

PREFABRICATED SYSTEMS FOR DEEP ENERGY RETROFITS OF RESIDENTIAL BUILDINGS

Deep-dive #1

SUMMARY

Off-site industrialisation of the construction of prefabricated building elements for the renovation market represents an enormous opportunity in the construction value chain, for new sources of revenue as well as new prospects of growth.

Important stakeholders finding new ways to grow their businesses are material manufacturing companies and medium or large contractors, by offering highly innovative and affordable renovation approaches to initiate a mass-market uptake of deep energy renovation. However, a further transition of the industrialised renovation process is required to achieve the long-term transformation targets of the existing building stock, both in renovation rate and depth.

The key innovation elements to apply successful prefabrication methods for the renovation market are:

- Customisation of the prefabricated elements per project;
- Innovative technologies such as robotics, 3D-scans and simulations;
- New cooperative business models;
- Aggregating renovation projects.

The industrialised process for new constructions is extremely mature all over Europe. The innovative solutions and competences built in this area, such as automated production lines, business models, cost optimisation and sales services, are fully developed. The challenge will now be to adapt and transfer these skills and knowledge to the industrialisation of the renovation market, for there is no mature industrialised approach for energy renovations yet.

The possible value to be captured in this innovation segment mainly comes from the module 'manufacturers and installers' and with home owners. The industrialisation of the construction process will lead to lower costs for holistic energy renovations, and lower renovation costs, combined with enabling measures, will lead to a higher renovation rate and depth. Expert opinions suggest that a deep energy renovation equates to a reduction in energy consumption for heating, cooling, ventilation and hot water in a range between 60 to 90%. Today, the renovation rate in the EU is at 1%. If it were to increase to 3%, energy demand in the current building stock could be reduced by 80% by 2050 compared to 2005 levels. The potential revenues for the total construction sector are estimated to amount to around €1200-1400 billion/year.

Since the construction sector is not perceived as an easy high-profit market, there is little incentive for outside actors to enter the market. However, shifts within the value chain itself will occur. The numerous micro-enterprises¹ active as on-site workforce will have to reposition themselves to capture value within this market segment, and manufacturers of prefabricated new buildings could make the shift towards the production of renovation modules. Similarly, it might lead to actors from the building services, such as architects and structural engineers, providing their services more integrated in 'one-stop-shop' business models and less as independent actors.

Finally, according to experts, there is no risk of production leakage outside the EU.

¹ These are enterprises with less than nine employees, which currently represent 94% of all enterprises active in the sector in Europe.

ENABLING MEASURES TO UNLOCK THE TRANSITION ARE:

- Policy regulation and support measures based on performance (e.g. energy savings per square meter) rather than the quantity for the entire building stock.
- Legislation on urban planning and architecture should allow more flexibility (e.g. spatial planning outside the perimeter, orientation of the building, look and feel of renovated buildings).
- Support by (local) governments or other organisations in aggregating and mediating with building owners and users.
- The introduction and further implementation of Building Information Modelling (BIM) and the likes.
- An attractive innovation system and support from banking institutions for enterprises.
- Ambitious energy efficiency renovations approached as a combination of cost, comfort and health.

Three main challenges need to be addressed:

- Renovation or demolition?
- Holistic application of prefab modules (incl. systems) or simplified prefab modules (such as insulation panels)?
- Transition or consolidation of the workforce?

Europe already has the necessary skill-base to make this shift happen, but converting this skill-base and workforce will be a challenge. Firms in the sector will need to adapt to new business models. Policy-making has a clear role to play in creating good framework conditions while actors in the segment will have to converge towards a unified approach.

