become imperative throughout the world. Decoupling in its literal sense means removing the link between any two variables. Although decoupling can be applied to many sectors, this paper focuses on decoupling resource use from growth in the Indian construction sector. Drivers of decoupling in India, along with some specific examples, are presented in *Figure 1*.

The International Resource Panel (IRP) distinguishes between two forms of decoupling (UNEP, 2011).

- A. Resource decoupling
- B. Impact decoupling

Resource decoupling (or increasing resource productivity): This means reducing the rate of use of (primary) resources per unit of economic activity. This understanding of ‘dematerialisation’ is based on the idea of using less material, energy, water and land for the same economic output, resulting in more efficient use of resources.

Figure 1: Drivers of decoupling in the Indian construction sector

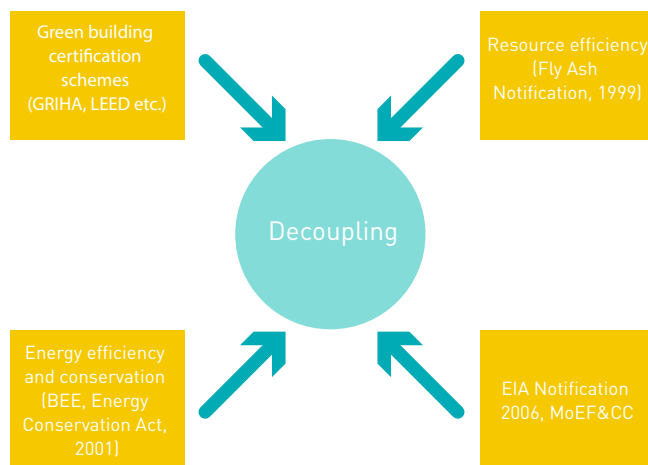
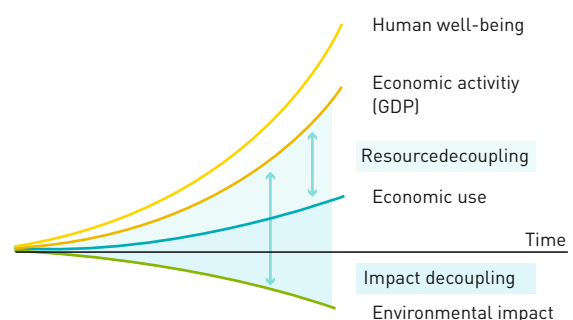


Figure 2: Decoupling resource use from growth



Source: UNEP, 2011

An example of resource decoupling in India

The use of **hollow bricks** in construction has been steadily increasing in India. These bricks utilise 25–60 % less raw materials (primarily soil) due to the cavities within them. However, their compressive strength is less than solid clay bricks but still sufficient to meet the Indian Standards (IS) code requirements for a framed construction. In this way primary resource use decreases without a drop in productivity.

Impact decoupling (or increasing eco-efficiency):

This means raising economic output while reducing the negative environmental impacts that arise from the extraction of resources (degradation of rivers and land caused by extracting sand and soil respectively), production (land degradation, waste and emissions), use of commodities (transport resulting in CO₂ emissions), and in the post-consumption phase (waste and emissions). Life cycle assessments can estimate impacts using various input-output techniques. However, their application at national level can become very challenging, as the parameters for input and output are not uniformly measured and are often contested. Reducing environmental impacts does not necessarily have a mitigating impact on resource scarcity or production costs and may even sometimes increase them.¹

Decoupling has also been divided into two types: weak (relative) decoupling and strong (absolute) decoupling. GDP growth with declining energy intensity indicates weak decoupling whereas GDP growth with declining energy consumption indicates strong decoupling. A weak decoupling trend has been observed at worldwide level. Strong decoupling has been observed among OECD countries with especially strong decoupling being seen in Germany. In its INDCs submitted at Paris, India claimed 'the emission intensity of India's GDP has decreased by 12 % between 2005 and 2010 (Government of India, 2015). This indicates weak decoupling. China has witnessed weak decoupling with the potential for it to turn into strong decoupling in the future.

For the purpose of this policy brief, further sections will concentrate solely on resource and impact decoupling, rather than delving further into the concepts of strong and weak decoupling.

Impact Decoupling Example from India

The use of **fly ash** bricks in construction is an example of impact decoupling. Fly ash is used in place of soil as a primary raw material. Electricity is used to operate the equipment, whereas conventional brick kilns are coal-fired. This reduces the environmental impacts caused by soil extraction and alleviates the pressure on soil as a resource, while reducing the embodied energy of the product.

¹ Background paper "Natural resources – decoupling growth from resource consumption".

The idea of energy efficiency and resource substitution in India developed from concerns about environmental sustainability, climate change mitigation and scarcity of resources and not really as a result of concerns about growth. So in a sense, the push has been generated due to both resource and impact decoupling concerns. However, the idea of impact decoupling is not very popular, as impacts cannot be directly attributed to specific causes, especially by consumers. The concerns problems, are starting to become a reality in the market e.g. river sand scarcity in Karnataka led to the shift towards Manufactured Sand (M-Sand).

1.2 THE INDIAN CONTEXT

The construction sector is one of the most energy and resource intensive sectors (DA and Wuppertal Institute, 2014). Buildings impose a burden on the environment by consuming a substantial amount of resources such as fossil energy and raw materials. A fast-growing middle class will prompt the growth of cities throughout the country, which in turn will trigger a rise in the need for new buildings, especially housing. Over 70–80 % of the buildings that will exist in 2030 have yet to be constructed (McKinsey Global Institute, 2010). To fill this gap, brick and cement demand will be 3.6 and 3.3 times higher than in the base year of 2010 (Sustainability Outlook, 2015). With conflicts and concerns over sand and soil – key ingredients in concrete and bricks – already on the rise, the sector will face massive resource constraints in the future. This translates into an urgent call to decouple our economic growth from resource use and promote greater sustainability.

2 NEED FOR DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR

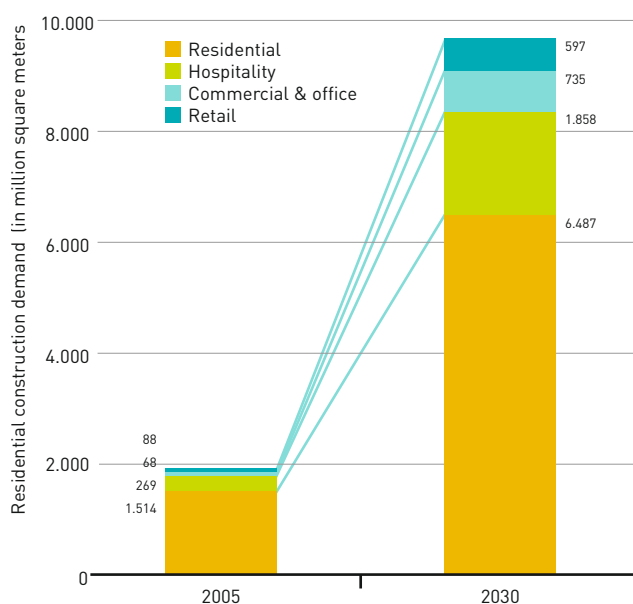
2.1 INDIA'S GROWING CONSTRUCTION SECTOR

The construction market in India is forecast to become the world's third largest by 2022 (Global Construction Perspectives and Oxford Economics, 2013). The sector is expected to grow at a rate of 7–8 % in the next 10 years as a result of increased demand (DMG Events, 2015) and enhanced proposed spending of USD 1 trillion in the 12th five-year plan period. A look at the projected growth trends shows that the majority of growth is predicted in the residential sector as seen in *Figure 3*. Overall residential construction demand is expected to increase more than fourfold by 2030 from its 2005 level. This translates into 4,972 million m² of residential floor space (Climate Works Foundation, 2010). Overall residential demand is expected to be 50 million urban households and about 60 million for rural households by 2022 (KPMG, 2014).

The total floor area of buildings is projected to increase fivefold, from approximately 1,940 million m² in 2005 to about 9,675 million m² in 2030, with residential buildings occupying the lion's share at 67 %, followed by commercial buildings (19 %), hospitality sector (8 %) and retail (6 %) (Climate Works Foundation, 2010).

The emerging wave of urbanisation in the country is fuelling the growth in the construction sector. As per the 2011 census, about 31.20 % of the total population, or 370 million people, currently live in urban areas, which is an increase of 3.35 % since 2001. This is expected to rise to about 600 million

Figure 3: Projected growth in residential construction demand



Source: Climate Works Foundation, 2010

by 2030. Currently, much of the urbanisation is occurring in India's Class I cities,² where 68.90 % of the total urban population live. The number of towns and cities increased from 2,774 in 2001 to 7,935 in 2011 (Census of India, 2011). By 2030, more of the population in Tamil Nadu, Gujarat, Maharashtra, Karnataka and Punjab will live in cities than villages. It is estimated that by 2030 India will have 68 cities with a population of more than one million, 13 cities with more than 4 million people and 6 megacities with populations of 10 million or more (Sankhe S. V., 2010). This trend in urban population growth will increase the need for buildings, especially housing, across all classes of towns and cities. The current

² According to the 2011 Census of India, Class I cities refer to those with a population between 100,000–1,000,000.

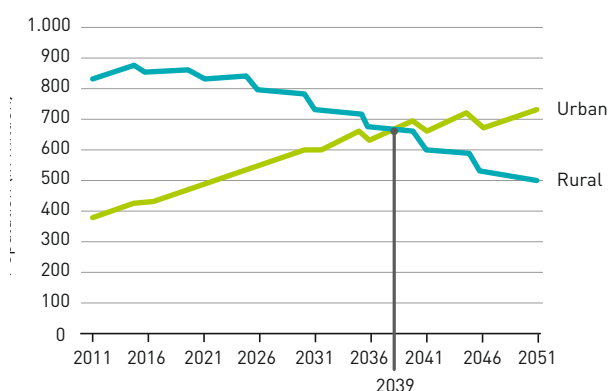
affordable housing deficit in urban areas already stands at about 19 million units (Ministry of Housing and Urban Poverty Alleviation, 2012) and additional 28 million units are required by 2022 (KPMG, 2014). Programmes of the Government of India such as Housing for All, Smart Cities Mission and the Atal Mission for Urban Rejuvenation and Urban Transformation will also boost growth in the sector. However, financial resource constraints are limiting public investment and the share of private investment is expected to increase to half as compared to the 30 % intended for the 11th five-year plan; hence there will be increasing emphasis on public private partnership based developments (Equity Master, 2012). As a result of these growth trends, the demand for and pressure on limited stocks of construction materials are expected to increase tremendously.

2.2 RESOURCE SCARCITY IN THE CONSTRUCTION SECTOR

Globally, the construction sector accounts for 30–40 % of all material flows. This also holds true for a rapidly developing country like India. Materials such as cement, concrete, steel, bricks and tiles, sand and aggregates, fixtures, fittings, paints and chemicals, petrol and other petro-products, timber, minerals, aluminium, glass and plastics account for nearly two-third of construction costs (Planning Commission, 2013).

