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Clean Energy Cooperation with India (CECI): Legal and policy support to the development and implementation of energy efficiency legislation for the building sector in India (ACE: E²)

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Role of research, development and demonstration (RD&D) programmes

EU EXPERIENCE ON EPBD - POSITION PAPER No 7



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FOREWORD

This position paper has been developed by the project “Clean Energy Cooperation with India (CECI): Legal and policy support to the development and implementation of energy efficiency legislation for the building sector in India (“ACE:E²”¹)”.

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The contents of this paper are, however, the sole responsibility of the contractor and can in no way be taken to reflect the views of any particular individual or institution, including the European Union, the Delegation of the European Union to India, and the Bureau of Energy Efficiency (BEE) in India.

¹ ACE: E² – Adoption, Compliance, Enforcement – Energy Efficiency

ABBREVIATIONS

ACE: E2	Acronym of the project (Adoption, Compliance, Enforcement – Energy Efficiency)
BIM	Building Information Modelling
BEE	Bureau of Energy Efficiency
BPIE	Building Performance Institute Europe
CECI	Clean Energy Cooperation with India
CEN	European Standards Body
EED	Energy Efficiency Directive
EUD	European Union to India
EPC	Energy Performance Certificate
IEE	Intelligent Energy for Europe
ICT	Information and Communication Technology
NZEB	Nearly Zero Energy Buildings

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SUMMARY

Support for RD&D has been a core feature of EU policy since the 1970s, and within its ‘framework’ programmes for research, sustainable energy – comprising energy efficiency and renewable energy - has been a significant priority theme. Over the past 10 years of these programmes, funding for energy efficiency and renewable energy has almost tripled, and has included close linkages to research activities supporting energy and environmental policies and to developments in information and communication technologies (ICTs).

In the context of informing and assisting implementation of the EPBD across EU Member States, RD&D activity is an important contributor to capacity building. A number of different types of research and associated activities have been supported, including the following:

- ▶ ‘Public good’ research (without direct commercial benefit) providing insights and intelligence on the characteristics of the building stock. This is often delivered by ‘think tank’ institutes.
- ▶ ‘Public good’ research aimed at exploring policy options tackling barriers, risk issues (e.g. healthy ventilation) and other needs in relation to the delivery of compliant low energy buildings, including developments in software and other tools, regional networks of complementary partners, initiatives in skills development and initiatives with financial instruments.
- ▶ ‘Public good’ research initiatives such as funding of post-doctoral fellowships and mobility within and outside the EU, aimed at strengthening EU research capacity (looking to more long-term benefits).
- ▶ ‘Shared cost’ research and development (R&D) into new product and service ideas (often incorporating ICT features) aimed at achieving lower energy, lower carbon buildings. This can extend from developments by SME companies or campus companies up to major integrated projects with multiple partners across several EU Member States (and beyond).
- ▶ ‘Shared cost’ demonstration projects highlighting the features, practicalities and benefits of low energy buildings deploying relatively mature design, technology and management solutions, providing visible evidence and building confidence among the developer community.
- ▶ ‘Public good’ support for national authorities in shared learning and development of pathways to administratively and economically effective ways of implementing the practical requirements of the EPBD – notably through the EPBD ‘Concerted Action’.

In general, ‘shared cost’ RD&D relates to EU or Member State funding programmes which invite applications for support through competitive ‘calls for proposals’. This may also be the case with ‘public good’ research for policy purposes, but such studies (e.g. on cost optimal methodologies) may be directly commissioned through a competitive tendering process by EU or Member State authorities.

From the list above, RD&D thus extends beyond the traditional boundaries of R&D aimed

at product development. Key drivers for these activities in Europe have been the EPBD and related policies with regard to mandatory ‘nearly zero energy buildings’ (NZEB) within building energy codes and the priority of mobilising and accelerating investment in energy efficient renovation of the existing building stock.

All EU Member States also have RD&D programmes aimed at stimulating the development of new and improved solutions in the built environment. Hence, this can be complementary to EU programmes and it is possible for R&D projects to be co-funded by both national and EU funds (subject to ‘State Aids’ limits under EU competition law).

Consistent with its encouragement of more integrated and collaborative initiatives between industry players across Europe in the interests of strengthening competitiveness, the EU encourages the activities of industry associated and their pan-European research networks. A notable example of such a network for the construction sector is the E2B network.

Overall, RD&D activities to drive continuous improvements in the policies, technologies, tools, skills and systems for achieving energy efficient buildings are thus an important ingredient in the EU mission to transform its construction market towards a low energy, low carbon society.

Several of the initiatives of the kind outlined and referenced by hyperlink within this report may be applicable to India’s circumstances in helping to drive innovation, capacity building and market stimulation towards full and widespread implementation of its Energy Conservation Building Code (ECBC).

1 SCOPE

An important contribution to decisions on particular EPBD implementation options, and to capacity and confidence building in almost all EU countries, has been through the funding and delivery of R&D and demonstration (RD&D) projects. These have covered the following types of products and services:

- ▶ Building materials – such as insulation, concrete products, brick products, windows, doors, vapour barriers, air tightness barriers, jointing details to avoid cold bridging (e.g. at window sills and lintels).
- ▶ Equipment – boilers, pumps, heat emitters, fans, heating controls (sensors, valves, actuators), air conditioning units, cogeneration systems, lighting products (lamps, luminaires, controls), heat pumps, solar thermal systems, solar photovoltaic systems, heat meters, smart meters, Building energy management systems (BEMS).
- ▶ Services – design and certification advisory services, software providers, ‘one stop shop’ energy efficiency renovation packages, ESCOs and energy performance contracting (EPC).