This focus paper on 'PREFABRICATED SYSTEMS FOR DEEP ENERGY RETROFITS OF RESIDENTIAL BUILDINGS' is part of a larger report looking into innovation within the construction value chain. The report and three other papers are available on BPIE and i24c's websites. www.bpie.eu and www.i2-4c.eu

ONGOING TRANSITION

Off-site industrialisation of the construction of prefabricated building elements for the renovation market represents an enormous opportunity in the construction value chain for new sources of revenue and new prospects of growth, primarily facilitated by the following trends:

- Increasing focus of governments on energy renovations;
- Increasing need for affordable (deep) renovation² techniques with minimal burden for building users;
- Modernisation of the building sector through the integration of ICT and automated solutions;
- For new buildings, improved off-site productivity combined with modular assembly on-site.

These trends have opened up opportunities in the construction sector. Mainly material manufacturing companies and medium or large contractors are finding new ways to grow their businesses by offering highly innovative and affordable renovation approaches to initiate mass-market uptake of deep energy renovation. A further transition of the industrialised renovation process is required to achieve the long-term transformation targets of the existing building stock for both renovation rate and depth.

“Europe is leading this kind of prefabrication for deep renovation of buildings. [...] In time, there is no question that other regions will also need to have these techniques applied. So, if we can develop these new techniques in Europe now through our innovation and smart development, then this can become an export market in the future.” Adrian Joyce, EuroACE

“I’ve never seen the construction sector change unless it was pushed by regulations. There is a massive inertia in the way the sector is structured and with the way contracts are written. There is a large problem in the demarcation between disciplines that go together in a design team. As a result, there is not enough collaboration.” Adrian Joyce, EuroACE

“On one hand, there will be job creation but on the other hand it will also help keep everyone at work much longer.” Berri De Jonge, Plegt-Vos

“We have to look differently at standardisation. Prefab used to be standardisation in the sense that you had no choice. It was a fixed module and that was that. [...] We have to look at it like an IT-platform where we have a basis that we can expand with add-ons. These add-ons are the clients’ wishes and demands.” Berri De Jonge, Plegt-Vos

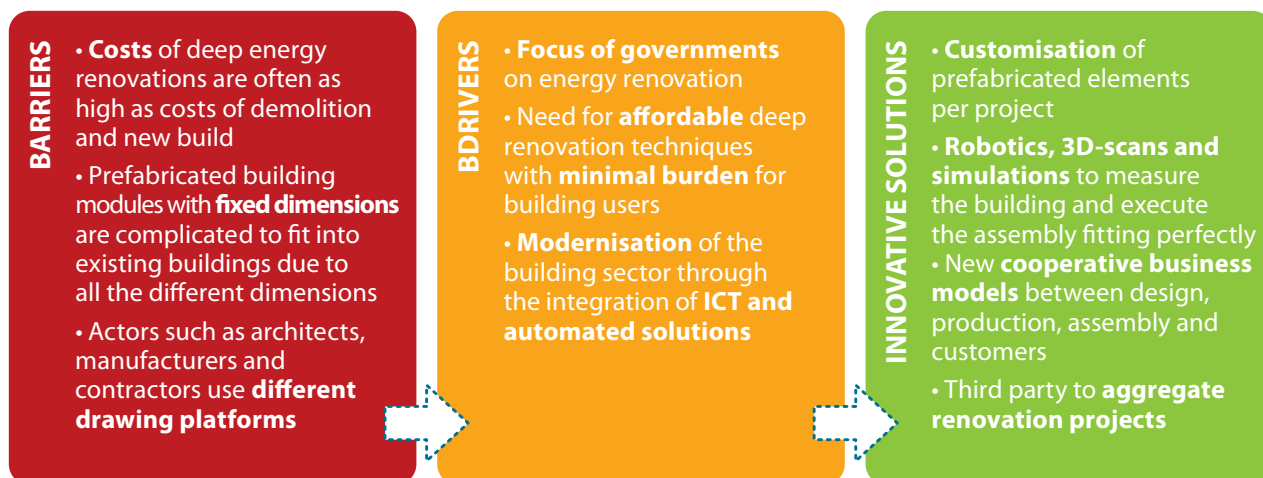
Energiesprong (Energy Leap) project in The Netherlands (Source: Platform 31)



² The costs of deep energy renovations with a traditional approach are often as high as costs of demolition and new build.