Urban construction is increasingly moving away from masonry load-bearing structures in favour of RCC (reinforced cement concrete) framed structures, which form a substantial part of a building, thus increasing the amount of cement and steel used. The cement industry has already shifted toward fly ash based Portland Pozzolona Cement (PPC). PPC utilises about 30 % less limestone than ordinary Portland cement, which is a valuable contribution to resource decoupling. PPC's share in total cement production in India is estimated to be 67 %. (Rajya Sabha Secreteriat, 2011). Steel is used as bars and rods in the construction sector and is 100 % recycled in the secondary market after buildings have been demolished.³ The Indian steel industry has adopted best practices and reduced its specific energy

Figure 4: Projected growth in the urban population in India



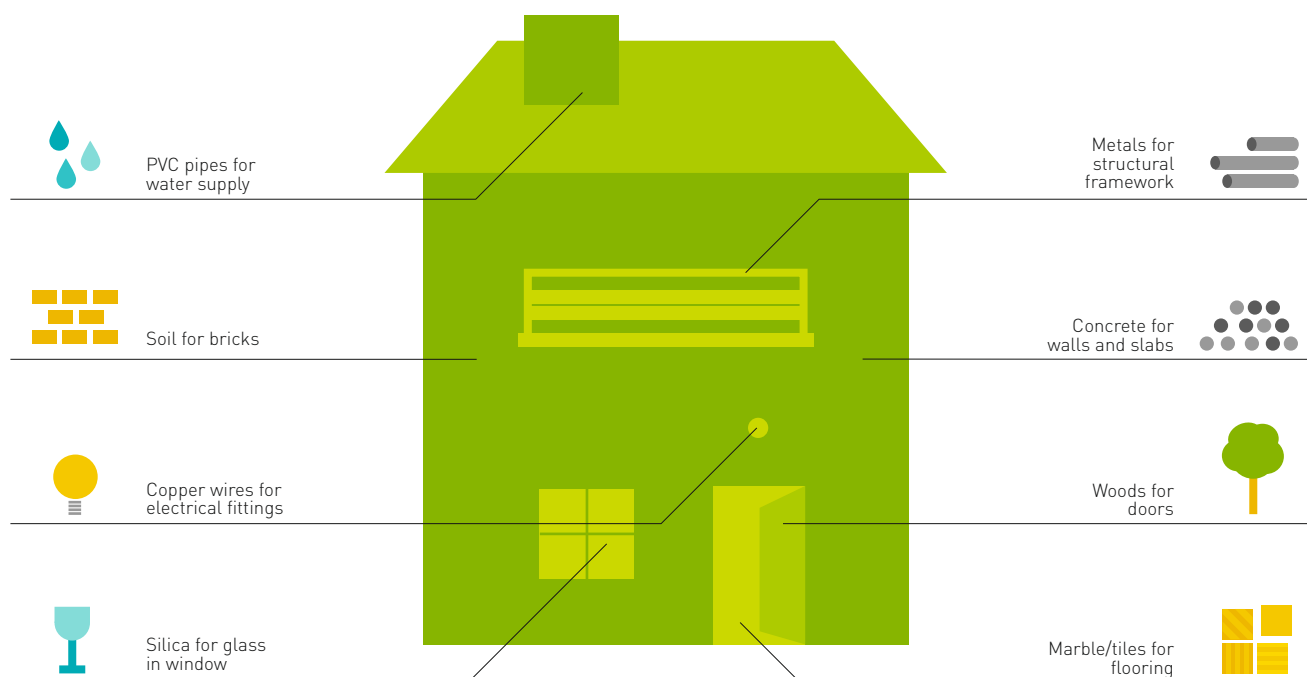
Source: NIUA, 2011

3 Based on the authors survey in 10 Indian cities

consumption from 8–9 Gcal/tcs (tonnes of crude steel) in 2004 (Thakkar, 2008) to 6–7 Gcal/tcs in 2015 (Ministry of Steel, 2015), thus supporting impact decoupling. Other materials such as paints and chemicals, plumbing and electrical fixtures, etc. are not used in large quantities in a building, but have a higher cumulative cost as compared to bulk materials such as bricks, cement, mortar etc.

This policy brief focuses on resources such as soil and sand that are used in large quantities to make the bricks, concrete and mortar used in construction. Soil and sand are also the most critical resources in India. This is primarily due to their scarcity, the conflict of uses – especially in the case of soil – and the legal restrictions and massive ecological impact on rivers associated with extraction of sand. Despite the issues involved, there is very little data on national availability and material flow of these resources.

Figure 5: Resources used in an urban house



Source: Development Alternatives, 2015

2.3 UNDERSTANDING CRITICALITY OF RESOURCES

Understanding criticality of resources on the basis of the triple bottom line impacts, i.e. economic, social/cultural and environmental viability, lays the foundation for identifying resource synergies and assessing and addressing the conflicts that may arise across sectors such as construction, agriculture, industry etc. The aspect of criticality can be assessed on the basis of economic environmental and social/cultural factors.

Economic factors: These factors include the cost of resources, the perceived scarcity of resources due to the high cost of limited resources and the consequent impacts of high resource cost on the affordability of houses and other buildings.

Environmental factors: Environmental impacts of extraction, production and processing of resources to manufacture building materials, embodied energy, conflicts of use with other sectors and/or regions and the potential for reusing and recycling, as well as use as secondary raw materials determine criticality.

Social/cultural factors: This includes the risk of the supply of resources becoming limited due to conflict of use and other political, physical, cultural and legal factors.

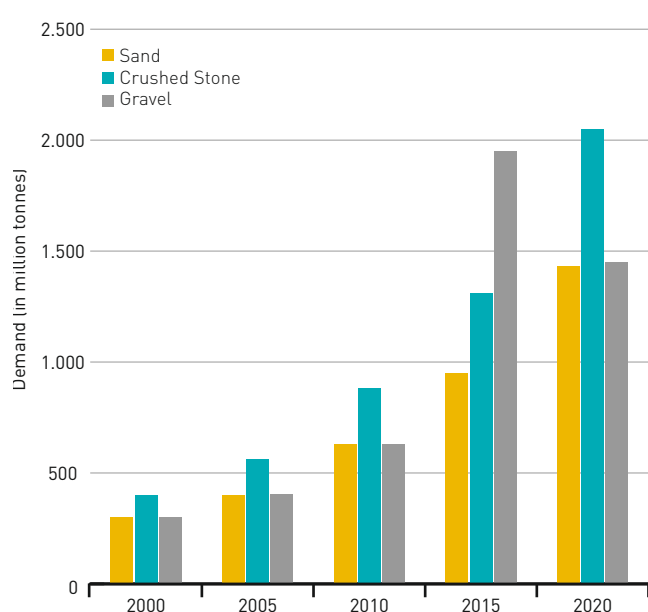
Besides the above-mentioned factors, regional variation also plays a key role in determining criticality. Availability of resources and construction practices vary from region to region and impact on consumption patterns, therefore influencing criticality.

2.3.1 SOIL

Bricks form the backbone of the construction sector. Increased urbanisation has resulted in excessive exploitation of topsoil for construction purposes and increased mining of raw materials for brick production. Every year 600 million tonnes⁴ of fertile topsoil are used to meet the demand for 200 billion bricks (Maithel, 2012). Alluvial soils are by far the largest and most important soil group for brick production in India. These soils also account for the largest share of our agricultural wealth (Negi, 2015) and cover about 1.5 million sq. km. or 45.6 % of the total land area of the country. Extraction of soil for brick production destroys about 175,000 sq. km. of land every year. As a result, land productivity decreases, paving the way for social conflicts due to increased concern over food security. In response to these concerns, the Government of India has made environmental impact assessments (EIAs) mandatory for brick earth extraction (Down to Earth, 2016). Furthermore, there are emission standards that regulate the pollution caused during brick-making. New technologies such as vertical shaft brick kilns and zig-zag kilns are best suited to meeting pollution standards, but they have no impact on soil resource use. The Government and market alike are also promoting alternative products such as hollow bricks (IS: 3952(1988)) and fly ash bricks (Fly ash notification, 1999) that abate both the resource and energy concerns connected with conventional fired clay bricks.

⁴ As per consultation with Sameer Maithel, Founder Director, Genentech Solutions Pvt. Ltd. (Email: sameer@gkspl.in)

Figure 6: Projected demand for aggregates in construction



Source: The Freedonia Group, 2013

2.3.2 SAND

The 1957 Mines and Minerals (Development and Regulation) Act classifies sand as a minor mineral if used for construction purposes and its management comes under the purview of state governments. Concrete and mortar are the most consumed materials after water (ICI, 2016). Sand is an essential component that goes into producing these materials. Sand used to make concrete must adhere to the specifications for fine aggregates set out in Indian Standard 383:1970, while sand used for masonry mortar must adhere to Indian Standard 2116:1980. Both the standards suggest use of 'natural sand

deposited by streams' (river sand). Mining of river sand for heavily consumed materials such as concrete and mortar has tremendously deleterious impacts on river ecology. Mining leads to downstream erosion, causing changes in channel bed and habitat type, as well as deepening rivers and estuaries, and enlarging river estuaries. As the depth of a riverbed increases, local groundwater is affected, causing water scarcities that have a negative impact on agriculture and local livelihoods.

Increasing demand due to the construction boom, coupled with easy availability and limited legislative actions, has given rise to thriving illegal sand mining. The annual turnover from illegal mining in India is estimated to be INR 10 billion (Centre for Science and Environment, 2012). The extent of illegal mining has forced certain state governments to impose a ban on sand mining. This has led to a gap between demand and supply. This gap will be further aggravated by the increase in demand to 1,430 million tonnes by 2020 (Figure 6)

In response, the Government of India has made EIA clearance mandatory for small-scale (lease areas of 5 hectares or less) sand extraction activities (Banerjee, 2016). States such as Karnataka, Tamil Nadu, Kerala, Rajasthan have fully or partially banned sand mining, forcing the construction sector to look for alternatives. Manufactured sand, or M-sand, derived from stone quarries, has already made its mark, especially in the southern states, where sand scarcity is alarming. Construction and demolition (C&D) waste processing facilities in Ahmedabad and Delhi also produce M-sand from C&D waste (and other construction products such as aggregates).