Table 1-1 shows a range of other RD&D activities which include research at informing the details of policy implementation decisions and mechanisms, and at helping to building the capacity of market players (specifiers, builders, developers, tradespersons) to comply with more ambitious building energy codes.

The present paper provides a brief overview of each of the types of RD&D activity which has contributed to the implementation of the building energy code and associated building energy certification/ labelling (EPC) provisions of the EPBD in EU Member States.

Table 1-1 Overview of grades of RD&D according to funding source and type of output

Funding or co-funding source	Individual companies	Collective – industry associations or networks	Member State authorities	EU Commission	Comment
Early phase basic research	✓	✓	✓	✓	Normally led at company level
Product or service R&D	✓	✓	✓	✓	Normally led at company level
Demonstration projects	✓	✓	✓	✓	
Compliance tools	✓	✓	✓	✓	Mainly at State and EU levels
Skills development, business models, financial instruments, other policies	✓	✓	✓	✓	
Policy studies, databases, resources		✓	✓	✓	Mainly at State and EU levels

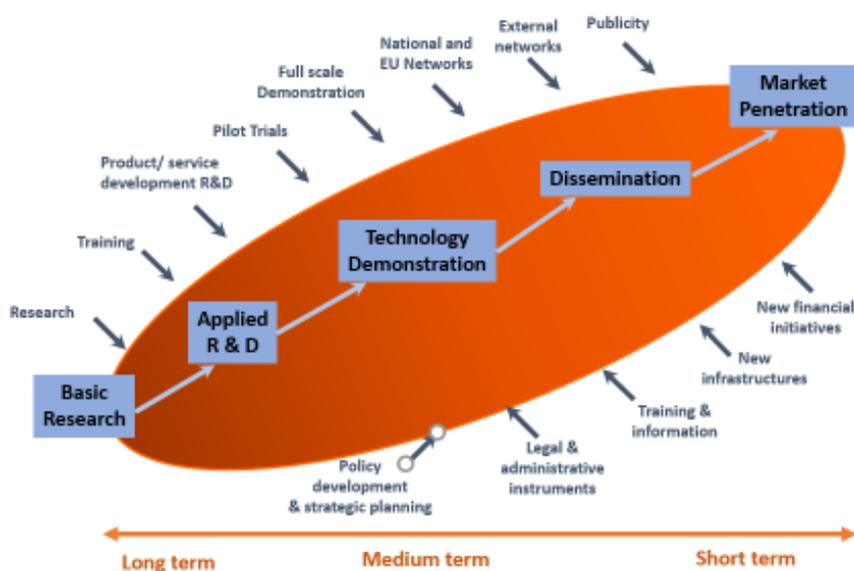
2 FROM IDEA TO MARKET: THE RD&D PROCESS

2.1 The journey to market

Figure 2-1 illustrates the journey of a product or service from the conceptual idea stage through the research, development and demonstration (RD&D) process, converting into a commercial market opportunity and ultimately gaining a worthwhile level of market penetration. The lateral arrows are examples of support actions at national or EU level which have been applied in order to accelerate that journey.

Figure 2-1 Notional pathway from idea through RD&D to market commercialisation

Bringing New Energy Technologies to Market: Process & Supports



The early stage research activities are also termed ‘long term’ insofar as it may require several years before the basic or early applied research will translate into a commercially feasible product offering. Moving out of research mode and into demonstration, dissemination and business model development activities would be in the ‘medium term’ or ‘short term’ categories insofar as they are close to full development and commercialisation.

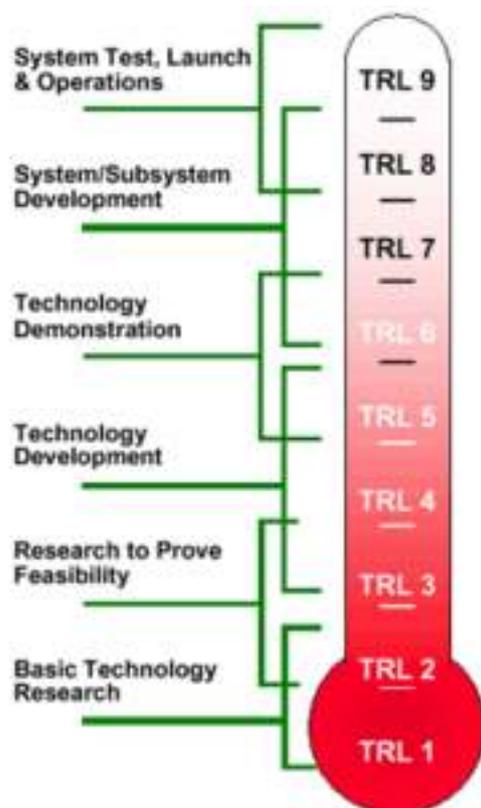
2.2 ‘Technology Readiness Levels’ (TRL)

Reflecting the stage of development maturity of a technological idea along the path shown in Figure 2-2 is the ‘Technology Readiness Level’ (TRL) scale. This scale was originally defined by NASA in the USA in the 1990’s as a means for measuring or indicating the maturity of a given technology. It is now used in EU RD&D support programmes to denote to highlight the EU Commission’s judgement on the state of progress of a technology and

the next steps in the development process for prioritisation. The TRL spans over nine levels as follows:

- TRL 1 – Basic principles observed
- TRL 2 – Technology concept formulated
- TRL 3 – Experimental proof of concept
- TRL 4 – Technology validated in lab
- TRL 5 – Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – System prototype demonstration in operational environment
- TRL 8 – System complete and qualified
- TRL 9 – Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Figure 2-2 NASA ‘Technology Readiness Levels’



Typically, many products go through the various stages of the TRL scale in their life cycle. It is possible that iterations will be needed between various TRL levels, especially during the development phase, although not limited to that.

