



NL Agency
Ministry of Economic Affairs

Future Buildings Forum 2013

Think Tank on “Transforming the Built Environment by 2035:
Meeting Energy and Environmental Targets”

11th and 12th April, 2013
Soesterberg
Netherlands

Results



Impressum

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This report is available from:

www.iea-ebc.org and www.agentschapnl.nl/energie-en-milieu-innovaties

Foreword

Dear Readers,

As Dutch delegate to the IEA Committee on Energy Research and Technology I was glad to be present at the IEA's most recent Future Buildings Forum. When there is talk about 'The Future', energy people tend to think in terms of 'scenarios'. There are many of these. The International Energy Agency is famous for its annual World Energy Outlook, and its more technology oriented Energy Technology Perspectives. Just the day before the Forum, I attended a Shell workshop on its own 'New Lens Scenarios'. Shell has developed two story lines, one in which the world is dominated by elites that rule from the top ('Mountains'), and another in which there is much more equality, but also more strife and competition ('Oceans'). Both story lines are fascinating, and rich in detail and context. From an ecological perspective, though, it was worrying to hear Shell state that they had not managed to come up with a scenario that keeps the world within the famous '2°C boundary'. From that perspective, Shell's oceans are dark, and its mountains are bleak.

The Shell scenarios may be compared with alternative 'backcasting scenarios'. In such scenarios, the emission boundaries are set, and societal, economic and technological pathways are explored to stay within these boundaries. The IEA's Energy Technology Perspectives (suitably sub-titled 'Pathways to a Clean Energy Future') contains such a scenario. The first striking difference is that backcasting scenarios show that the dominance of renewables must come far earlier than Shell deems possible – within decades, rather than within a century. The second key difference is that backcasting scenarios need a far stronger de-coupling of wealth and well-being from energy consumption. The world must become very efficient very fast.

This is my bridge to the Future Buildings Forum. A significant part of the world's energy consumption is linked to buildings. Here, if anywhere, radical reductions are possible. And there is no need to compromise on shelter, comfort, wealth or wellbeing. Quite the opposite probably, buildings may become even better places in which to live and work.

The scenarios contain important messages. Backcasting scenarios provide the comforting notion that a clean energy future is possible. This may be so, but the world is not heading that way and the Shell scenarios act as a stark warning. If we do not get our act together, we will cross many environmental boundaries. The Future Building Forums help us to avoid that. Here credible pathways to a clean and sustainable future for our buildings are mapped out and explored. If these pathways are followed, oceans and mountains will no longer appear as environmental nightmares, rather as marvellous holiday destinations.

Bert Stuij

Manager Energy Strategy and Transition
NL Agency

Executive Summary

The fifth IEA Future Building Forum Think Tank took place in the Netherlands on 11th and 12th of April, 2013. During one and a half days, a total of 35 experts from 13 countries discussed how the built environment could be transformed into a zero-energy and low emissions state.

The discussion on the broad field of energy conservation in the built environment was structured into 3 main themes, namely:

- energy reduction;
- energy storage and management;
- energy production.

Prof. Ronald Rovers gave the keynote speech setting the scene for the discussions to follow. He sketched out a truly sustainable world in 2050. Given that both materials and energy production may be based on 100% renewable sources by that time, he concluded that the main bottleneck would be the materials rather than energy production.

Introductory speeches into the three main themes were given by the experts Dr. Morad Atif, Prof. Halime Paksoy and Dr. Gerhard Stryi-Hipp. They provided an overview of the existing technologies and trends, taking in account relevant existing R&D roadmaps. Following these presentations, three break-out groups then discussed the main themes, each with a mixture of experts from different backgrounds.

During the first workshop, the main barriers that could be expected in the near future in striving towards an energy neutral built environment were identified and discussed. The problems identified were divided into:

- political, social, environmental and legal barriers;
- economic barriers;
- technical barriers.

The discussions focussed on energy. However, it was noted that in the future it could be the demand for (scarce) materials that is more important.