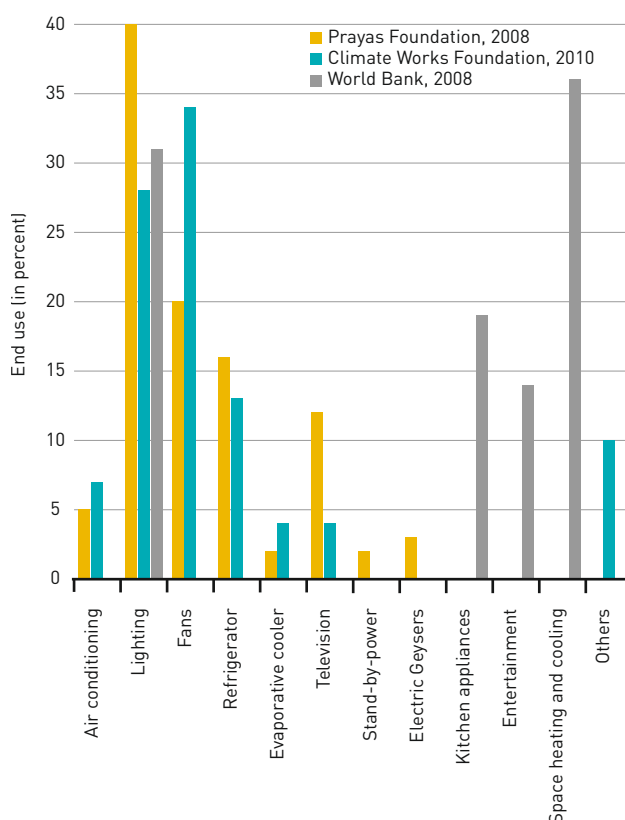
2.4 ENERGY CONSUMPTION IN THE CONSTRUCTION SECTOR

The energy footprint of buildings includes embodied and operational energy. Embodied energy comprises the energy consumed during the extraction, production, and transport of materials and demolition of buildings. The operational phase consists of energy consumption for the day-to-day functioning of the buildings, which is also referred to as specific or final energy consumption. Both embodied and final energy consumption can be accounted for under total primary energy consumption. Of the total electrical energy consumption in the country during the year 2013–2014, 22.5 % was consumed by the residential sector and 8.7 % by the commercial sector, taking total consumption by building-related uses to approximately 31 % (CSO, 2015). The energy use in the buildings sector in India is projected to increase over the coming decades due to population growth, the rate of urbanisation, growth in access to modern energy and ownership of appliances as income levels rise. Urbanisation has improved access to energy, but lack of planning has resulted in inefficient patterns of energy use (OECD and IEA, 2015). It is estimated that a growth rate of about 6 % in total energy use from all sources is needed to sustain a growth rate of 8 % in GDP (Planning Commission, 2013)

2.4.1 RESIDENTIAL BUILDINGS

Lighting, ceiling fans, and appliances such as television, refrigerators, air conditioners and water heaters and cooking make the greatest contribution to energy consumption in residential buildings in India. Although cooking accounts for the major share of energy consumption in the residential sector, the chief fuel used for cooking is either liquefied petroleum gas (LPG) in urban areas and to some extent biomass and kerosene in rural areas (Chaturvedi, Eom, E. Clarke, & Shukla, 2011). The

Figure 7: Distribution of end use energy consumption



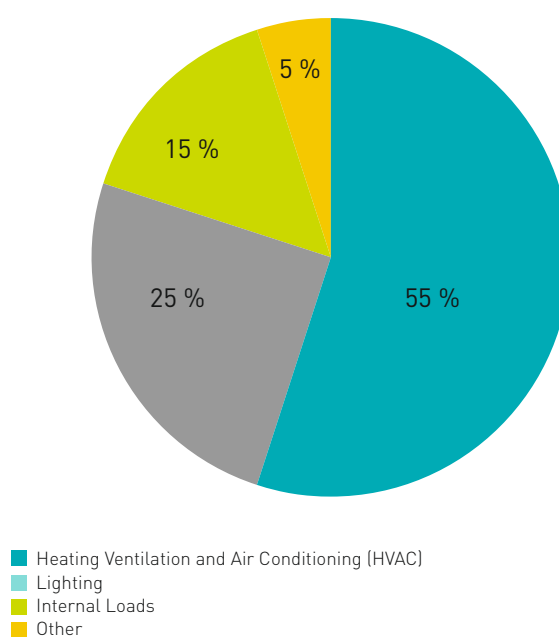
Source: Prayas Foundation, 2008, Climate Works, 2010 and World Bank, 2008

focus of this report is, however, on embodied and operational energy, excluding cooking-related energy. The energy consumed during the operational phase accounts for 80–90 % of total primary energy use by air-conditioned buildings and decreases to about 40–50 % in the case of non-air conditioned buildings (Ramesh et al., 2013) (Praseeda, Venkatarama Reddy, & Mani, 2016). Energy consumed by different end uses varies by usage and household income and according to whether the residential unit is air-conditioned or not. *Figure 7* shows the energy consumption for various end uses as projected by three different studies.

2.4.2 COMMERCIAL BUILDINGS

A major chunk of energy consumption in commercial buildings in India is due to heating, ventilation and air conditioning (55 %) and lighting (25 %), and the rest is due to plug loads (15 %) and other minor standby loads (Planning Commission, 2014). Consideration of factors such as electrification of households is still an on-going project and, given the low levels of appliance ownership (all appliances in rural areas and energy intensive refrigerators and air conditioners in both rural and urban areas), residential energy consumption is set to see a manifold increase. This anticipated increase in demand for energy and resources will exert added pressure on limited stocks. Increasing conflicts over access and use of natural resources to satisfy the demands from various sectors are already becoming the norm (GIZ, 2013). Since the sector's environmental and resource footprint is high, it also offers great potential to decouple resource use from growth. Understanding the criticality of resources is also essential to identify the key resources that need to be addressed to create resource synergies.

Figure 8: Energy consumption in commercial buildings



Source: Planning Commission, 2014

3 EXISTING RESEARCH AND DEVELOPMENT CONNECTED WITH DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR

This section focuses on research and development connected with resource and impact decoupling in the construction sector. Previous and on-going research has been analysed to establish its contribution to decoupling in the construction sector.

3.1 R&D CENTRES WORKING TOWARDS DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR

The principal institutions involved in research and development in the construction sector in India are the Central Building Research Institute (CBRI), the Building Materials and Technology Promotion Council (BMTPC), the Institute for Steel Development and Growth (INSDAG), the Central Institute of Plastics Engineering and Technology (CIPET), the National Council for Cement and Building Materials (NCCBM), the Central Road Research Institute (CRRRI) and the Research Designs and Standards Organisation (RDSO). Educational institutions such as the various Indian Institute of Technology and Indian Institute of Science campuses have been involved in research and innovation in the field of resource utilisation. Civil society organisations, such as Development Alternatives, have developed a framework that can be applied to various natural resources, specifically raw materials, to assess their criticality and identify the key resources that would need to be addressed to form resource synergies (Development Alternatives, 2015). Auroville Earth Institute has also done significant research on developing unique construction technologies that use locally sourced materials. Examples include bamboo houses, poured earth, and earth blocks for roads (Auroville Earth Institute, 2016).

The Fly Ash Utilization Programme (FAUP) is a mission mode programme of the Department of Science and Technology (DST), with the Technology Information, Forecasting and Assessment Council (TIFAC) as implementing agency. FAUP has undertaken various projects and activities in technology innovation, development and demonstration, dissemination of information, creating awareness, facilitating multiplier effects, and providing inputs for policy intervention in the area of safe management and gainful utilisation of fly ash (DST, 2015).

The National Bamboo Mission of the Ministry of Agriculture's Department of Agriculture and Cooperation is designed to promote the growth of the bamboo sector in the country through area-based, regionally differentiated strategies. The aim is to increase the area under bamboo cultivation with appropriate varieties of the species to enhance its production and productivity, and to promote its use as a key natural resource in the housing and construction sector (DAC, 2015). The Government of Uttarakhand has been promoting the use of bamboo as a wood substitute in construction, and the state has seen an increase in poly houses created using the resource.

Many institutes have also entered into collaborative research agreements with other institutes and universities. Lawrence Berkeley National Laboratory (LBNL) in the United States and CEPT University in India jointly proposed the U.S.-India Joint Center for Building Energy Research and Development (CBERD). The research aims to significantly reduce energy use in buildings in both nations.

3.2 FUNDING FOR RESEARCH, DEVELOPMENT AND DEMONSTRATION (RD&D) PROJECTS

A Regional Energy Efficiency Centre (REEC) for buildings has been established at the Centre for Sustainable Environment and Energy (CSEE), which in turn is part of CEPT University (Centre for Environmental Planning and Technology) in

Ahmedabad to raise awareness among stakeholders and to further the adoption of Energy Conservation Building Codes (ECBC). In addition, a Building Energy Performance Laboratory (BEPL) has also been established to facilitate training and test thermos physical properties of buildings materials. Another REEC for Home Appliances has been established at the West Bengal Renewable Energy Agency (WBRDEA), Kolkata, to support the Bureau of Energy Efficiency's (BEE) star-rating programme for appliances.

Table 1: Building-related research and development institutions in India

Research Body	Areas
Indian Institutes of Technology (IITs)	Solar, zero-energy buildings, heat transfer.
Centre for Environmental Planning and Technology (CEPT)	Openings and fenestration in buildings.
National Institute of Solar Energy (NISE), MNRE	Solar buildings, solar photovoltaics, solar energy materials.
Indian Institute of Science (IISc)	Alternative building technologies and materials, energy-efficient and environmentally sound technologies; functional efficiency of buildings including climatic performance
Bharat Heavy Electricals Corporate R&D Centre	Solar photovoltaics, solar water heating systems, surface coatings, and building energy management.
National Council for Cement and Building Materials (NCCCBM)	R&D of innovative technologies, their transfer and implementation in partnership with the cement and construction industries to enhance quality, productivity and cost-effectiveness; improving the management of materials, energy and environmental resources; developing technologies for durable infrastructure and affordable housing.
Central Road Research Institute (CRRI)	Areas of R&D: utilisation of industrial waste by-products in road construction; use of marginal materials in road construction and re-use of material from building demolition in roads; waste plastic in modified bitumen; warm and half-warm mix asphalt; cold mix technology; use of recycled asphalt pavement and use of polymer modified bitumen.

3 EXISTING RESEARCH AND DEVELOPMENT CONNECTED WITH DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR

Institute for Steel Development and Growth (INSDAG)	Providing a prompt advisory service on materials, construction practices, interpretation of codes etc. and creating an environment for better usage of steel by acquiring and disseminating knowledge about best practices; providing advisory services on interpretation of standards, construction techniques, cost-benefit analysis, best practices etc.
Central Institute of Plastics Engineering and Technology (CIPET)	Offers services in tooling and precision machining on CNC machines, design and manufacturing of moulds, tools & dies for manufacturing plastic products, CAD/CAM/CAE services, plastic product manufacturing through state-of-the-art injection moulding machines, blow moulding, PET, stretch blow moulding, pipe and film extrusion etc., standardisation, testing and quality control for plastic materials and products, pre-delivery inspection (PDI) of plastic products such as PVC and PE pipes, woven sacks, water storage tanks, micro-irrigation equipment, engineered bamboo boards, polymer-based composite doors etc.
Promoting body	Areas
Central Building Research Institute (CBRI)	Building materials: development of new technologies to promote building materials and systems; technology transfer to industry for commercialisation. R&D in the field of energy efficiency of buildings. Drafting standards for thermal comfort, developing guidelines and methods for designing energy-efficient buildings. Development of devices for solar energy utilisation has resulted in commercial exploitation of various types of solar water heaters. An autonomous hybrid PV-thermal system has also been developed for electrical and thermal use in buildings.
Building Materials and Technology Promotion Council (BMTPC)	Recommended technologies such as fly ash based bricks, RCC blocks, cellular lightweight concrete, bamboo-based materials, bagasse boards. Partial pre-fabrication technology, along with easy-to-operate machines for deployment. Monolithic concrete technology using plastic/aluminium composite formwork. Rapid wall construction system.
Network cluster	Areas
Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE)	Development and promotion of heating, ventilation, and air conditioning (HVAC) standards and test procedures.

Source: TERI. (2015). Science, Technology and Innovation for Low Carbon Development in India. Retrieved 8 February 2016 from http://www.teriin.org/projects/loccl/pdf/res/Discussion_Paper_LCD_STI.pdf.

3.3 GAP ANALYSIS

India is the eighth largest investor in research and development in the world, but the volume of investment made is about half that of Germany and a quarter that of Japan, despite the fact that these countries are much smaller than India in terms of population and geographical area. Out of all the institutes mentioned above, only IITs, IISC and TERI are recognized as key institutes for research and development. Construction-specific R&D institutes, such as CBRI, CEPT, NISE, INSDAG, CRRI etc. are not on the list of leading patent-filing institutions (IBEF, 2016). Thus, there is a clear gap in funding for R&D on buildings and construction. Another issue is the weak link between innovation and incubation. A lot of research done on energy and alternative materials does not achieve market incubation due to lack of incentives and regulations. An audit report submitted by the Comptroller and Auditor General (CAG) of India on the renewable sector in the country concluded that there is a lack of industry participation in commercially scaling up research technologies as well as observable delays in filing patents or publishing papers as envisaged (CAG, 2015).