The current EU RD&D framework programme, Horizon 2020, has selected the TRL scale as an indicator to better position the requested projects in each of its annual work programmes and associated ‘Calls for Proposals’. The TRL, as a unified scale, enables applicants and reviewers to align with the expectations of the EU Commission in this context. For example: a higher TRL in the call text clearly means that the EC is looking for a more applicative solution in the scope of the project. Alternatively, a lower TRL in the call text indicates an expectation for a more basic research project, and so on.

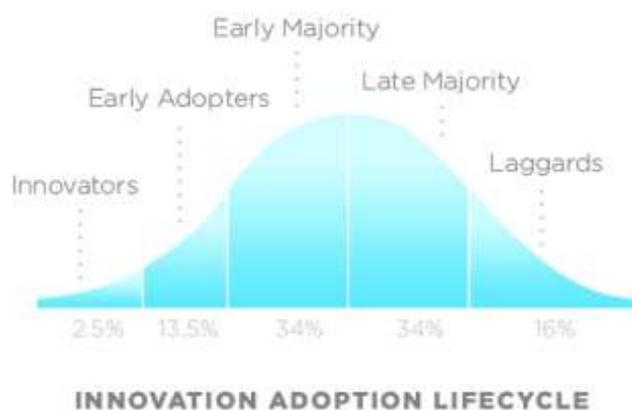
Another use of the TRL is an indication of the ‘entry point’. This refers to the maturity level of the given technology/product/process at the *beginning* of the project. In this case, a given TRL serves as a ‘lower boundary’. For example, if the entry point is set at TRL 6 (System/ subsystem model or prototype demonstration in a relevant environment), this means that R&D-intensive projects, typical of products positioned in lower TRL levels, are

not being sought. In such as case, it is more appropriate for mature projects with higher probability of getting to the market.

2.3 Technology and Market Diffusion

At the dissemination and market penetration end of the pathway in Figure 2-1, a classic diffusion profile commonly used to characterise the evolving state of adoption of a particular technology, product or other market offering is shown in Figure 2-3. Those segments to the left-hand side of the diagram relate to those users who first adopt the new offering, called ‘innovators’, followed by early adopters. As the offering becomes more visible and ‘normal’ in a market, assisted by promotional activities by policy and commercial interests, the progress moves into capturing the majority segments of the market. A process along these lines might be expected to apply in India in relation to the uptake and market penetration of the ECBC standard of energy performance.

Figure 2-3 Standard market diffusion profile



Many RD&D programmes cover a portfolio of project types operating at different TRL levels. Typical common objectives of the energy and built environment aspects of such programmes are threefold:

- Accelerate the development and uptake of workable, least-cost policy and market solutions leading to impact within the relatively short term;
- Support the generation of a pipeline of new and improved energy technologies and practices with the potential to impact in the medium and long term;
- In the process of delivering the above projects, support the acquisition and development of an enduring capacity in the building energy research community.

3 RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D) PROGRAMMES AND PROJECTS

An important contribution to technological innovation, to decisions on particular EPBD implementation options, and to capacity and confidence building in almost all EU countries, has been through the funding and delivery of R&D, demonstration and market support projects through competitive funding programmes. More details on the categories and forms of RD&D projects and their supports are given in Section 4.

3.1 EU Member State programmes

Following EPBD publication, and sometimes prior to it, RD&D funding programmes at EU level and within a number of Member States had already established grant subsidy schemes for a range of project types. These included design studies, research studies, product/ technology development support, tools and skills development, market analysis and model demonstration projects aimed at identifying the practical and cost issues, and the feasibility, in achieving energy performance standards superior to current norms. Examples of a range of demonstration projects are shown in Figure 3-1, more details of which can be found at https://www.epbd-ca.eu/wp-content/uploads/2011/05/CT5_Report_Selected_examples_of_NZEBs-final.pdf.

Figure 3-1 Energy efficiency demonstration buildings



Most EU countries commissioned their own studies to inform the judgements of the authorities regarding the form, content, tools, systems and performance targets appropriate to different types of buildings. Likewise, national and regional pilot trials have demonstrated the practical design, construction, installation and operation steps involved in delivering to the proposed new energy performance standards.

Similarly, pilot training and field trials on the process of energy performance certification were used to identify and point to solutions on various issues, difficulties and indicative

costs. Overall, these activities contributed to an evidence base for more ambitious performance levels, helping to build capacity and confidence among both market professionals (mainly architects, building services engineers and modellers) and policy makers in regard to setting sufficiently (but not excessively) ambitious energy performance levels – while consistently bearing in mind the obligatory roadmap to NZEB standards.

3.2 Pan-European programmes

EU RD&D programmes supporting the advancement of energy efficiency and renewable energy have been running for over 35 years. The dominant programmes have been the ‘Framework Programmes for Research and Technological Development (RTD)’ which have operated on a four to six-year cycle. In its current form, it covers the full spectrum of activities illustrated in Figure 2-1 above. The current programme is called ‘Horizon 2020’, spanning the period 2014-2020 (<https://ec.europa.eu/programmes/horizon2020/en>). Its overall budget for all research sectors is around €70 billion, of which non-nuclear energy directly accounts for almost €6 billion. Its thematic priorities are Energy Efficiency, Low Carbon Technologies and Smart Cities and Communities. All these themes, but particularly the latter, involve working towards the practical deployment of advances in ICT (which is itself a further priority sector within the overall Horizon 2020 programme).