During the second workshop, the experts formulated solutions to solve the problems identified during the first session. It is of course important to have many solutions available for achieving the final desired energy situation, but they are not always within the scope of the IEA (economic or legal items). It was also concluded that these barriers probably constitute an even larger barrier than the technical ones.

In the third session the experts focussed on solutions relating to R&D activities, to be addressed within the IEA buildings-related Implementing Agreements in the coming years.

The main subject areas where R&D will be required for energy reduction were identified as follows:

Energy Reduction

- There is still a need for new, cost effective technologies; these new technologies should be developed as systems not isolated products;
- System integration on several levels is important, including monitoring and control;
- There is a need for metrics for real data validation and standardised protocols, taking into account user behaviour;

- Technical capacity and knowledge on operation of different building types concerning building / user system interactions;
- Knowledge of user behaviour. Understanding smart meter experience, and in-house display impacts; providing education to users and appropriate support media.

Energy Storage

- System Dynamic Modelling:

Modelling needs to be based on system dynamics and simulations should incorporate technical and economic parameters, as well as addressing the overall management and control strategies of the storage as part of the system.

- Multiple Storage Systems:

Research is required to develop sound storage systems whereby the interaction (thermal, chemical, biological) with adjacent functions underground can be mapped out.

- Seasonal Storage:

Used to balance the electric grid with unpredictable renewable energy production such as wind and solar energy.

- Multifunctional Facades:

Façades provide climate and acoustic protection, daylight penetration, ventilation and potentially (renewable) energy production and storage. By incorporating storage in this multifunctional approach the need for active heating or cooling will be reduced.

- Time indifferent / Compact Storage:

Thermo / chemical materials and reactors (TCM/TCR); objective to reach a factor of 7-8 compactness compared to water.

Energy production

- Data and methods for decision-making about energy systems for districts;

- Business models;

- System integration - the future could be an urban energy system based on 100% renewables and the interaction between grids and between the building level, local level and regional level needs to be considered.

Some specific general conclusions

To achieve the target to build an energy neutral environment by 2035, there is an enormous requirement for R&D to be conducted by the various IEA buildings-related Implementing Agreements. However, it was also concluded that many non technical problems need to be solved. Not only economic problems need to be addressed, but also legal aspects and human behaviour. It is to the responsibility of the buildings-related Implementing Agreements to draw the IEA Secretariat's attention to these barriers and to address these in other networks.

System integration is important on several levels: the integration of energy systems in building elements, the integration of different installation technologies, the integration between local energy production and regional grids. This also requires close cooperation between the different Implementing Agreements: Collaboration is crucial!

Table of contents

| | |
|--|----|
| 1. Introduction..... | 7 |
| 2. Method | 7 |
| 3. Workshop Report..... | 7 |
| 4. Problems and Solutions | 9 |
| 4.1 Energy Reduction | 9 |
| 4.2 Energy Storage and Management | 10 |
| 4.3 Energy Production | 12 |
| 5. Roadmap for future R&D Items | 14 |
| 5.1 Future R&D Items for Energy Reduction | 14 |
| 5.2 Future R&D Items for Energy Storage and Management | 15 |
| 5.3 Future R&D Items for Energy Production | 15 |
| 6. Conclusions | 16 |
| 7. Annexes | 18 |
| Annex 1..... | 18 |
| Programme of the FBF Think Tank Workshop | 18 |
| Annex 2 Presentations..... | 19 |
| Annex 3 Discussion papers : based on the discussions in workshop 1 and 2 | 20 |
| Annex 4 Overview R&D: based on the A-4 formats during workshop | 34 |
| Annex 5 List of participants..... | 46 |
| Annex 6 Existing Roadmaps | 48 |

1. Introduction

IEA Future Buildings Forum (FBF) Think Tank Workshops are convened every five years to agree on strategic R&D priorities for the IEA buildings-related research programmes, known as 'Implementing Agreements' (IAs). The collective long term goal of the programmes is that appropriate, and if necessary, disruptive changes should be made to the design, construction and operation of building and community scale energy systems to meet the challenging goals for clean energy supply and demand reduction. Internationally renowned experts and creative thinkers have been invited to these Workshops to share their knowledge and to anticipate which new technologies and business models will be needed to achieve this goal.