INNOVATION POTENTIAL

Figure 1: Outlining the innovation of 'Prefabricated systems for deep energy retrofits of residential buildings'
(Source: BPIE)



The renovation market has an enormous potential for process, marketing and organisational innovation. The key innovation elements to apply successful prefab construction methods for the renovation market are:

- Customisation of the prefab elements per project. While the dimensions of the façades are customised to the specific project, prefabrication for renovation means fixed compositions and complete façades.
- The use of innovative technologies such as robotics, 3D-scans and simulations to perfectly measure the existing building and execute the assembly that fits almost perfectly to the existing one. Prices for laser scanning and building the detailed model vary from €800-2,500. The larger the project, the lower this cost impact is.
- New cooperative business models with guidance and flow of information between design, production, assembly and customers. For example, very often there is a mismatch between the design and manufacturing stages where both architects and prefab manufacturers draw their 3D-model.

- Aggregating renovation projects (=organisational innovation) to benefit from economies of scale for 3D-scanning, the facilitation of project management, dissemination, etc. Certain building typologies, such as social housing, apartment blocks and larger offices are more appropriate to be aggregated and renovated in a collective approach.

The industrialised process for new constructions is mature all over Europe (e.g. The Netherlands, Italy, The UK, Ireland and Scandinavia). Examples of companies in this field are Sommarnöjen (SE), Riko (SL), Syspro (DE) and Huf Haus (DE). The innovative solutions and competences developed in this area, such as automated production lines, business models, cost optimisation and sales services, are fully mature. The challenge will now be to adapt and transfer these skills and this knowledge to the industrialisation of the renovation market, for there is no mature industrialised approach for energy renovations yet.

THERE ARE DIFFERENT POSSIBLE APPROACHES WITHIN THE INTEGRATION OF BUILDING ELEMENTS IN THE PREFABRICATED RENOVATION SYSTEMS:

- Current best practice in The Netherlands and Switzerland is the prefabrication of complete modules. Companies shifted from producing separate roof and façade modules to holistic building solutions, integrating windows and special techniques such as ventilation and renewable energy systems, in the new building façade.
- In other examples, like the EASEE project, companies develop prefabricated façade insulating panels, optimised in terms of size and geometries as well as in terms of application, structural behaviour, insulating materials and aesthetic options.

VALUE TO CAPTURE

The possible value to be captured in this innovation segment is mainly located in the module manufacturers and installers and with home-owners.

The industrialisation of the construction process will lead to lower costs for holistic energy renovations. Pilot projects in The Netherlands are showing a potential cost decrease from €130.000 (2010) to €60.000 (2014). These cost reductions are achieved by implementing the following actions:

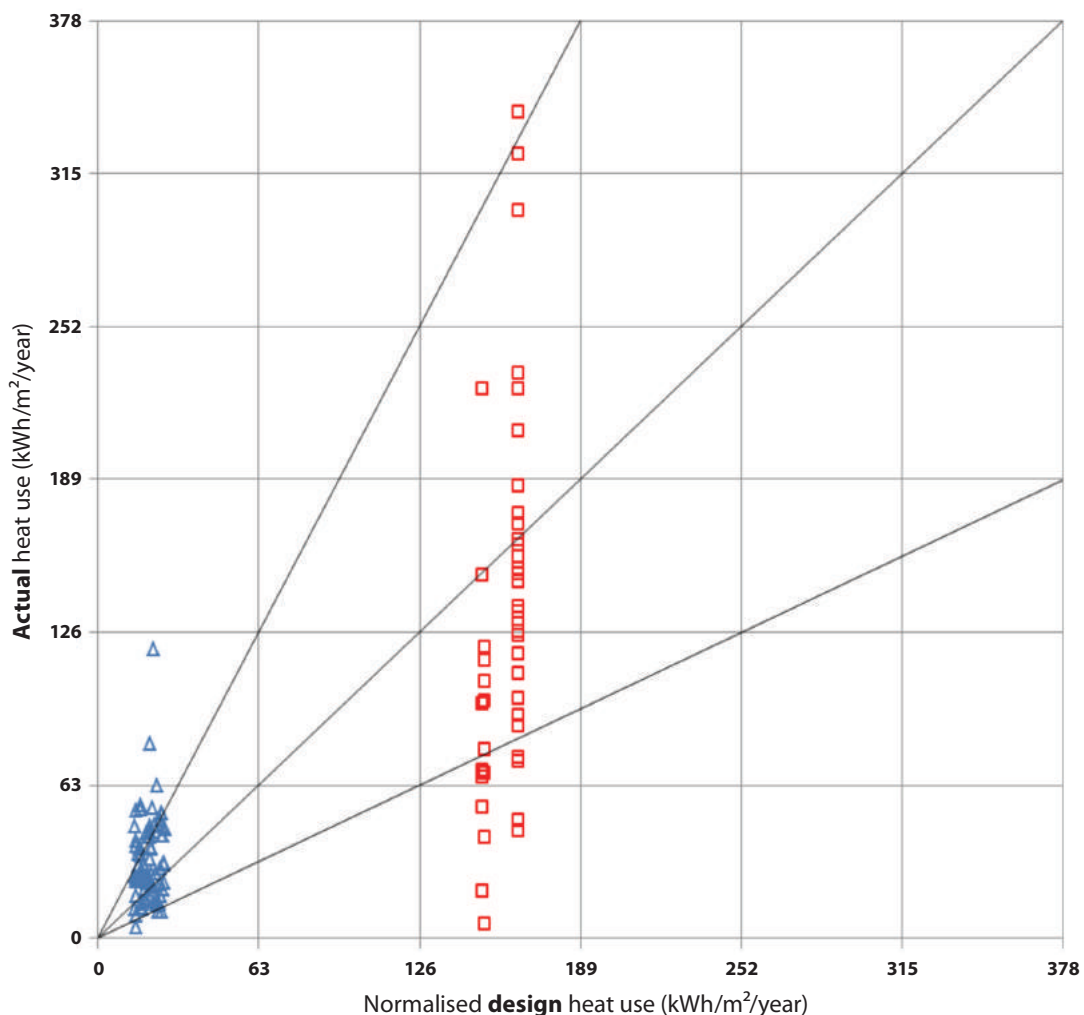
- Reduced person-hours (labour has always been a bigger cost than materials and equipment);
- Limiting conventional wharf costs significantly since scaffolding, crane, construction site infrastructure, etc. are no longer needed;
- Economy of scale to reuse models and limit the time spent on individual projects;
- Decreased transportation and logistics needs.

Lower renovation costs, combined with enabling measures, e.g. government incentives for renovation, will lead to higher renovation rate and depth. Expert opinions suggest that deep energy renovation equates to a reduction in energy consumption for heating, cooling, ventilation and hot water in a range between 60-90% (0-30% shallow, 30-60% moderate).

The market uptake of affordable industrialised renovation techniques will:

- Drastically decrease energy consumption in buildings;
- Improve the market value, comfort level and indoor air quality of the property for the benefit of the building owner and user;
- Stimulate the circular economy and reduce waste during the building process;
- Increase gender equality employment and keep older workforce longer at work, while also attracting young and more technical employees.³

Figure 2: Actual heat use and designed heat use before (red squares) and after (blue triangles) deep energy renovation, pilot project Venningwijk (BE) (Source: University Ghent)



³ The reason being that the construction process is executed in a safe indoor environment with largely automated production lines, allowing less mobile or strong workforces to enter the sector. The time spent outdoors on the construction site is kept to a minimum.

Today, the renovation rate in the EU is at 1%. If it were to increase to 3%, energy demand in the current building stock could be reduced by 80% by 2050 compared to 2005 levels. Potential revenues for the total construction sector are estimated to amount to around €1,200-1,400 billion/year, which is a boost of ca. €700-800 billion/year. If prefabrication modules are counted as material and equipment, which accounts for 25% of the total renovation cost, this still leaves an added value of around €200 billion/year specifically for prefabricated renovation modules.