4 EXISTING POLICIES THAT ADDRESS DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR

This section focuses on identifying policies that are linked to both resource and impact decoupling in the construction sector, and the key gaps that need to be addressed to develop integrated policies on decoupling in the construction sector as a whole. At the outset, it must be noted that many of the policy frameworks for both resource and energy efficiency are voluntary, barring a few that have been made mandatory.

4.1 EXISTING POLICIES FOR FOSTERING ENERGY EFFICIENCY IN BUILDINGS

Energy-efficient and environmentally friendly building techniques focus mainly on (operational) energy and overall resource efficiency (including embodied energy) in the buildings and construction sector respectively. They are the key elements to decoupling energy and resources from economic growth in order to support a green economy in the country.

The 2001 Energy Conservation Act, which was a result of the Indo-US bilateral cooperation project entitled the Energy Conservation and Commercialization (ECO) Program, is an important piece of legislation for energy efficiency in India. The Act was amended in 2010 to include commercial buildings with a connected load of 100 kW or a contract demand of 120 kVA and above. It aims to reduce baseline energy consumption by setting minimum energy performance standards for new commercial buildings, including building envelopes; mechanical systems and equipment, including heating, ventilation and air conditioning (HVAC) systems; interior and exterior lighting system; service hot water, electrical power and motors. The first

phase (2001–2005) of the programme (ECO-I) led to the notification of the Act and the establishment in 2002 of the Bureau of Energy Efficiency (BEE), a central statutory body dedicated to enforcing and helping to implement the provisions of the Act. ECO Phase II was instrumental in implementing Energy Conservation Building Codes (ECBC) in 2007 to provide minimum requirements for energy-efficient design and construction. It has been estimated that the implementation of ECBC (ECO III, 2010) has brought about a considerable reduction in energy usage, especially in commercial buildings. The adoption of ECBC in a number of states is at various stages of progress. While a few states have mandated the use of ECBC in commercial buildings, a number of others are still in the process of adapting the code to suit their specific requirements, and it is therefore voluntary at present (ASCI & NRDC, 2012).

The third phase – ECO III (2006–2011) – focused on implementing ECBC in various states through capacity building, education and training, tool development and dissemination activities at national, state, municipal and local levels. The ECO project was closely followed by another Indo-US bilateral venture called Partnership to Advance Clean Energy or PACE (2009–2014), which focused on energy efficiency in buildings, renewable energy, demonstration, capacity building, finance for clean energy and implementing ECBC at state level.

BEE also introduced the Standards and Labelling Programme in May 2006. Under this programme, manufacturers of electrical appliances are required to label their products to inform the customer of the amount of electricity the particular appliance will consume under certain conditions. The scheme is mandatory for some appliances and voluntary for others. A star-rating programme for popular

domestic appliances such as ceiling fans, air conditioners and refrigerators has proved a success. In terms of overall rating standards for green buildings, there are currently two rating systems in India: Leadership in Energy and Environmental Design (LEED) and Green Rating for Integrated Habitat Assessment (GRIHA), both of which incorporate ECBC requirements.

Broadly speaking, policies that are concerned with building energy efficiency focus on implementation of the Energy Conservation Building Code (ECBC) through the deployment of renewable sources of energy in buildings (e.g. solar hot water systems), or by encouraging the use of efficient appliances and lighting. Some of these standards and codes are incorporated in the green building rating systems, of which energy efficiency is an integral component.

However, it needs to be noted that a higher green building rating does not necessarily indicate increased energy efficiency. Green building rating schemes are overall performance-based systems, which include components such as water conservation, handling of consumer waste, reduced dependency on virgin materials etc. Thus, the scheme offers the possibility of acquiring points from a range of criteria, which can result in a building achieving a high green building rating even with relatively low energy efficiency.

4.1.1 POLICY ROADMAP AND TARGETS

India's 2008 National Action Plan on Climate Change (NAPCC) points to building efficiency measures as essential to carbon emission reduction. Several national missions that focus on scaling up energy efficiency in buildings have recently been initiated, such as the National Mission on Sustainable Habitat and the National Mission on Enhanced Energy

Efficiency. The former focuses on large-scale solar thermal power generation, solar photovoltaics, R&D, capacity building, technology transfer, manufacturing etc., of which rooftop solar PV technology is of particular importance in the buildings sector. The latter focuses on energy conservation in residential and commercial buildings by promoting and implementing ECBC, R&D in technologies such as LEDs, evacuated tubes etc.

Many national strategies and policies supplement the above efforts. The 2005 National Electricity Policy (NEP), developed under the provisions of the 2003 Electricity Act, underscores the focus on universalising access to electricity and promoting renewable sources of energy. Similarly, the 2006 Integrated Energy Policy (Planning Commission, 2006) and the 2006 Tariff Policy (Ministry of Power, 2006) focus on demand-side management (DSM) measures, and include a Regulation on Renewable Energy Certificate (REC) and the Renewable Energy Purchase Obligation (RPOs), as mandated by the central and state Electricity Regulatory Commissions.

The 12th Five-Year Plan (FYP) (2012–2017) also focuses on enhancing energy efficiency in buildings by improved appliances and equipment and energy-efficient designs. Keeping this in mind, the government plans to promote the Energy Conservation Building Code (ECBC) as an integral component of urban planning.

Indian Energy Security Scenarios 2047 (IESS 2047), developed by NITI Aayog, present the country's energy situation and future projections of demand and supply under various scenarios. A web-based/XLS IESS 2047 tool, which projects energy use in the domestic and commercial sector, is also available (IESS, 2015). Based on its findings regarding feasibility, the Government of

India then embarked on an ambitious path of revising an initial target of 20 GW to 100 GW by the year 2022. The target will principally comprise 40 GW of rooftop projects and 60 GW large and medium-scale grid-connected solar power projects (PIB, 2015). India has committed to a 33–35 % reduction in emission intensity per unit of GDP by 2030, compared with 2005 levels.

Smart cities are clearly the emerging model for urban development in India. Smarter buildings that are designed efficiently will be a vital component of these smart cities. India is the country with the second largest green building footprint in the world – over 278 million square metres – and is poised to add significant value to the global green building movement (IGBC, 2015).

The report by the Planning Commission's Working Group on Construction for the 12th Five-Year Plan (2012–2017) points out three core areas (TERI, 2015):

- focus on innovation;
- strengthening R&D institutions and facilitating establishment of new institutes (given the huge lack of R&D in academia, research institutes and industry);
- incentivising R&D and innovating initiatives.

Further, it emphasizes making 'green construction' (including green buildings) a core area and adhering to environmental protection laws without compromising development needs. Energy efficiency is one of the sub-tasks of demand side management where efficiency in buildings plays a critical role.

Thus, in terms of decoupling in the construction sector, the above policies mainly aim at resource decoupling as a consequence of energy efficiency, while renewable energy aspects target impact decoupling.

4.1.2 ENERGY EFFICIENCY COMPLIANCE SERVICES FOR BUILDING DESIGN AND CONSTRUCTION

A series of compliance check tools and information brochures have been made available as part of the Energy Conservation and Commercialization (ECO) programme. Two compliance tools – EConirman Prescriptive and EConirman – have been developed to check whether buildings comply with the ECBC, based on prescriptive and whole-building performance methods. A number of supporting publications have also been developed, including guidelines for energy efficiency in buildings and tool tip sheets (ECO III, 2010). In addition, a web-based benchmarking tool, called ECObench, has been developed to monitor and improve building performance by way of voluntary data gathering to enable peer comparison (ECO III, 2010).

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), in consultation with the Ministry of New and Renewable Energy (MNRE), has also launched a web-based platform called **SOLAR GUIDELINES**, under the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). It aims to disseminate information to various stakeholders to ensure timely implementation of projects under the Jawaharlal Nehru National Solar Mission. The platform provides technical assistance and up-to-date information on the policy and regulatory frameworks, contractual agreements, approvals and clearances, funding and financing, and support schemes necessary to commission and efficiently operate and maintain solar installations in the country (Solar Guidelines.in).

In order to facilitate the Energy Efficient Homes programme, a free software called ITToolkitEnEff: ResBuildIndia has been developed by Fraunhofer IBP, in conjunction with TERI, with the objective of assessing the energy savings obtained. The tool has an easy-to-use interface, calculates the energy consumption of the building based on user inputs and generates loan application certificates for refinancing the programme (Fraunhofer IBP, 2012).

The Swiss Agency for Development and Co-operation, in conjunction with BEE, developed Design Guidelines for Energy-efficient Multi-storey Residential Buildings for Composite and Hot-Dry Climates, under component 3 of the Indo-Swiss Building Energy Efficiency Project (BEEP). The guidelines were developed to achieve energy efficiency by assessing the impact of building shape and orientation, building envelope, space cooling, appliances, common services and renewable energy integration in residential buildings. The National Capital Region (NCR) was taken as a base case for the survey (BEEP, 2014).

4.2 EXISTING POLICIES FOR RESOURCE EFFICIENCY IN BUILDINGS

The Government of India has introduced policies and regulations to promote the use of secondary raw materials in construction. One of the most commendable policies is the Fly Ash Notification (S.O. 763 (E))⁵ issued by the Ministry of Environment, Forests and Climate Change (MoEF&CC) in 1999. The notification supports impact decoupling. It was further amended in 2003, 2007 and 2009. It placed restrictions on the excavation of topsoil to manufacture bricks and promotes the utilisation of fly ash within 100 km of coal/lignite based thermal power plants. The notification was amended on 25th January 2016 to increase the distance to 300 km (MoEF&CC, 2016).

In line with the MoEF&CC notification, some states also promote the use of fly ash bricks in government construction. Use of fly ash in public construction within a 100-km radius (now 300-km) around thermal power plants is mandatory in Odisha, Madhya Pradesh and Bihar. These bricks should contain a minimum of 50 % fly ash by weight. In other areas, 50 % use of fly ash bricks is a statutory requirement.

⁵ According to the notification, all construction agencies within a radius of 100 km from a coal or lignite-based thermal power plant must use only fly ash-based products for construction. These products will have a minimum of 50 % fly ash by weight. It also stipulates that thermal power plants should provide at least 20 % of dry fly ash free of charge to units manufacturing fly ash or clay fly ash bricks, blocks and tiles on a priority basis over other users. It directed central and state government agencies and State Electricity Boards to help manufacturers by making available land, electricity and water for manufacturing activities and providing access to the ash lifting area to set up ash based units. If the manufacturing unit is within a radius of 100 km, the cost of transportation of fly ash to the manufacturing site should be borne by the power plant. Beyond that distance, the cost is to be borne equally by the manufacturers and the thermal power plants.

4 EXISTING POLICIES THAT ADDRESS DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR

Construction and demolition (C&D) waste is another secondary raw material that can be used in the construction sector. The 2016 **Construction and Demolition Waste Management Rules** encourage the use of recycled C&D waste products such as paving blocks, kerb stones etc. in non-structural applications. The rules address impact decoupling. These products can be used in cities where processing facilities are available. Mandatory procurement of a minimum percentage of products for use in public construction is mentioned as one of the methods to encourage their use (MoEF&CC, 2016).