The 2013 FBF Think Tank Workshop had the theme "Transforming the Built Environment by 2035". It focused on the priorities necessary to transform the built environment and its supporting industries by 2035 into a truly knowledge-based sector that meets all energy and environmental requirements. The ideas generated and the consensus from the Workshop discussions is documented in the present report. This strategy document describes the outcome of a technology and environment scan, emerging technologies, a gap analysis, and emerging opportunities. All building related Implementing Agreements of the IEA are invited to make use of the findings for setting their strategies and developing R&D roadmaps.

2. Method

At the beginning of the FBF Think Tank Workshop a provocative keynote presentation set the scene for the subsequent discussions. The discussion was structured in 3 main themes:

- < Energy reduction
- < Energy storage and management
- < Energy production

After one input speech per theme, three break-out groups were formed, each with a mixture of experts from different backgrounds, such as manufacturers, building owners, utilities, regulators, innovators, community energy planners, and academia. These parallel workshops were guided by professional moderators. The number of participants was limited to a maximum of 20 per group to be able to manage the valuable discussions.

The parallel workshops in the break-out groups were each divided in three sessions. In the first session the potential problems on the way to transform the built environment by 2035 were anticipated. In a second session solutions were proposed to solve the identified problems. And finally in a third session R&D items were developed to realize these solutions. These selected items form the main results of the FBF.

3. Workshop Report

The Workshop was opened by the FBF Chair, **Mr. Rob Kool** (IEA Demand Side Management, DSM IA Chair). On behalf of the NL Agency he welcomed the delegates and gave a short explanation about the structure of the workshops and the agenda.

During the Future Buildings Forum it would be discussed how the built environment could be transformed into a zero-energy and low emissions state, and what might be the barriers to this being achieved. From there, the barriers would have to be explored, as well as solutions to overcome these. Finally research themes, to be addressed within the

relevant (buildings-related) IAs would have to be elaborated to help make a zero-energy and low emissions built environment a reality. For each technology and solution, a set of questions has to be asked: Does this work for 9 billion people worldwide and a growing population? Do we need this technology or could we avoid it by use of other solutions? Can we afford it?

After that, the Chair of the Implementing Agreement on Energy in Buildings and Communities (EBC, formerly known as ECBCS), **Mr. Andreas Eckmanns**, gave a brief historical retrospective. The first FBF was initiated by EBC in 1989 as a 'think tank' jointly run with other buildings-related Implementing Agreements of the IEA. It was aimed at identifying long term energy, environmental and economic developments and to assess their potential effects on future buildings. As a result, new areas of activity and common interest among these Implementing Agreements were identified.

The welcome from the host and organizer of this event was given by **Mr. Bert Stuy**, General Manager at NL Agency and national member of the CERT for the Netherlands (see foreword).

A keynote presentation was given by **Prof. Ronald Rovers** to set the scene for the subsequent discussions. In his provocative speech he sketched a truly sustainable world in 2050. Given that both, materials and energy production may by then be based 100% on renewable sources, he concluded that the bottleneck would be the materials rather than the energy production. He suggested a further interesting hypothesis: A zero-energy built environment will be largely built upon solar radiation, and so far this has been a non-issue in the building and planning sector. But, if somehow the right to solar radiation could be established legally, this could act as a game changer: making people aware of its importance, giving a price to solar radiation access, and claiming their share.

Introductory speeches to the three main themes (energy reduction, storage and production) were given by renowned experts in their fields. They gave an overview of the existing technologies and trends, taking in account the relevant existing R&D roadmaps. The speakers were:

Dr. Morad Atif, National Research Council, Ottawa, Canada: "Consolidation of Technology Roadmaps for Energy Reduction in Buildings: Overview",

Prof. Halime Paksoy, Çukurova University, Adana, Turkey: "Energy Storage and Management",

Dr. Gerhard Stryi-Hipp, Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany: "Energy Production in Future Buildings".

After these presentations three break-out groups discussed the main themes, each with a mixture of experts from different backgrounds.