Within these successive EU programmes, sustainable energy technologies and their application have become ever more prominent as a component of overall RD&D policy. Demonstrating the growth of energy as a priority, by comparison the preceding Framework programme provision for the period 2007-2013 was €50 billion, of which less than €3 billion was assigned to energy efficiency and renewable energy projects (and the previous Framework programmes to that had an average budget of less than €25 billion). Moreover, the programme has become increasingly integrated, covering the full process from concept to commercialisation.

Most of the funding is spent on grants to research actors all over Europe and beyond, in order to co-finance research, technological development and demonstration projects. Grants have been determined on the basis of ‘calls for proposals’ and a peer review process, which are highly competitive. Leading manufacturers of construction products and equipment have participated and collaborated through these programmes for the purposes of developing more energy efficient products and service solutions. This contributes to the capacity of the market to innovate and respond actively to meet or surpass the requirements of the EPBD and other policies. Details on projects supported under the successive Framework RD&D programmes can be found on the database at <https://cordis.europa.eu/projects/en>.

In addition to operating a competitive RD&D programme, up until 2013 the EU Commission operated a support programme entitled ‘Intelligent Energy for Europe’ (IEE) to tackle barriers and assist market deployment of energy efficiency and renewable energy technologies, i.e. at the ‘short term’ or near market end of the spectrum shown in Figure

2-1. Supported projects were in the fields of improving technologies, tools, skills development, market analysis, databases, market awareness initiatives and financial initiatives, and generated useful insights, findings and case examples. Details on projects supported under this programme can be found on the projects database at <https://ec.europa.eu/energy/intelligent/projects/en> . A selection of projects supported by IEE in the field of low energy buildings is given in Table 3-1.

Table 3-1 Examples of low energy buildings research projects supported by EU

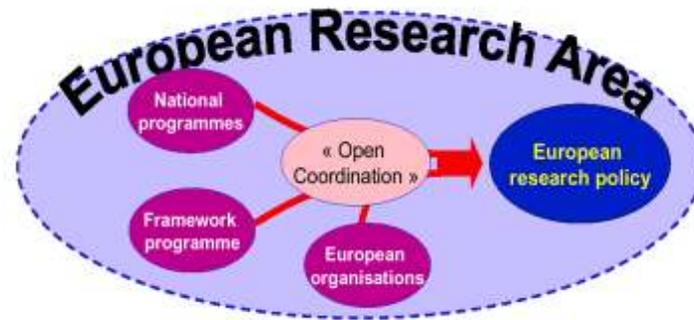
AIDA:	Support to NZEBs in municipalities
ENTRANZE:	Policy support to EPBD
MaTriD:	Integrated Energy Design for NZEBs
mountIEE:	Support to NZEBs in mountain communities
NZB2021:	Open door campaigns
PassREG:	NZEBs in regional policy
POWER HOUSE NZC:	Support to NZEBs in social housing
Sustainco:	Support to NZEBs in rural communities
COHERENO:	One stop solutions
EuroPHit:	Passive House standards
EPISCOPE:	Market development
LEAF:	NZEB renovation in multi-ownership buildings
NEZEH:	NZEB refurbishment in hotels
ZEMEDS:	NZEB refurbishment in schools
RenoValue:	Strengthening the role of valuation professionals in market transition

The ‘Framework’ RD&D and IEE programmes were merged in 2014 as part of the ‘Horizon 2020’ programme and continue to support work in all of these fields, capturing the full range of support measures shown in Figure 2-1.

The EU Commission funded the development and ongoing enhancement of a wide ranging website called ‘BuildUp’ (www.buildup.eu), covering all aspects of energy efficiency in buildings from policy level (e.g. national reports on EPBD implementation) to practical case studies on various technology and market issues.

A significant initiative supported under these programmes has been the ‘EPBD Concerted Action’, described in Position Papers 1 and 2, which has been an important collaborative shared learning platform for Member State authorities in addressing many of the challenges in implementing the EPBD – including the technical methodologies, NZEB standards, training, quality assurance and incentives. An example of a useful report on progress towards NZEB across Europe can be found at <https://epbd-ca.eu/ca-outcomes/outcomes-2015-2018/book-2018/ct/new-buildings-nzebs>.

An important and growing aspect of EU research policy is the creation of structures for enduring collaboration across a variety of parties in different Member States (Figure 3-2).

Figure 3-2 Concept of European Research Area

Consistent with the European Research Area concept is the intention of building durable partnerships and networks of excellence with inter-disciplinary engagement to a world class level of competence. Such inter-disciplinary partnerships would draw upon and integrate research capabilities from EU, national, regional and private levels. They can also include training and dissemination activities.

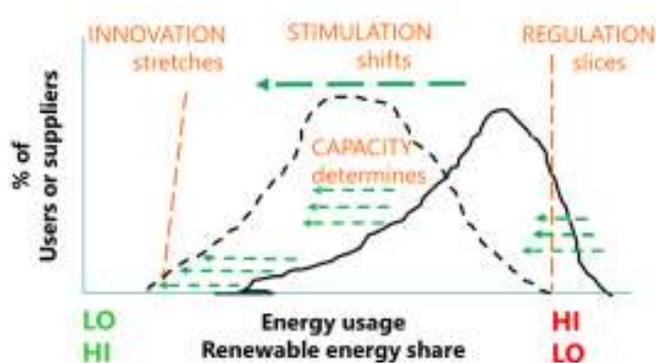
EU RD&D programmes have also been placing increasing emphasis on projects and networks of scale. Typically, these projects involve a balanced set of diverse partners from at least three EU Member States, incorporating an integrated set of energy technologies, possibly spanning the spectrum of research, development, demonstration and training, acting as models of influence and aimed at achieving impact on a large scale.