MoEF&CC, Government of India, has also notified the 2015 Sustainable Sand Mining Management Guidelines. The major objectives of these guidelines are:

- to ensure that sand and gravel mining is done in an environmentally sustainable and socially responsible manner;
- to ensure sustainable availability of adequate quantities of aggregate;
- to improve the effectiveness of monitoring of mining and transportation of extracted material;
- to ensure conservation of the equilibrium of rivers and their natural environment by protecting and restoring the ecological system.

The guidelines encourage the use of renewable and recycled materials such as quarry dust, incinerator ash and manufactured sand (M-sand) as sand substitutes, thereby addressing impact decoupling for sand. It also highlights the need for capacity building (architects and engineers), new laws and regulations, and positive incentives to initiate a shift towards lower dependency on sand.

The guidelines hope to curb illegal mining, maintain the ecological balance of rivers and create national inventories to make informed decisions in sand management for each region in India (MoEF&CC, 2015).

While the formulation of these guidelines at national level is a recent development, a few state Governments such as Madhya Pradesh, Kerala, Karnataka and Uttar Pradesh have already imposed a ban on sand mining to curb illegal extraction activities.

The 2011 Karnataka Sand Policy and the 1994 Karnataka Minor Mineral Concession Rules (amended in 2011) aim to curb illegal mining and streamline the process of sand mining in the state. The Madhya Pradesh Sand Mining Policy was launched in 2015. It aims at regulating the availability and price of sand in the state.

Several other policies and pieces of legislation also advocate the use of resource-efficient building materials. The National Housing Policy (1988) aimed to improve conditions for the inadequately housed and provide basic amenities for all. Since then, the policy has been updated twice – in 1998 and 2007. The policy recognised the unsustainable patterns of consumption of resources such as coal and topsoil by the construction sector. It advocated the use of low-cost building materials including fly ash. The

2007 National Urban Housing and Habitat Policy also reiterated the concerns on sustainability of its predecessor, especially in the light of increasing urbanisation. It also promotes research to facilitate a transition from conventional to innovative, cost-effective and environmental friendly technologies.

To provide policy support for resource efficiency in India, the Ministry of Environment, Forest and Climate Change (MoEF&CC) launched the Indian Resource Panel (InRP). It is the first national resource panel in the world. The overall objective of InRP is to advise the Government of India on the design and implementation of a framework to promote primary raw material productivity and secondary resource management, thereby taking forward the need for consolidated policies on resource decoupling.

4.2.1 REGULATORY FRAMEWORKS FOR DECOUPLING

India has a functional regulatory framework, using incentives and deterrents to mainstream energy efficiency and green buildings. Environmental impact assessment (EIA) is an important management and regulatory tool which makes it mandatory to obtain an environmental clearance for construction projects with a footprint $\geq 20,000$ square metres and $\leq 150,000$ square metres. For townships and large-scale development projects with a footprint $\geq 150,000$ square metres environmental clearance is required. The Ministry of Environment, Forests, and Climate Change has also initiated a procedure to enable fast-track environmental clearance for buildings and construction sector projects with a green rating (pre-certification or provisional certification) under the rating programmes run by GRIHA (Green Buildings Rating System India) and IGBC (Indian Green Building Council). The Ministry of Urban Development has

proposed model building by-laws which suggest that states should update local building by-laws and integrate the environmental clearance and building planning permission processes following approval from MoEF&CC. Urban local bodies, development authorities or any other body authorized to sanction building will be responsible for amending local building by-laws and getting them approved by MoEF&CC. The proposed building by-laws promote resource decoupling by suggesting the use of factory-made building components and recycled construction and demolition waste. They also give specific instructions for the use of fly ash in all categories of buildings. The new proposed integrative approach will improve implementation of environmental measures, but the model building by-laws do not suggest monitoring mechanisms for compliance with the regulations (except for rain water harvesting) after a building has been completed (MoUD, 2016)

The Central Public Works Department (CPWD) has issued an official circular, which states that all construction undertaken by CPWD must have a sustainability component. In view of this, all projects undertaken by CPWD must comply with GRIHA guidelines and benchmarks and be at least internally certified as green by CPWD officers. To facilitate the process, CPWD introduced the approved guidelines regarding green buildings in the 2007 CPWD Works Manual. In the context of green buildings, it is also important to refer to the National Building Code of India (NBC), which is a national instrument that provides guidelines for regulating construction activities across the country. It serves as a model code for adoption by all agencies involved in construction work, such as the Public Works Departments, other government construction departments, local bodies, or private construction agencies.

4 EXISTING POLICIES THAT ADDRESS DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR

Furthermore, the Central Public Works Department (CPWD) publishes the **Schedule of Rates (SoR)**, which is a comprehensive document providing guidance for government departments, public sector undertakings, private builders etc. on procurement of building materials and execution of construction work. Innovative and environment-friendly materials such as fly ash bricks, autoclaved aerated cement (AAC)⁶ blocks and other materials are included in the SoR. Based on the CPWD's SoR, the State Public Works Departments also publish SoRs. Any alternatives can only be used in public construction work if they are included in the SoR.

Furthermore, harmonisation of ECBC with the 2005 National Building Code (NBC) has been finalized by including a chapter entitled 'Approach to Sustainability,' which should be adopted in all future buildings in the country. The chapter focuses on resource and energy efficiency in construction. The Cabinet Committee on Economic Affairs has recently approved the Housing for All by 2022 scheme, which focuses on economically weaker sections (EWS) and low-income groups (LIG). This will bring greater opportunities to focus on green buildings and use of local resources for a sustainable habitat. It would need greater capacity building in the urban local bodies (ULBs) currently responsible for construction of such housing, along with innovative investment models.

Table 2: Key interventions made by the brick-making industry

Agency/ Programme	Type of intervention	Type of decoupling promoted
Central Building Research Institute (CBRI)	Introduction of zig-zag firing technology and semi-mechanisation processes (1970s)	Impact decoupling
Central Pollution Control Board/ Ministry of Environment and Forests	Air emissions regulation for brick kilns (1990s)	Impact decoupling
Swiss Agency for Development and Cooperation	Introduction of vertical shaft brick kiln (VSBK) technology (1995–2004)	Impact decoupling
United Nations Development Programme's Global Environment Facility (UNDP-GEF)	Introduction of hollow bricks and other resource- efficient bricks (2009– ongoing)	Resource decoupling
1999 Fly Ash Notification and amendments	Introduction of the use of fly ash in building materials including bricks for buildings falling within a 100-km radius of a coal/lignite based thermal power station	Resource and impact decoupling

Source: Shakti Sustainable Energy Foundation & Climate Works Foundation, 2012 and MoEF&CC

⁶ ACC blocks offer better insulation compared to burnt bricks and they are produced using fly ash instead of soil.

A scheme to set up a National Network of Building Centres (Nirman or Nirmithi Kendras) was introduced in 1988. It focused on demonstrating the manufacture and use of low-cost, appropriate and indigenous building materials, and materials produced from industrial and agricultural waste. These centres also deliver training to artisans in low-cost construction skills and use innovative techniques to produce building materials and components, including fly ash bricks and stabilised mud blocks.

4.2.2 INTERNATIONAL COOPERATION AND CAPACITY BUILDING

Various bilateral and international cooperation projects were critical in handholding and shaping endeavours to achieve building energy efficiency in India. The outcomes of such programmes helped to constitute and support various policy elements such as the establishment of energy agencies, standards and labelling, energy advice financing, education and training, promotion of energy services and R&D.

As already mentioned, the Energy Conservation and Commercialization (ECO) Programme (2001–2011), which is a bilateral project agreement between the Government of India (GOI) and the United States signed in January 2000, has been critical in laying the foundations for energy efficiency in buildings in India. It was closely followed by the Partnership to Advance Clean Energy (PACE) (2009–2014) – an Indo-US venture, which includes three components: research (PACE-R), deployment (PACE-D), and off-grid energy access (PEACE). Key focus areas are energy efficiency in buildings, renewable energy, capacity building, clean energy finance mechanisms, and implementing ECBC at state level (PACE-D, 2016).

Another programme, the UNDP-GEF-BEE project on commercial buildings (2012–2014) was developed to assist in the implementation and operationalisation of the ECBC through a comprehensive and integrated approach, strengthening institutional capacities, capacity building, and facilitating demonstration and dissemination (undp.org, 2016).

A five-year (2012–2016) Indo-Swiss Building Energy Efficiency Project (BEEP) bilateral cooperation project has been signed by the Ministry of Power (MoP), Government of India and the Federal Department of Foreign Affairs (FDFA) of the Swiss Confederation. The Bureau of Energy Efficiency (BEE) is the implementing agency on behalf of MoP, while the Swiss Agency for Development and Cooperation (SDC) is the agency in charge on behalf of FDFA. The project contributes to strengthening and expanding the Bureau of Energy Efficiency's (BEE) building energy conservation programme for the 12th Five-Year Plan by providing technical assistance in the design of energy-efficient buildings, capacity building, production of information, guidelines and tools, and dissemination (BEEP, 2014).

A refinancing scheme called the Energy Efficient Homes Programme was launched in 2010 in a cooperative venture between Germany's KfW Development Bank and India's National Housing Bank to promote an increase in energy efficiency in the residential building sector. 'Since its inception sub-loans in the equivalent amount of EUR 50 million have been refinanced for more than 1900 home loans (National Housing Bank, 2016).

The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has supported numerous bilateral projects with a view to scaling up solar energy projects in

India and increasing energy efficiency in buildings. Projects of importance include setting up the Indo-German Energy Forum (IGEF) in 2006; a solar energy project called Commercialisation of Solar Energy in Urban and Industrial Areas (ComSolar) in partnership with MNRE, which focuses on demonstration projects, policy advice, supporting a regulatory framework, capacity and awareness building, including the development of a web-based tool called Solar Guidelines (giz.de); development of an online knowledge and information portal for energy efficiency in buildings called bigee.net in collaboration with the Wuppertal Institute and TERI (bigEE.net, 2016).

4.3 INCENTIVES AND FINANCE

Banks, municipal corporations and ministries have devised various financial and non-financial schemes to accelerate the development of environmentally sound buildings. Examples include the State Bank of India's nationwide programme to promote green homes, where customers buying IGBC-certified green homes are given preferential interest rates (a 0.25 % discount) and loan processing fees are waived. The Bank of Maharashtra and ING Vysya Bank have also initiated a green mortgage scheme for eco-housing certified projects, which allows up to a 0.5 % discount on interest rates, a longer repayment term or a three-month repayment deferral and Pune Municipal Corporation offers a 10–50 % concession on the total premium paid by developers of certified eco-housing projects.

Incentives are offered to different stakeholders to promote the adoption of resource-efficient measures. Many incentives are offered to GRIHA- rated projects. Some of them are explained below:

- 10 % discount on property tax for flat owners in Pimpri-Chinchwad Municipal Corporation;
- discount on premium charges payable to urban local bodies (ULBs) by developers;
- additional 5 % FAR (floor area ratio) for GRIHA projects in Rajasthan, Punjab, Noida and Greater Noida
- additional 10 % FAR for GRIHA projects in West Bengal;
- financial assistance from the Small Industries Development Bank of India (SIDBI) for green buildings certified by accredited rating agencies including GRIHA.

The Sikkim Government has issued a notification stating that all government and semi-government buildings in the state (residential, non-residential, healthcare, institutional, industrial, recreational etc.), including those belonging to autonomous bodies like boards, corporations, companies and public sector undertakings (PSU), must have at least a 3-star GRIHA rating.