An example: In Energiesprong (NL), the value of industrialised prefab renovation of 110,000 houses is estimated at €5 billion. This is just a small fraction of the total Dutch value to be captured, and an even smaller one if compared to the whole EU potential.

Experts estimate that per €1 million investment in the construction sector, 17-19 jobs are created. When considering that prefab modules limit labour hours, a job creation of

10-12 jobs per €1 million investment could be foreseen. With a possible growth of €200 billion/year for this particular renovation segment, this could create up to 2 million jobs per year. It is generally considered that the ripple effect of one additional employment in the construction sector leads to 2.5 extra jobs in the overall economy.

Europe is leading the industrialisation of prefabrication materials for deep renovation of buildings. In the years to come, other regions will obviously also need to apply these techniques. European enterprises that successfully achieve market maturity for these new techniques in Europe through innovation and smart development could become leaders in the export market.

Best practices in The Netherlands (Energiesprong, Platform 31) and Switzerland (IEA ECBCS Annex 50) show that aggregated demand, large production capacities and strong marketing campaigns result in large market uptake at lower prices.

THE COUNTRIES WITH BEST POTENTIAL VALUE TO CAPTURE ARE CHARACTERISED BY:

- A mature prefab construction market for new constructions;
- An existing building stock in need for renovation;
- The availability of suitable building typologies for an aggregated prefab construction approach, such as (social) housing, apartment blocks and offices.

According to these criteria, Sweden, Germany and The Netherlands would be the first markets to target.

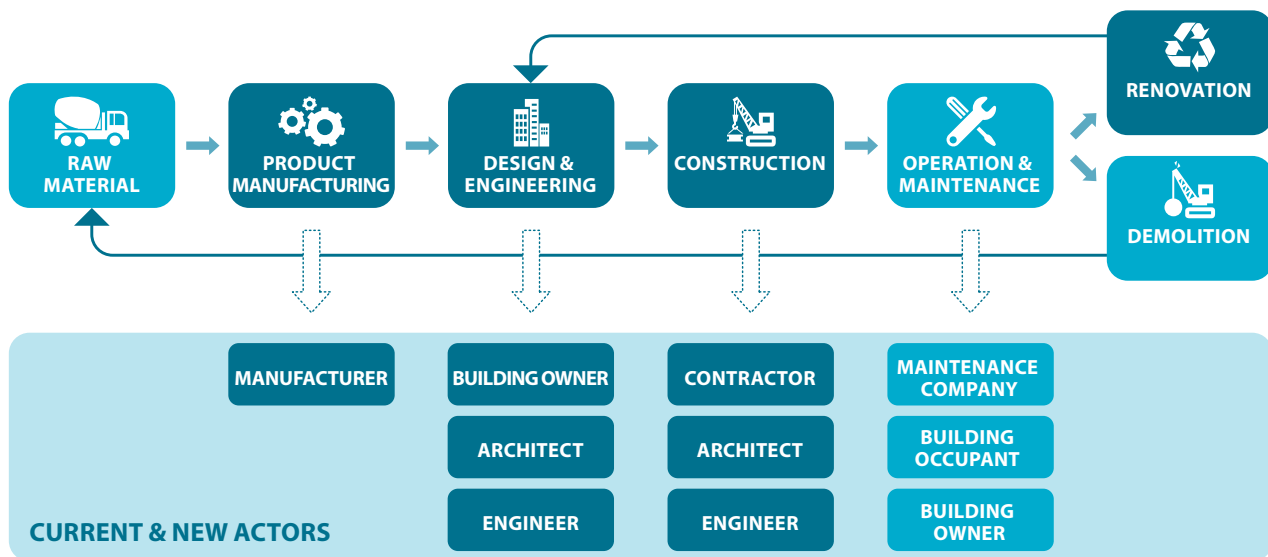
Explicit markets to capture value are:

- Social housing: In Europe, 90% of social housing is in need of refurbishment, often in poor energy efficiency conditions and with many tenants affected by fuel poverty.