4 RD&D CATEGORIES, FORMS AND PARTICIPATION

4.1 Categories of RD&D

As traditionally understood, RD&D might be perceived to focus solely on the **Innovation** end of the performance spectrum shown in Figure 4-1. This would be true of traditional product development. However, in reality, a wider spectrum of RD&D activities of various kind has contributed to informing public policy and to helping to build **Capacity** (tools, skills, technical and administrative systems), to provide evidence to inform the implementation of the EPBD in respect of strengthened building energy codes and **Regulations**, and likewise informing market **Stimulation** actions such as energy performance certification systems and promotional programmes.

Figure 4-1 The four drivers of market transformation towards energy efficient buildings



In the context of informing and assisting implementation of the EPBD across EU Member States, a number of different types of research and associated activities have been supported, including the following:

- ‘Public good’ research (without direct commercial benefit) providing insights and intelligence on the characteristics of the building stock. This is often delivered by ‘think tank’ institutes.
- ‘Public good’ research aimed at exploring policy options tackling barriers, risk issues (e.g. healthy ventilation) and other needs in relation to the delivery of compliant low energy buildings, including developments in software and other tools, regional networks of complementary partners, initiatives in skills development and initiatives with financial instruments. Such research also include pilot trials of voluntary energy performance certification or labelling schemes, covering both technical and behavioural issues.
- ‘Public good’ research initiatives such as funding of post-doctoral fellowships within and outside the EU, aimed at strengthening EU research capacity (looking to more long term benefits).
- ‘Shared cost’ research and development (R&D) into new product and service ideas (often incorporating ICT features) aimed at achieving lower energy, lower carbon buildings. This can extend from developments by SME companies or campus

companies up to major integrated projects with multiple partners across several EU Member States (and beyond).

- ▶ ‘Shared cost’ demonstration projects highlighting the features, practicalities and benefits of low energy buildings deploying relatively mature design, technology and management solutions, providing visible evidence and building confidence among the developer community.
- ▶ ‘Public good’ support for national authorities in shared learning and development of pathways to administratively and economically effective ways of implementing the practical requirements of the EPBD – notably through the EPBD ‘Concerted Action’.

Here ‘public good’ refers to research projects, usually involving public authorities and independent bodies, generating information and resources which are openly available or applied in the public domain. Such projects may be funded up to 100% of costs. Examples could include reports, databases, software methodologies, impact assessments and shared learning forums of Member State authorities. ‘Shared cost’ refers to projects from which the findings may be the intellectual property of the participating commercial interests, and/or where co-funding by different funding sources (e.g. EU programmes, national programmes, regional programmes, company’s own funds).

In general, ‘shared cost’ RD&D relates to EU or Member State funding programmes which invite applications for support through competitive ‘calls for proposals’. This may also be the case with ‘public good’ research for policy purposes, but such studies (e.g. on cost optimal methodologies) may be directly commissioned through a competitive tendering process by EU or Member State authorities.

It will be seen from the above list that RD&D extends beyond the traditional boundaries of R&D aimed at product development.

4.2 Drivers and priorities of RD&D

At both Member State and EU level, key drivers and priorities for upscaled RD&D activities in Europe have been five-fold:

1. Firstly, the EPBD itself, insofar as Member State authorities have needed information, insights and tools to enable them to adopt efficient and effective approaches to ensuring implementation of the Directive.
2. Secondly, also the EPBD itself, particularly with regard to the target requirement for mandatory ‘nearly zero energy buildings’ (NZEB) within building energy codes and the priority of mobilising and accelerating investment in energy efficient renovation of the existing building stock. These two EPBD requirements represent a technical and cost challenge to building specifiers, builders, developers and financiers, and a corresponding opportunity for product and service developers and suppliers to create new, high performance and more cost-effective solutions.

3. Thirdly, by extension of the EPBD to include accompanying EU Directives on EcoDesign and Energy Labelling, the outcomes of RD&D activity in relation to improved building products and energy using equipment help to stimulate manufacturers to create products to higher performance standards.
4. Fourthly, the generic driver of gaining and maintaining competitiveness for EU industry and services sectors, based on showing leadership and innovation in the ‘clean’ energy and environmental arena. Energy efficiency technologies and practices are seen as one of the most promising areas of enterprise and jobs opportunity. Maintaining a pipeline of superior energy related products and systems is seen as a strategically important element of ‘greentech’ innovation.
5. Related to the fourth driver, the specific opportunity afforded by the integration of advances in both sustainable energy (energy efficiency plus renewable energy) technologies and methods with fast moving advances in information and communications technologies is seen as an arena of enormous potential, and hence a very fertile field of current research by ICT global leaders in partnership with traditional construction industry players and local authorities. This has led in most Member States an overarching concept across Europe of ‘smart cities’, extending beyond energy supply and use in buildings (with possibilities for buildings which are ‘energy positive’ on average over the year) to water, waste, public lighting, transport and real time citizen information, engagement and empowerment. In turn, this is linked in particular to the concept of the smart electricity grid (possibly with dynamic tariffs) which has new flexibility features that enable the benefits of variable renewable energy generation from sources such as wind and solar photovoltaics to be maximised.

Underpinning these direct drivers have been the three fundamental policy pillars of improving security of energy supply, reducing greenhouse gas emissions and improving economic competitiveness – all of which are advanced by developments in energy efficiency and renewable energy deployment.