All states in the country have an industrial promotion policy. These policies outline the priority sectors for industrial development and the actions initiated by the state to develop industrial sectors. Most of these initiatives take the form of incentives or subsidies. States like Odisha and Chhattisgarh have identified resource-efficient products such as fly ash bricks as their priority sectors. Financial and marketing support such as stamp and excise duty exemptions and interest subsidies on capital expenditure, as well as support for the development of infrastructure, is provided for the priority sectors. Tamil Nadu has identified cost- effective building materials as a priority sector.

The Super Energy Efficient Programme (SEEP), a part of the Market Transformation for Energy Efficiency (MTEE) initiative, seeks to increase domestic manufacturing of energy-efficient appliances using market incentives to reduce their cost. This programme would offer incentives to the manufacturers to produce appliances that are 30–50 % more energy-efficient than the most efficient ones available on the market (BEE, 2015b).

Currently, BEE is in the process of improving the energy efficiency of ceiling fans. Bachat Lamp Yojana (BLY) is also an innovative business model to promote compact fluorescent lamps (CFL). BLY is a public-private partnership between the Government of India, private sector CFL suppliers and state-level electricity distribution companies (DISCOMs). Compact fluorescent lamps would be sold to households at the same price as incandescent lightbulbs. The difference in price would be recovered as carbon credits. The scheme has estimated a reduction of 6,000 MW of electricity generation capacity, which translates into a potential saving of INR 240 billion per annum (BEE, 2015a).

Bachat Lamp Yojana's CFL programme has been followed up by a more efficient and dynamic programme called the Domestic Efficient Lighting Programme (DELP), also known as Unnat Jyoti by Affordable LEDs for All (UJALA). This programme is driven by Energy Efficiency Services Limited (EESL)⁷ and is exemplary in its bulk procurement process and ESCO model. The DELP programme successfully lowered the cost of domestic LED bulbs (40–60W) from INR 400 to INR 75 and uses an energy service (ESCO) model to sell the bulbs at low capital cost

(INR 10 per bulb), recovering the remaining amount from subsequent electricity bills.⁸ The Ministry of New and Renewable Energy (MNRE) is implementing a scheme named Energy Efficient Solar/Green Buildings. It aims to promote the widespread construction of energy-efficient solar/green buildings in the country through a combination of financial and promotional incentives, mainly involving exemption from registration and rating fees for government buildings that acquire GRIHA ratings developed by TERI. It also engages in capacity building, awareness-raising and other promotional activities.

The Solar Energy Corporation of India, a not-for-profit company registered under MNRE, has launched a pilot scheme to further the Jawaharlal Nehru National Solar Mission's (JNNSM) aim to promote large-scale grid-connected rooftop solar power generation in the 100 kW to 500 kW capacity range. Identification of the beneficiaries is through competitive bidding in consultation with the state designated agency (SDA), MNRE, and state distribution companies (DISCOMs), at the end of which a 30 % financial subsidy is provided on the system costs, including annual maintenance charges, for two years. Eligible participants include various establishments such as government buildings, commercial builds, hospitals, cold storage facilities, warehouses, industrial and educational institutions with available shadow-free roof area of 1,000–1,200 square metres/100 kW and approved funds to meet the cost of the systems. Besides the financial incentive, the beneficiary is supported in terms of procurement, installation, maintenance, and payment for power supplied to the grid (SECI, 2016).

⁷ A Joint Venture Company of Public Sector Undertakings of Ministry of Power, Govt. of India

⁸ As per consultation with BEE

A joint programme run by India's National Housing Bank and Germany's KfW Development Bank has launched a refinancing scheme called the Energy Efficient Homes programme, providing financial and technical assistance to borrowers through retail lending institutions. Apartment buildings in urban areas that consume at least 30 % less energy than conventional buildings are eligible to participate in the programme and sub-loans in the equivalent amount of EUR 50 million have been refinanced for more than 1,900 home loans.

4.4 GAP ANALYSIS

India does not have a consolidated policy package for energy and resources in the construction sector. Various ministries have developed a wide spectrum of policies but they are not strongly linked to each other and hence sometimes do not support each other.

Implementation of policies framed by central government for resource-efficient construction or minor mineral extraction etc. lies with the states. For example, in order to meet the targets defined under IESS 2047, a consolidated effort has to be made by central, state and local governments. Broad national-level targets should be broken down and distributed across state and local levels so that they can be effectively implemented and monitored.

States with limited capacity (in terms of numbers of staff as well as expertise) to undertake the tasks of developing and implementing policies/regulations are unable to put them into practice at state and local level.

Even after a state has modified the policies, there are very few cases where they are complemented by other facilitative actions such as providing knowledge, training and financial support. A prominent example is the Energy Conservation and Building Code. The code is currently voluntary, which has resulted in its slow uptake and a reliance on the market to ensure progress. Lack of finances and capacity has also resulted in weak adoption of the code by India's states.

While the existing policies have made efforts to incorporate resource efficiency, there is a continuous need for stronger policies that identify the underlying potential for enhancing resource efficiency and promoting secondary resource management across the Government of India's different initiatives and missions.

5 EXISTING INSTITUTIONS INVOLVED WITH DECOUPLING IN THE INDIAN CONSTRUCTION SECTOR

This section analyses the different institutions involved with decoupling energy and materials in the buildings and construction sector. Institutions fostering energy efficiency in buildings are relevant to the operational phase of buildings, while those fostering resource efficiency are relevant to the construction phase of the building. The work of institutions connected with both resource and impact decoupling is also analysed. The section also focuses on the institutional set-up with regard to finance and capacity building, which ultimately supports decoupling in the construction sector.

5.1 ENERGY INSTITUTIONS

The Bureau of Energy Efficiency (BEE) is the premier authority in India in policy matters relating to energy efficiency. The Government of India formed it in 2002 under the Ministry of Power as per the provisions of the 2001 Energy Conservation Act (EC Act). “The mission of BEE is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the EC Act, 2001 with the primary objective of reducing the energy intensity of the Indian economy” (BEE, 2016). Besides BEE, state governments have notified state designated agencies (SDAs) under section 15 (d) of the 2001 EC Act to coordinate, regulate and enforce various provisions of the Act at state level. Most of the states have assigned SDA responsibility to existing relevant departments such as renewable energy, power and distribution etc. (BEE, 2015c). BEE also enables various building professions, such as architects and engineers, to become well versed in applying the Energy Conservation Building Codes (ECBC). These certified experts can then assist and

facilitate projects that are ECBC-compliant. Various capacity building and training activities have been undertaken as part of the ECO III project. The Institute of Solar Technology (IST) delivers training and skills development courses in installation and maintenance of renewable technologies including PV.

MNRE set up the Solar Energy Corporation of India (SECI) in 2011 as a non-profit company. Key objectives of SECI include developing large-scale solar plants, developing, owning and operating both grid-connected and off-grid solar installations, including rooftop systems, and facilitating energy access programmes for rural and remote areas.

In order to promote, develop and extend financial assistance for renewable energy and energy efficiency/conservation projects, the GOI has established the Indian Renewable Energy Development Agency (IREDA). It is a public limited government company established as a non-banking financial institution in 1987 under the administrative control of MNRE.

The national Clean Development Mechanism (CDM) Authority approves CDM projects after evaluating them on the basis of guidelines and general criteria laid down in the relevant rules and modalities pertaining to CDM. The Authority carries out activities to ensure that the project developers have reliable information relating to all aspects of Clean Development Mechanism which include creating databases on organizations designated for carrying out activities like validation of CDM project proposals and monitoring and verification of project activities, and to collect, compile and publish technical and statistical data relating to CDM initiatives in India.

5.2 ENERGY EFFICIENCY CLUSTERS/NETWORKS

With the help of the USAID ECO III project, an alliance of various stakeholders such as manufactures, end users, service providers, utilities, academic and R&D institutes called Alliance for an Energy Efficient Economy (AEEEE) was formed in 2008 on the lines of the American Council for an Energy Efficient Economy (ACEEE) and the Alliance to Save Energy (ASE). Its aim is to save energy by promoting energy efficiency practices and to support energy efficiency policy formulation and analysis. AEEEE India also organizes training and examinations through its Certified Measurement and Verification Professional (CMVP) programme.

A similarly interdisciplinary organisation, the Solar Energy Society of India (SESI), which is the Indian Section of the International Solar Energy Society (ISES), was established in 1976 to promote solar energy in India. It consists of leading energy researchers, academics and manufacturers of renewable energy systems, utility providers and others interested in the field of renewable energy.

USAID projects have been instrumental in promoting the ESCO market in India, which began in 1992. It was followed by the ECO-I project, which was supported by a development programme for energy service companies (ESCOs) through numerous training activities, providing vital tools, including model performance contracts, financial analysis and screening software for projects, model financial feasibility study formats for lender approval, and monitoring and verification protocols. ECO-I also assisted BEE with the development of an energy auditor certification programme. (IRG, 2015). Public

sector undertakings (PSUs) under the Ministry of Power have joined together to form an ESCO venture called Energy Efficiency Services Limited (EESL). Of late, EESL has emerged as an important player in the field of energy efficiency commercialisation, with programmes such as the Domestic Efficient Lighting Programme (DELP). BEE accredits and grades ESCOs operating in India based on the performance of projects undertaken, organisational turnover and strength etc. There are approximately 129 BEE-accredited ESCOs to date.

5.3 ENERGY EFFICIENCY FUNDS

In addition to creating SDAs, Clause 16 (1) of the 2001 EC Act requires state governments/U.T. administrations to set up a fund called the State Energy Conservation Fund (SECF) for the purpose of promoting efficient use of energy and energy conservation within the state. The Government of India for its part has approved expenditure of INR 660 million and INR 500 million during the 11th and 12th plan periods and so far 26 states have set up an SECF and around 16 states have provided a matching contribution to the fund. The financial assistance is intended to strengthen the SDAs' institutional capacities and capabilities through demonstration projects, enforcement, regulation, and human resource development and capacity building activities (BEE, 2015c).

BEE has set up an Energy Efficiency Financing Platform (EEFP) with the objective of improving access to project developers to implement energy efficiency projects in consultation with financial institutions. The bureau signed MoUs with financial institutions such as M/s PTC India Ltd, M/s SIDBI, HSBC Bank, Tata Capital and IFCI Ltd to devise

special instruments for financing energy efficiency in the fields of performance contracting, DSM initiatives, energy efficiency in the commercial sector etc. BEE has also launched a booklet on Success Stories for Energy Efficiency Projects Financed in India and a Training Manual for Energy Efficiency Financing in India, consisting of 50 success stories about energy efficiency projects financed by SIDBI covering 20 industrial sectors across the country, which have adopted energy-efficient technologies and processes.

The National Mission for Enhanced Energy Efficiency (NMEEE) lays emphasis on two key instruments – the Partial Risk Guarantee Fund (PRGF) and the Venture Capital Fund for Energy Efficiency (VCFEE) – to use the ESCO route to promote energy efficiency in manufacturing energy-efficient products in small and medium-size government buildings and municipalities.