- DIY-renovation market: The largest market value to capture in terms of renovation today is still represented by home-owners undertaking (stepwise) renovations by themselves, often missing the comprehensive overview and creating a lock-in effect for future energy-saving measures. To capture value in this target group, an innovative marketing approach is needed.

IMPACT ON EXISTING AND NEW ACTORS ENTERING THE VALUE CHAIN

Figure 3: Actual heat use and designed heat use before (red squares) and after (blue triangles) deep energy renovation, pilot project Venningwijk (BE) (Source: University Ghent)



Since the construction sector is not perceived as an easy, high-profit market, there is little incentive for outside actors to enter the market. However, shifts within the value chain itself will occur:

- The numerous micro-enterprises⁴ active as on-site workforce will have to reposition themselves to capture value within this market segment. They can do so by:
 - Producing prefab elements themselves;
 - Operating as sub-contractors for on-site assembly;
 - Offering project-management services.
- Manufacturers of prefabricated new buildings could make the shift towards the production of renovation modules.

If this innovation towards industrialised renovation systems were to be consolidated, it might lead to the following:

- Actors from building services, such as architects and structural engineers, will provide their services more integrated in the 'one-stop-shop' business models and less as independent actors in the building process. The design and engineering would be fully taken over by the manufacturer core business, primarily with an industrial approach (production line) and less from an individual building perspective. Few architects have experience with prefabricated systems for renovations, which is why repositioning is appropriate. Opportunities lie not only in the design of these systems, but also in project management, coordinating the collaboration structure and the contact with customers.

- Municipalities might have to change the way they execute the spatial planning regulation today, for the outside perimeter and the look and feel of renovated buildings might not fall within current regulations.

According to experts, there is no risk of production leakage outside the EU: a decrease of involved person-hours gives less incentive to export production to countries with lower labour costs. Moreover, logistics and the accuracy of the product are very important and more reliable and easy to monitor with production nearby.

However, production and assembly will not necessarily take place in the same countries. Dutch manufacturers see opportunities to export ready-to-install prefab systems and work with local contractors abroad for the measurement and assembly.

⁴ These are enterprises with less than nine employees, which currently represent 94% of all enterprises active in the sector in Europe.

IMPORTANT ENABLING MEASURES TO UNLOCK THE TRANSITION

Policy regulation and support measures based on performance (e.g. energy savings per square meter) rather than the quantity for the entire building stock with regular compliance and control mechanisms. There is also a need for a regulation that understands and translates the dynamics of the construction sector, allowing for new contractual relationships within the construction sector, while also paying special attention to not slowing down innovation.

Plegt-Vos (Dutch prefab manufacturer): *“It would be possible to renovate your house in 3 days but you will have to wait 28 weeks for a permit because the government procedure takes that much time.”*

Main actors to engage with on this topic:

- European policy makers responsible for buildings and energy;
- National (or regional) policy makers responsible for buildings and energy;
- Sector federations representing the different stakeholders in the construction sector.

Legislation on urban planning and architecture should allow more flexibility in the expansion of houses due to energy renovation but also concerning their exterior appearance. Materials, glazed surfaces and other parameters can be different from usual ones due to standardisation of the renovation modules.

Main actors to engage with on this topic:

- National (or regional) policy makers responsible for relevant cross-thematic environments (e.g. housing, spatial planning, energy);
- National (or regional) sector federations representing stakeholders from architecture, spatial and urban planning.

Support by (local) governments or other organisations, such as social housing organisations, in aggregating and mediating with building owners and users.

Main actors to engage with on this topic:

- Local governments such as municipalities (Covenant of Mayors), provinces or district bodies;
- Social or public service housing organisations, associations or cooperatives⁵;
- End-user alliances or federations.