4.3 Participants in RD&D

The above categories of RD&D programmes and activities at both EU level and Member State level are open to participation from a wide range of business and institutional partners, including:

- › Large industrial manufacturers
- › SMEs with specialist products, services, skills (indeed, many programmes in Member States and at central EU level place special emphasis on SME participation)
- › Energy supply companies
- › Energy services and facilities management companies
- › Builders and developers
- › Architectural, planning and engineering professionals providing energy efficient planning, design and management services

- › Regional/ local and national energy agencies
- › Research institutes (e.g. Building Performance Institute Europe ‘think tank’, BPIE (www.bpie.eu) and policy research companies)
- › Academic institutions
- › Construction research organisations
- › Local authorities
- › National authorities including Ministries, specifically in relation to EPBD Concerted Action activities.

Many individual RD&D projects have involved networks and alliances of suppliers, combining materials, equipment and services specialists in delivering innovative solutions for full buildings or key components, thus engaging complementary skills and capacities.

4.4 Research networks

4.4.1 E2B network

The E2BA (Energy Efficient Buildings Association) was established in 2008 (<http://www.e2b-clusters.eu/index.php/partners/eeb/> and <http://e2b.ectp.org/>). Its overall objective is to deliver, implement and optimise building and districts concepts that have the technical, economic and societal potential to drastically reduce energy consumption and CO₂ emissions due to existing and new buildings on an EU scale. The network aims to speed up research on key technologies, thus helping to develop a competitive industry with new business opportunities in the fields of energy efficient construction processes, products and services. By such activities, it also aims to address climate change issues and contribute to improved EU energy independence, in conjunction with reaching the radical energy goals set for 2020 and 2050.

E2BA has around 130 members across Europe, including SMEs and large companies, Research Centres, Universities, regional agencies and end users. It covers the full supply and value chain of energy efficient buildings and districts. It has entered into an ‘Energy Efficient Buildings’ (EeB) contractual Public Private Partnership (cPPP) with the EU Commission, for which it provides a useful consultative voice on specific RD&D priorities. Arising from this, a financial envelope from the EU H2020 programme is allocated over the period 2014-2020, while the participating construction sector and related industry has committed to continuing investing in Research, Demonstration and Innovation (RDI) activities, and to leverage investments in this field by a factor of 4.

The EeB PPP project review for 2019 presents the progress of a portfolio of 174 European research projects aiming at developing new technologies for energy efficient buildings. It highlights current results and achieved or expected benefits of the projects. The overall target is to develop breakthrough affordable technical and business driven solutions at building and district scale. The projects demonstrate scientific and technological excellence, across the whole value chain, from early stage conception to demonstration of

almost ready-to-market innovations. The review can be downloaded from http://e2b.ectp.org/fileadmin/user_upload/documents/E2B/o_EeB_PPP_Project_Reviews_Roadmaps/EeB_PPP_Project_Review_2019.pdf.

Categorised into 7 technology-clusters defined according to the construction-related research & innovation value chain from the EeB PPP Roadmap (Design, Technology Building Blocks, Advanced materials and nanotechnology, Construction process, Energy performance monitoring & management, ICT and BIM), the 174 research projects illustrate the diverse innovation approaches and the importance of embracing all aspects of the building and construction sectors. Notably, 6 new H2020 projects in the BIM cluster spotlight the growing tendency toward digitalization of the built environment.

Since its creation, E2BA has interacted strongly with its members, partnership projects and other stakeholders. For example, it has worked in close cooperation with relevant European Technology Platforms from other sectors and applied a clustering approach. Also, E2BA has been active in an annual workshop series by the EU Commission to analyse project impacts through a clustering approach. An illustration of its different thematic activities is given in Figure 4-2.

Figure 4-2 Thematic activities of E2BA network for construction industry energy research



4.4.2 Other networks

Brought forward from Position Paper 6, Table 4-1 lists a wide range of industry associations and a selection of their member companies, illustrating the strength of activity of this sector across the EU. This covers insulation materials and methods, glazing, HVAC systems, lighting, cogeneration, renewable energy systems, building controls and automation and energy services companies (ESCOs).

Many of these networking associations have a role in providing technical support services to their members. This extends to encouraging their members to participate in EU and

Member State RD&D programmes, and may in some cases include direct participation by the industry association, for example in the area of skills development.

A further common characteristic of these associations is their role as the voice of the industry, advocating public policy, at EU and Member State level, which favours more ambitious uptake of more energy efficient products in the building sector, including appropriate renewable energy deployment. A common element of this role is monitoring of policy developments and issuing of position papers in support of the outcomes being advocated.

In conjunction with the above direct industry interests, professional bodies such as the Architects Council of Europe, the professional engineering bodies ASHRAE and CIBSE, and the Royal Institution of Chartered Surveyors (RICS), and facilities management organisations and associations, play an active developmental role in providing direct educational and upskilling services to their members. Bodies such as REHVA, CIBSE and ASHRAE engage in research and standards development work in relation to energy performance calculation and other methodologies and software tools. Such representative bodies and networks also have a consultative voice at EU level in advocating practical policy actions to improve energy performance.