5.4 MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS) AND APPLIANCE LABELLING

BEE's standards and labelling (S&L) programme has helped to increase consumer awareness about energy-efficient appliances. The programme enabled savings in installed capacity of over 7500 MW during the 11th Five-Year Plan period. BEE is expected to tighten the standards for refrigerators and air conditioners set by the programme from 2014. As a result of such interventions, a further 30 % reduction in the average energy consumption of refrigerators and air conditioners is expected by 2016–17, as compared to those sold in 2011–12 (Planning Commission, 2013). While the S&L programme is

mandatory for some appliance categories such as domestic air conditioners, refrigerators etc., participation is still voluntary for others such as washing machines, ceiling fans etc. and will be made mandatory in due course (BEE, 2013).

BEE has launched a range of star-rating programmes for various kinds of buildings such as office buildings used in the daytime, office buildings operated day and night, malls and hospitals with the objective of establishing a benchmark for the performance of such buildings and increasing the visibility of best-performing buildings by awarding star ratings. However, at present the rating is voluntary in nature (BEE, 2009).

5.5 INSTITUTIONS FOR BUILDING MATERIALS

The Bureau of Indian Standards (BIS) is the national body responsible for developing technical standards for different building materials. It has formulated a number of standards for sustainable alternatives promoting the use of waste materials in building products without compromising their quality and hence supporting resource decoupling in the construction sector. The IS codes for alternative materials increase their market acceptability and hence scale up their use.

Table 3: IS Codes to promote resource decoupling in India

IS Code	Specifications
IS 12894:2002	Fly ash-lime bricks
IS 13757:1993	Burnt clay fly ash bricks
IS 3812	Fly ash as Pozzolona in cement, cement mortar and concrete
IS 456	Slag, crushed over-burnt bricks and tiles as an alternative to natural aggregates
IS 9142	Lightweight aggregates including manufactured aggregates, such as foamed blast furnace slag, bloated clay aggregates etc.

The National Green Tribunal (NGT), established under the 2010 National Green Tribunal Act, handles cases relating to environmental protection and conservation of forests and other natural resources, including enforcement of any legal rights relating to the environment. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues. NGT has been instrumental in enforcing the ban on illegal quarrying of soil and sand across the country and promoting the use of alternative materials through legal orders (NGT, 2016).

5.6 GREEN RATINGS AND CERTIFICATION SCHEMES

Green building rating systems have emerged as a popular tool to encourage the construction sector to adopt sustainable practices by stimulating market and consumer interest, hence promoting impact and resource decoupling. They measure the environmental performance of a building throughout its life cycle against set criteria. The building's total score is determined as a result of the number of measures adopted and the rating awarded on the basis of the total score. Apart from encouraging water and energy efficiency and waste management, they also put emphasis on the use of sustainable and resource-efficient building materials.

The Green Rating for Integrated Habitat Assessment (GRIHA) is a national rating system for buildings, which was jointly developed by The Energy and Resources Institute (TERI) and the Ministry of New and Renewable Energy (MNRE). GRIHA is a five-star rating system for green commercial, institutional and residential buildings with a built footprint of between 2,500 and 150,000 square metres. A set of 34 criteria, broken down into various sections, has been developed under GRIHA. It also looks at the use of sustainable building materials in construction, in addition to operating energy efficiency, and design and siting parameters. The criteria here are:

Criterion number 19 – utilisation of BIS-recommended waste materials (such as fly ash or blast furnace slag) in building structures:

- minimum 15 % replacement of ordinary Portland cement with fly ash by weight of cement used in structural concrete;
- minimum 40 % by volume fly ash in building blocks/bricks, for 100 % load-bearing and non-load-bearing walls;
- minimum 15 % replacement of ordinary Portland cement with fly ash in plaster/masonry mortar.

Criterion number 20 – reduction in embodied energy of building structures:

- demonstrate reduction in combined embodied energy of load-bearing structure and masonry walls by 10–30 % below the base case.

Small Versatile Affordable Housing GRIHA (SVAGRIHA) is an off-shoot of the GRIHA system and is designed for small standalone buildings such as individual houses, commercial office buildings, motels and dispensaries, with a cumulative built footprint of 2,500 square metres or less. Rating is based on 14 criteria. Points are awarded for use of energy-efficient appliances, renewable energy, generating resources from waste, use of renewable energy on site and reducing the building's embodied energy.

The IGBC Green New Buildings Rating System also encourages the use of sustainable building materials. It promotes retention of at least 50 % (by area) of the structural and non-structural (interior) elements of the existing buildings, use of salvaged materials (5 % or more by cost) and use of recycled materials (20 % or more by cost). Points are also assigned for the use of locally available materials and wood-based materials (IGBC, 2014). The IGBC Green Homes Rating System also rates buildings on the following criteria:

- reuse of salvageable materials;
- use of materials with recyclable content;
- use of local materials;
- use of rapidly renewable building materials & certified wood (IGBC, 2012)

The city of Pune developed an Eco-Housing rating system in 2004. It is now being modified to address the variable requirements of the five distinct climatic zones in the country. This five-star rating system is specifically designed for residential buildings. Similarly to GRIHA, it also focuses on efficient building materials.

The International Finance Corporation (IFC) has developed an Excellence in Design for Greater Efficiencies (EDGE) certification system. It is a software-based system, which provides a business case for a green building by identifying the capital costs and projected operational savings.

5.7 CAPACITY BUILDING AND NETWORKING

The Indian construction sector is plagued by a skills deficit. This lack of technical capacities can be seen at the levels of planning, design and construction. To tackle this issue, the Construction Skill Development Council was set up. The Construction Federation of India (CFI), Builders' Association of India (BAI), National Highways Builders Federation (NHBF) and Confederation of Real Estate Developers Association of India (CREDAI) are promoting it. Its functions include identifying skills development needs and gaps in the sector and devising a skills development plan.

The GRIHA council actively organises an annual summit, national and regional conferences, training sessions and workshops on green building rating schemes, daylighting, shading, passive building design, HVAC optimisation, façade and glazing system optimisation and efficiency etc. Similar subjects are also being covered by continuing professional development courses organized by various institutions and private bodies.

5.8 GAP ANALYSIS

Green building certification in India has not yet been made mandatory except for those buildings for which the Central Public Works Department (CPWD) is responsible. There are a number of certification bodies that give green ratings to buildings based on certain set criteria but there is no third-party audit mechanism to check the effectiveness of these certifications. Although globally accepted certification systems such as GRIHA and LEED focus on materials and energy efficiency, the voluntary nature of these schemes attracts the attention of very few builders. Green building certifications are also popular in large-scale construction projects because of the many subsidies and other benefits associated with them. Developers of small buildings in secondary and tertiary towns are still wary of the idea of green buildings. Lack of awareness among small homeowners in small towns prevents them from opting for green rating certifications. These gaps maintain the level of demand for virgin materials in the market. Indian Standards that focus on resource decoupling are not very popular, apart from IS codes for fly ash use. Adherence to traditional building and construction practices is also a major factor in consumption of virgin materials.

6 THE WAY FORWARD

The Indian economy has grown rapidly in the last few decades, resulting in higher levels of natural resource extraction and consumption. If India continues on the path of its impressive economic development and rapid urban transformation, its demand for resources will triple by 2030. Other factors that contribute to high resource extraction and use include its growing population, rising industrial and service-related production, a burgeoning middle class and the population's increasing income. A transition towards a resource and energy-efficient pathway is therefore critical.

Synergies between different resources must be identified to overcome resource conflicts across different sectors and regions. The traditional methods of construction have been resource and energy-intensive, causing high levels of environmental degradation. Minimising energy consumption in India, which relies heavily on imported coal to fuel its thermal power plants, is necessary for obvious reasons.

However, over the years many resource-synergetic options and approaches have been developed and have the potential to advance decoupling and mitigate the pressure on natural resources. The approaches include resource substitution, multiple uses, and use of secondary raw materials. Energy efficiency and increase of renewable energy in the total energy mix act as primary instruments to advance decoupling in the operational phase of the building. This ensures that growth takes place with a minimum of energy use and resource consumption. Yet there is limited spontaneous adoption of these options and approaches beyond the isolated oasis of good practice.

There is a clear funding gap in buildings and construction R&D and links between innovation and incubation are weak. Strengthening research will bring in newer resource and energy-efficient products and practices in the construction sector. Policies framed for states should be underpinned with financial resources and capacity building mechanisms to ensure their implementation. While the existing policies have made efforts to incorporate resource efficiency, there continues to be a need for stronger policies on enhancing secondary resource use and management across the Government of India's various initiatives and missions. Finally, there are many green building certification schemes in India and all of them are voluntary for larger sections of buildings and building enterprises. These certifications should be made mandatory for all buildings.