The introduction and further implementation of Building Information Modelling (BIM) and other standardised protocols. This will harmonise the collaboration between all building actors on matters such as 3D-drawings. BIM implementation and take up is very much country-dependent and has been relatively slow in the construction industry compared to industries such as manufacturing and engineering.

Main actors to engage with on this topic:

- EU BIM Working Group of the European Commission;
- National Building Councils, bringing together all stakeholders of the construction sector;
- National standards bodies;
- All levels of governments for public procurement.

An attractive system and support from banking institutions for enterprises that want to make these types of investments in innovation of their products or services. After the 2008 crisis and the significantly decreased margins in the construction sector, it is very hard to get bank support for these investments.

Main actors to engage with on this topic:

- Financial institutions (and the national federations representing them).
- European policy makers responsible for finance and economy;
- National (or regional) policy makers responsible for finance and economy;
- European and national authorities responsible for support programmes on innovation.

The calculation of costs and benefits, not only from the financial point of view, but also taking into account the cost to society for higher comfort and better health. Ambitious energy efficiency renovations should be approached as a combination of cost, comfort and health, where the broader impact on society should also be monetised.

Main actors to engage with on this topic:

- European research institutes;
- European executive agencies responsible for EU support programmes;
- European policy makers responsible for buildings and energy;
- National (or regional) policy makers responsible for buildings and energy.

⁵ Structures, size and typologies of these organisations are country-dependent. More information on how social housing is defined in the different countries of Europe (<http://www.housingeurope.eu/page-91/the-observatory>).

THREE MAIN CHALLENGES NEED TO BE ADDRESSED:

- **Renovation or demolition:** prefabricated renovation systems should always be considered alongside the idea of demolition. Renovation is, in some cases, suboptimal in terms of costs, energy savings and quality.
- **The holistic application of prefabrication modules (integrating both the building envelope and building techniques)** is more complex and often only used in subsidised demo cases. It is technically possible but not yet always economically feasible.
- **Transition or consolidation of the workforce.** A different kind of skills is needed for these new processes. The challenge will be to maintain a stable employment rate and use the opportunity to also employ an older workforce in the indoor facilities, for instance. An additional challenge is how to avoid job losses, almost inextricably connected with industrialised processes.

BEST PRACTICES AND PILOT PROJECTS

STROOMVERSNELLING – “RAPIDS/ACCELERATION”

- **What?** Collaboration between demand- and supply-side actors to realise 110,000 zero-energy renovations at no cost to occupants.
- **Where?** The Netherlands.
- **Stakeholders?** Energiesprong consortium and Platform 31.
- **Target Group?** Home-owners, communities, builders.
- **Type of works?** Whole-house renovation with minimal burden for the occupants (renovation of 4-10 days).
- **Timing?**
 - Prototyping: September 2013-December 2014 (1,000 homes)
 - Industrialization: January 2015-December 2016 (10,000 homes)
 - Scaling up: January 2017-2020 (100,000 homes).
- **More information?**
 - www.stroomversnelling.net
 - www.energiesprong.nl
 - www.stroomversnellingkoopwoningen.nl



Source: Energiesprong

PREFABRICATED SYSTEMS FOR LOW-ENERGY RENOVATION OF RESIDENTIAL BUILDINGS – ANNEX 50 IEA'S ENERGY IN BUILDINGS AND COMMUNITIES PROGRAMME

- **What?** The development and demonstration of an innovative whole-building-renovation concept for typical European apartment blocks. The concepts are largely based on standardised façade and roof systems suitable for prefabrication. The highly insulated new building envelope includes the integration of a ventilation system. Case studies are taken from six demonstration sites.
- **Participating countries?** Austria, Czech Republic, France, The Netherlands, Portugal, Sweden, Switzerland.
- **Target Group?** Building industry and building designers.
- **Timing?** Completed (2006-2012)
- **More information?** www.ecbcs.org/annexes/annex50.htm



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