Table 4-1 EU industry associations working towards low energy, low carbon buildings

Association	Activities	Examples of members
EURIMA www.eurima.org	European mineral wool insulation manufacturers association	Knauf, Isover, Paroc, Rockwool, Ursa, etc.
Euro ACE https://euroace.org	European Alliance of Companies for Energy Efficiency in Buildings	Armacell, Daikin, Danfoss, Grundfos, Ingersoll Rand, Johnson Controls, Kingspan, Knauf, Rockwool, Saint Gobain, Signify, United Tehnologies, Ursa, Velux
Glass for Europe https://glassforeurope.com	Represents the building glass value chain across Europe	AGC Glass Europe, Guardian, NSG-Group, Saint-Gobain Glass, Şişecam-Trakya Cam
REHVA www.rehva.eu	Federation of European Heating, Ventilation and Air Conditioning associations	27 national associations, 1500 industrial companies, 120000 engineers and technicians
Eurovent https://eurovent.eu	Industry Association for Indoor Climate (HVAC), Process Cooling and Food Cold Chain Technologies	Over 1.000 manufacturers from over 30 countries, employing around 150.000
EAE www.ea-etics.eu	European Association for External Thermal Insulation Composite Systems (ETICS). Umbrella body of 11 national ETICS associations and 6 EU supplier associations (insulation materials, reinforcements, profiles).	25 members from manufacturers and representative associations
COGEN Europe www.cogeneurope.eu	European Association for the Promotion of Cogeneration	60 members

Association	Activities	Examples of members
Lighting Europe	Represents the lighting industry in Europe.	Over 1000 lighting companies employing over 100,000
EREF www.eref-europe.org	Federation of national renewable energy associations from EU Member States	34 member associations representing wind, solar, small hydro, bio-energy, tidal, wave, and geothermal sectors
EHPA www.ehpa.org	European Heat Pump Association.	120 organisations - heat pump and component manufacturers, research institutes, universities, testing labs and energy agencies
Solar Heat Europe www.solarheateurope.eu	Representative body of European solar heating industry	50 members
Solar Power Europe www.solarpowereurope.org	Voice of European solar power industry	Over 200 members from 35 countries
European Building Automation and Controls Association https://eubac.org Associated with European Association of Energy Services Companies https://euesco.org	Represents major European manufacturers of products and systems for building automation. Founded the European Association of Energy Services Companies for promoting Energy Performance Contracting as an economically sustainable solution.	Aramark, Belimo, Broen, Comap, Danfoss, Delta Dore, Distech, Frese, GFR, Honeywell, Herz, Hager Group, IMI, Johnson Controls, Kiebach & Peter, Loytec, Oventrop, Priva, Sauter, SBC, Shneider, Siemens, Sonder, Theben, Thermo, Trend, Tridium, Wago

A further example is the global network of 70 Green Building Councils (www.worldgbc.org), whose membership at national level often includes a strong representation from leading construction product manufacturers, builders and developers. Within Europe there are 23 national Green Building Councils, covering over 4,500 companies.

4.5 Product research and development

A natural priority for industry participants in RD&D activities, whether self-funded or co-funded by EU or Member State programmes, has been in projects aimed at improved products and services, applicable to either the newbuild or building renovation sectors. Improvement can be in energy performance, reliability and durability or cost efficiency. Examples of such products and services could be:

- ▶ Building materials – such as insulation, concrete products, brick products, windows, doors, vapour barriers, air tightness barriers, jointing details to avoid cold bridging (e.g. at window sills and lintels).

- ▶ Equipment – boilers, pumps, heat emitters, fans, heating controls (sensors, valves, actuators), air conditioning units, cogeneration systems, lighting products (lamps, luminaires, controls), heat pumps, heat recovery systems, solar thermal systems, solar photovoltaic systems, heat meters, smart meters, Building energy management systems (BEMS).
- ▶ Services – design and certification advisory services, software providers, ‘one stop shop’ energy efficiency renovation packages, ESCOs and energy performance contracting (EPC).

Accompanying measures to facilitate or accelerate market uptake can include adoption of voluntary standards and obtaining independent voluntary certification of innovative products (e.g. certification of windows, boilers, air conditioners, heat pumps, lighting systems, solar panels). Such certification has become increasingly relevant in Europe due to expansion of the coverage and stringent compliance requirement in relation to a wide range of products covered by the EU EcoDesign and Energy Labelling Directives.

4.6 Demonstration projects

The role of pilot or demonstration projects has been to act as early market trials, forming a bridge between the research and development phases of concept development and the commercial deployment phase, aiming to accelerate such deployment. The exemplary role of such projects is intended to act as visible evidence of technical and economic feasibility and thus help to gain market confidence, and encouraging replication.

Frequently, a monitoring period of up to three years is required in order to provide sufficient stable data to enable actual performance to be verified.

Examples of demonstration projects exemplifying NZEB or other low energy buildings were referenced in Figure 3-1.

4.7 Other capacity building activities

Reference has already been made to the role of RD&D activities in helping to build capacity in the building supply chain and among the administrative and enforcement authorities for the EPBD. These have included tackling market barriers, supply chain issues and sectoral initiatives in a range of areas. These have been orientated particularly at delivering on the twin objectives of NZEB for new buildings and deep energy efficiency renovation of the existing building stock. These areas have included tools development, educational and training initiatives for upskilling the building workforce and in the fields of financing and promotion. An important example is the BuildUp Skills initiative, <http://www.buildup.eu/en/skills> which has provided a foundation for developing future skills initiatives in individual Member States and for associated recognition of qualifications and competencies for low energy building construction.

In relation to financing, for example, EU programmes have funded the development of an extensive database of over 600 case examples of building energy renovation, entitled ‘De-risking Energy Efficiency Platform’ or DEEP, viewable at <https://deep.eefig.eu/>. Other initiatives have sought to increase the impact of energy performance certificates/ labels (EPCs), ESCO models and development of new business models such as packaged ‘one stop shop’ service solutions for smooth energy efficiency renovation, combining public and private sector interests.

4.8 Concerted Action

The EU Commission provided active assistance to Member States to support the processes of EPBD implementation. These have included the funding of pilot and demonstration projects on various aspects of implementation, the issuing of guidelines, for example on the cost optimal methodology and on NZEB definition, and funding the development of a suite of technical standards by CEN.