BIBLIOGRAPHY

- ASCI & NRDC. (2012). Constructing Change: Accelerating Energy Efficiency in India's Buildings Market. Natural Resources Defense Council; Administrative Staff College of India.
- Auroville Earth Institute. (2016). Research. From Auroville Earth Institute: http://www.earth-auroville.com/poured_earth_research_en.php
- Banerjee, S. (2016, January 28). EIA notification amended to bring small-scale mining under its ambit. Down to Earth. New Delhi, Delhi, India: Down to Earth. Retrieved 6 June 2016 from <http://www.downtoearth.org.in/news/eia-notification-amended-to-bring-small-scale-mining-under-its-ambit-52628>
- BEE. (2015a). Bachat Lamp Yojana (BLY). Retrieved 20 December 2015 from Bureau of Energy Efficiency: <https://beeindia.gov.in/content/bachat-lamp-yojana-bly-0>
- BEE. (2013). Bureau of Energy Efficiency. Retrieved January 2016 from About Standards & Labeling Program: <https://www.beestartlabel.com/>
- BEE. (2009, February). Scheme for BEE star rating for office buildings. Retrieved January 2016 from <https://beeindia.gov.in/sites/default/files/BEE%20Star%20Rating%20for%20existing%20Office%20Buildings.pdf>
- BEE. (2015b). SEEP. Retrieved 20 December 2015 from Bureau of Energy Efficiency: <https://beeindia.gov.in/content/seep-0>
- BEE. (2015c). Self-Contained Detailed Brief Note on SDA scheme. Retrieved 22 December 2015 from Bureau of Energy Efficiency: <https://beeindia.gov.in/content/sdas-0>
- BEE. (2016). BEE: About us. Retrieved 25 June 2016 from <https://beeindia.gov.in/content/about-us>
- BEEP. (2014, 2 September). Design Guidelines For Energy-Efficient Multi-Storey Residential Buildings (Composite and Hot-Dry Climates). Retrieved 16 August 2016 from http://beepindia.org/sites/default/files/resources/Design%20Guideline_Book.pdf
- bigEE.net. (2016). bigEE Countries. Retrieved 2 August 2016 from bigEE.net: <http://www.bigee.net/en/country/in/overview/>
- CAG. (2015). Report of the Comptroller and Auditor General of India on Renewable Energy Sector in India. Ministry of New and Renewable Energy. New Delhi: Ministry of New and Renewable Energy, GOI.
- CASI. (2012). From <https://casi.sas.upenn.edu/iit/rkhosla>
- Census of India. (2011). Census of India. From www.censusindia.gov.in
- Centre for Science and Environment. (2012, 5 July). Grains of Despair: Sand mining in India. New Delhi, New Delhi, India: Centre for Science and Environment. Retrieved August 2016 from Centre for Science and Environment: <http://www.cseindia.org/node/3878>
- Chaturvedi, V., Eom, J., E. Clarke, L., & Shukla, P. (2011, December). From Joint Global Change Research Institute: http://www.globalchange.umd.edu/wp-content/uploads/2011/12/CMM_IndiaBuilding_Chaturvedi.pdf
- Climate Works Foundation. (2010). Reducing GHG Emissions in the Building Sector in India: A Strategy Paper. New Delhi: Climate Works Foundation.
- CSO. (2015). Energy Statistics 2015. Central Statistics Office, Ministry of Statistics and Programme Implementation. New Delhi: Central Statistics Office.
- DA and Wuppertal Institute. (2014). Decoupling Growth From Resource Consumption. Background Paper. 2nd Indo-German Expert Group Meeting on Green and Inclusive Economy.
- DAC, M. o. (2015). Retrieved 2016 from http://nbnm.nic.in/minutes_11th.html
- Development Alternatives. (2015). Resource Efficiency in the Construction Sector. New Delhi: Development Alternatives and GIZ.
- DMG Events. (2015). Construction Market in India. Mumbai: DMG Events.
- Down to Earth. (2016, January 28). News. Retrieved 16 August 2016 from Down to Earth: <http://www.downtoearth.org.in/news/eia-notification-amended-to-bring-small-scale-mining-under-its-ambit-52628>
- DST. (2015, November 06). Fly Ash Mission. Retrieved 3 April 2016 from Department of Science & Technology: <http://dst.gov.in/fly-ash-unit-1>
- ECO III. (2010). ECO III. Retrieved January 2015 from Energy efficiency in buildings – Energy Conservation Building Code [ECBC]: <http://www.eco3.org/ecbc/>
- ECO III. (2010, 23 February). ECObench – Building Energy Benchmarking. From Energy Conservation and Commercialization (ECO): <http://www.eco3.org/ECObench/>
- Equity Master. (2012). Construction Sector Analysis Report.
- Fraunhofer IBP. (2012, October 12). Press releases. Retrieved 21 December 2015 from Fraunhofer IBP: http://www.ibp.fraunhofer.de/en/Press/Press_releases/pm-05-10--energy-efficient-buildings-india.html
- GIZ. (2013). India's Need for Future Resources. Indo-German Environment Programme.
- giz.de. Commercialisation of solar energy in urban and industrial areas. Retrieved 14 February 2016 from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH: <https://www.giz.de/en/worldwide/15776.html>
- Global Construction Perspectives and Oxford Economics. (2013). Global Construction 2025 – A global forecast for the construction industry to 2025. London: Global Construction Perspectives and Oxford Economics.
- Government of India. (2015). UNFCCC. From <http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf>
- IBEF. (2016, January). India Brand Equity Foundation. From <http://www.ibef.org/download/Innovation-and-Patents-January-2016.pdf>
- ICI. (2016). Indian Concrete Institute. Retrieved 25 June 2016 from Indian Concrete Institute: <http://www.theconcreteportal.com/>
- IESS. (2015). India Energy Security Scenarios 2047. Retrieved February 2016 from <http://ieess2047.gov.in/pathways>
- IGBC. (2012). IGBC Green Homes Rating System, Version 2.0. Abridged Reference Guide. Hyderabad.
- IGBC. (2014). IGBC Green New Buildings Rating System, Version 3.0. Abridged Reference Guide. Hyderabad.
- IGBC. (2015). Indian Green Building Council Annual Review 2014–2015. Retrieved on 8 February 2016 at https://igbc.in/igbc/html_pdfs/aboutGBC/IGBC_Annual_Review_2014_2015.pdf
- IRG. (2015). ECO-III Project Compendium – Energy Conservation and Commercialisation. From <http://www.econolerint.com/documents/upload/ECOIII%20Compendium%20NEW.pdf>
- KPMG. (2014). Funding the Vision – Housing for All by 2022. KPMG in India.
- Maithel, S. (2012). Brick Kilns Performance Assessment- Roadmap for Cleaner Brick Production in India. New Delhi: Shakti Sustainable Energy Foundation.
- McKinsey Global Institute. (2010). India's urban awakening: Building inclusive cities, sustaining economic growth. McKinsey Global Institute. McKinsey & Company.
- Ministry of Housing and Urban Poverty Alleviation. (2012). Report of the Technical Group on Urban Housing Shortage (TG 12). Government of India.
- Ministry of Power. (2006, January). Tariff Policy. Extraordinary Gazette of India, I/I.

- Ministry of Steel. (2015). Annual Report 2014-2015. New Delhi: Ministry of Steel.
- MoEF&CC. (2016). Construction and Demolition Waste Management Rules, 2016. New Delhi: MoEF&CC.
- MoEF&CC. (2016, 25 January). Hazardous Substances Management. Retrieved 7 June 2016 from Ministry of Environment, Forest and Climate Change: <http://www.moef.nic.in/sites/default/files/fly%20ash%20amendment%202016.pdf>
- MoEF&CC. (2015). Sustainable Sand Mining Management Guidelines. New Delhi: MoEF&CC.
- MoUD. (2016, 21 Jan). News. Retrieved 16 August 2016 from India Environmental Portal: <http://www.indiaenvironmentportal.org.in/files/file/MODEL%20BUILDING%20BYE%20LAWS-2016.pdf>
- National Housing Bank. (2016). Achievements. Retrieved 2016 from National Housing Bank: <https://nhb.org.in/>
- Negi, M. (2015, 8 August). Soil Groups: 8 Major Soil Groups available in India. From yourarticlelibrary: <http://www.yourarticlelibrary.com/soil/soil-groups-8-major-soil-groups-available-in-india/13902/>
- NGT. (2016). National Green Tribunal. (NGT) Retrieved 11 March 2016 from National Green Tribunal: <http://www.greentribunal.gov.in/>
- NIUA. (2011). India's Urban Demographic Transition – The 2011 Census Results (Provisional). New Delhi: Ministry of Urban Development and National Institute of Urban Affairs (NIUA).
- OECD and IEA. (2015). India Energy Outlook: World Energy Outlook Special Report. International Energy Agency. OECD/IEA.
- PACE-D. (2016). Building Energy Efficiency. Retrieved 14 July 2016 from PACE-D Technical Assistance Program: <http://www.pace-d.com/building-energy-efficiency-3/>
- PIB. (2015, June 17). Revision of cumulative targets under National Solar Mission from 20,000 MW by 2021-22 to 1,00,000 MW – India Surging Ahead in the Field of Green Energy – 100 GW Solar Scale-Up plan. From Press Information Bureau – Government of India Cabinet: <http://pib.nic.in/newsite/PrintRelease.aspx?relid=122566>
- Planning Commission. (2006). Integrated Energy Policy – Report of the Expert Committee. Planning Commission, New Delhi.
- Planning Commission. (2014). The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth. Planning Commission, New Delhi.
- Planning Commission. (2013). Twelfth Five Year Plan (2012-2017)-Faster, More Inclusive and Sustainable Growth, Volume 1. New Delhi: SAGE Publications India Pvt Ltd.
- Planning Commission. (2013). Twelfth Five Year Plan (2012-2017) Economic Sectors Volume II. New Delhi: SAGE Publications India Pvt Ltd.
- Planning Commission. (2013). Twelfth Five Year Plan- Economic Sectors Volume 2. New Delhi: SAGE Publications India Pvt Ltd.
- Praseeda, K., Venkatarama Reddy, B., & Mani, M. (2016, January 01). Embodied and operational energy of urban residential buildings in India. *Energy and Buildings* (110), pp. 211–219.
- Rajya Sabha Secretariat. (2011). Performance of cement industry. New Delhi: Rajya Sabha Secretariat.
- Ramesh et al. (2013). Life Cycle Energy Analysis of a Multifamily Residential House: *Open Journal in Energy Efficiency*, Vol. 2, 34-41.
- Sankhe, S. V. (2010). India's Urban Awakening: Building Inclusive Cities, Sustaining Economic Growth. McKinsey Global Institute.
- SECI. (2016, August 14). Jawaharlal Nehru National Solar Mission (JNNSM). Retrieved 14 August 2016 from Solar Energy Corporation of India: <http://www.seci.gov.in/content/innerinitiative/jnnsnm.php>
- SERI. (2012). Material Flows database. www.materialflows.net
- Shakti Sustainable Energy Foundation & Climate Works Foundation. (2012). Brick Kilns Performance Assessment-A Roadmap for Cleaner Brick Production in India. New Delhi: Shakti Sustainable Energy Foundation & Climate Works Foundation.
- Solar Guidelines.in SOLAR GUIDELINES. Retrieved 12 January 2015 from SOLAR GUIDELINES: <http://www.solarguidelines.in/>
- Sustainability Outlook. (2015). Sustainable Materials in the Construction Industry. New Delhi: Sustainability Outlook.
- TERI. (2015). Science, Technology and Innovation for Low Carbon Development in India. Retrieved February 8, 2016 from http://www.teriin.org/projects/loci/pdf/res/Discussion_Paper_LCD_STI.pdf
- Thakkar, V. (2008). Life Cycle Assessment of some Indian steel industry with specific reference to the climate change. *Journal of Environmental Research And Development*, 2 (April-June 2008), 774.
- The Freedonia Group. (2013). World Construction Aggregates.
- Thomas, B., & Patil, V. (2013). Energy Saving Approach for Buildings. *International Journal of Engineering and Innovative Technology (IJEIT)*, 2 (11), 185-191.
- undp.org. (2016). Energy Efficiency Improvements in Commercial Buildings. Retrieved 28 November 2015 from United Nations Development Programme in India: http://www.in.undp.org/content/india/en/home/operations/projects/environment_and_energy/energy_efficiencyimprovementsincommercialbuildings.html
- UNEP. (2011). Decoupling Natural Resource Use and Environmental Impacts from Economic Growth – A Report of the Working Group on Decoupling to the International Resource Panel. UNEP.

RESEARCH TEAM

THE SOCIETY FOR TECHNOLOGY AND ACTION FOR RURAL ADVANCEMENT (TARA)

Vaibhav Rathi
Rohan Jain
Pratibha Ruth Caleb
Zeenat Niazi

CONTACT DETAILS

Development Alternatives
B-32, Tara Crescent,
Qutub Institutional Area
New Delhi – 110 016, India
T +91 (11) 2656 4444, 2654 4100,
F +91 (11) 2685 1158

info@devalt.org
<http://www.devalt.org>



ABOUT DEVELOPMENT ALTERNATIVES GROUP

Development Alternatives (DA), the world's first social enterprise dedicated to sustainable development, is a research and action organisation striving to deliver socially equitable, environmentally sound and economically scalable development outcomes. Established in 1982 and headquartered in New Delhi, the DA Group pioneered the concept of business-like approaches to eradicating poverty and conserving the natural resource base on which human development depends. The Society for Technology & Action for Rural Advancement (TARA) is a social enterprise set up in the year 1985 at New Delhi, India. It is an "incubation engine" of the Development Alternatives Group which has been providing development solutions in India and elsewhere.

WUPPERTAL INSTITUTE

Sriraj Gokarakonda
Dr Shritu Shrestha
Kilian Topp
Dr Stefan Thomas

CONTACT DETAILS

Wuppertal Institute for Climate,
Environment and Energy
Döppersberg 19
42103 Wuppertal, Germany
T +49 202 2492-0
F +49 202 2492-108

info@wupperinst.org
<http://www.wupperinst.org>



ABOUT WUPPERTAL INSTITUTE

The Wuppertal Institute undertakes research and develops models, strategies and instruments for transitions to sustainable development at local, national and international level. Sustainability research at the Wuppertal Institute focuses on the challenges connected with resources, climate and energy and their relation to economy and society. Special emphasis is put on analysing and stimulating innovations that decouple economic growth and wealth from natural resource use.