In particular, it also included its support for the EPBD ‘Concerted Action’ collaborative forum between Member State authorities which enabled much systematic exploration and sharing of experiences – approaches, challenges, achievements - and learnings, and helped to accelerate some best practice solutions, for example on training/ upskilling systems, on databases and on quality assurance and enforcement practices. Its activities included plenary workshop meetings, working groups, study tours, publications and webinars. It has played an important role in assisting Member States with the practical details of implementing the Directive.

5 DISSEMINATION AND PROMOTION

An important contribution to building awareness and capacity in the building construction market and in encouraging replication of successful projects and methods is the dissemination of information regarding the options and methods for delivering buildings compliant with the building energy codes mandated by the EPBD.

Since 2005, the EU Commission has funded the development and ongoing enhancement of a major website called ‘Build Up’ (www.buildup.eu), illustrated in Figure 5-1, which serves as a comprehensive portal to all sources of legislative, technical and market information, policy studies, demonstration projects and practical case studies, and numerous thematic topics. This information can be in the form of documentary reports on progress on specific topics at EU and national level, and often links to other websites and webinars. It is directed equally at public authorities, building industry practitioners and the more general public. Webinars have become an increasingly important ingredient in the awareness, education and dissemination process.

Figure 5-1 The EU ‘Build Up’ web portal



Many lead Ministries and energy agencies responsible for EPBD implementation in individual Member States published similar libraries of reference and support material on their websites, including using such a medium to assist their stakeholder consultations on various details of their proposed implementation of the Directive. This would be complemented by face to face meetings with stakeholders and other initiatives, such as study tours to individual buildings demonstrating superior energy performance standards. In recent years, this has included visits to case examples of buildings reaching ‘nearly zero energy building’ (NZEB) standards.

6 CONCLUSION

Support funding for RD&D has been a core feature of EU policy since the 1970s, and within its ‘framework’ programmes for research, sustainable energy – comprising energy efficiency and renewable energy – has been a significant priority theme. Over the past 10 years of these programmes, funding for energy efficiency and renewable energy has almost tripled, and has included close linkages to research activities supporting energy and environmental policies and to developments in information and communication technologies (ICTs).

In informing and assisting implementation of the EPBD across EU Member States, **RD&D activity is an important contributor to capacity building**. A number of different types of research and associated activities have been supported, including the following:

- ▶ ‘Public good’ research (without direct commercial benefit) providing insights and intelligence on the characteristics of the building stock. This is often delivered by ‘think tank’ institutes.
- ▶ ‘Public good’ research exploring policy options, tackling barriers and needs in delivering low energy buildings, including developments in software and other tools, regional networks of complementary partners, initiatives in skills development and with financial instruments.
- ▶ ‘Public good’ research initiatives such as funding of research fellowships and mobility within and outside the EU, aimed at strengthening EU research capacity (looking to more long term benefits).
- ▶ ‘Shared cost’ research and development (R&D) into new product and service ideas (often incorporating ICT features) aimed at achieving lower energy, lower carbon buildings. This can extend from developments by SME companies or campus companies up to major integrated projects with multiple partners across several EU Member States (and beyond).
- ▶ ‘Shared cost’ demonstration projects highlighting the features, practicalities and benefits of low energy buildings deploying relatively mature design, technology and management solutions, providing visible evidence and building confidence among the developer community.
- ▶ ‘Public good’ support for national authorities in shared learning and development of pathways to administratively and economically effective ways of implementing the practical requirements of the EPBD – notably through the EPBD ‘Concerted Action’.

RD&D thus extends beyond traditional boundaries of R&D aimed at product development. Key drivers for these activities in Europe have been the EPBD and related policies mandating ‘nearly zero energy buildings’ (NZEB) within building energy codes and the priority of mobilising and accelerating investment in energy efficient renovation of the existing building stock.

All EU Member States also have RD&D programmes aimed at stimulating the development of new and improved solutions in the built environment. Hence this can be complementary

to EU programmes and it is possible for R&D projects to be co-funded by both national and EU funds (subject to 'State Aids' limits under EU competition law).

Consistent with its encouragement of more integrated and collaborative initiatives between industry players across Europe in the interests of strengthening competitiveness, the EU encourages the activities of industry associated and their pan-European research networks. A notable example of such a network for the construction sector is the E2B network.

Overall, RD&D activities to drive continuous improvements in the policies, technologies, tools, skills and systems for achieving energy efficient buildings are thus an important ingredient in the EU mission to transform its construction market towards a low energy, low carbon society.

Several of the initiatives of the kind outlined and referenced by hyperlink within this report may be applicable to India's circumstances in helping to drive innovation, capacity building and market stimulation towards full and widespread implementation of its Energy Conservation Building Code (ECBC).

7 WEB RESOURCES

In addition to the various websites referenced in this paper, the following is a small selection of portal websites from which useful information can be obtained on EPBD implementation.

Website title and address	Description
Build Up www.buildup.eu	EU portal for energy efficiency in buildings. Extensive library of documents, webinars etc. relating to EPBD and related implementation
Building Performance Institute Europe (BPIE) www.bpie.eu	A European ‘think tank’ providing policy research and advice on energy in buildings, with publications and monitoring of progress with EPBD implementation
EU Commission – energy efficiency in buildings https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings	Covering EPBD and allied Directives, independent reports, national reports, events
EPBD Concerted Action www.epbd-ca.eu	Public website for collaborative forum of Member States to assist EPBD implementation
EU Horizon 2020 Research Programme https://ec.europa.eu/programmes/horizon2020/en/area/energy	Six year framework programme supporting the full RD&D spectrum across Europe