In the first workshop session the problems were discussed that can be anticipated if we want to "Transform the Built Environment by 2035". In a second workshop session, the groups tried to find possible solutions to solve the identified problems.

The first day was rounded off with a presentation by **Mr. Roger Cox**, partner of a renowned law firm in The Netherlands and author of the book "Revolution Justified". Mr. Cox gave a presentation with the title "Revolution justified – why only the law can save us now". He imparted an insight into the powerful world of the fossil energy business, its consequences for the world economy and on the inescapable natural force of climate change. He showed that implementing a new energy design, necessary for continued prosperity urgently needs judicial leadership to break the status quo in the energy economy. He gave a completely alternative view about matters concerning energy and energy saving measures.

On the second day a third workshop session was convened, in which all experts participated. In that session, ideas for R&D items within the scope of the relevant IEA buildings-related Implementing Agreements were gathered. Finally, all experts could give their comments on the results of the three workshops themes (presented on posters).

After this plenary task Prof. Ronald Rovers drew his own conclusions out of the two day workshop. The FBF Think Tank 2013 was then closed by Rob Kool and Andreas Eckmanns.

4. Problems and Solutions

4.1 Energy Reduction

Domestic and commercial buildings, and both new and retrofit were considered. In the introduction Morad Atif gave a clear presentation concerning the present situation, dealing with:

- ◁ Strategic intent: Vision/Policy, Needs/Barriers, Technology Push/Pull
- ◁ Product/system: Building Products, Building Systems, Energy management, Appliances
- ◁ Sector/markets : Residential, Commercial, Communities, Energy Infrastructure

Starting with considering the barriers to improving energy efficiency and to reaching energy neutral built environment by 2050, it was notable that most barriers identified by the group fell into either Economic, or (the majority) Political, Social, Environmental and Legal categories: and not into Technical, the area in which the IEA Implementing Agreements concentrate their efforts. It may be that some reconsideration of the focus of the research effort is warranted.

Among the barriers identified in the Political, Social, Environmental and Legal area, two were highlighted by the participants. The first was summed up in a quotation from a politician: "we know what we should do; but we don't have a clue having done it, how to get re-elected". The second related to cost effectiveness, and noted how this analysis would vary greatly by region, climate and country.

Among the Economic barriers, the need for an initial investment was identified as the most important barrier, regardless of payback periods, and so on. The need of life cycle analysis (LCA) was discussed, and questions were raised about the validity of the return on investment criterion. But, protests were raised at the separation of economic and technical barriers, it being argued that innovation requires both. The contrary point was made that while technical barriers involve the laws of physics, economics reflects a political construct that could be subject to carbon taxes, and so on.

Also, the impact of behaviour was proposed as a relevant factor to reach the 2035 goals. In that discussion, it was also mentioned that poor performance and reliability of technical innovations influence energy saving and efficiency during their life time. One of reasons is poor or missing 'metrics' and the shortage of capacity (numbers of experts and also their levels of expertise). Clients (customers) only receive stand alone solutions and not well functioning and integrated systems. So, the integrated approach, or integrated systems, needs careful attention together with business models to convince installers and clients.

The customer is not fully interested in the efficiency of his installations, so the need was recognized to have robust installations with automatic control and feedback systems.

The discussion led to the identification of six clusters of technical barriers.

System integration: an elegant four dimensional hierarchy of building aspects highlighted the need for systematic thinking. Areas identified for R&D application include monitoring and control, and interaction with the grid; industrialised packaging of components; and deep retrofitting.

Knowledge for CO₂ impacts: a scientific approach is needed to provide for reliable LCA-based decisions, with data on the embodied energy and CO₂ of materials and the development of LCA-based standards.

Cost-effective technologies: define the efficiency and non-energy benefits of a proposed technology; define markets for critical high-priority technologies delivering the largest savings potential; pursue pre-competitive R&D with multiple solutions and market players. The new technology should be driven forward as a system not product; 'generic' equivalents should be sought to address affordability; it should be 'proven' through demonstrations and case studies.

Metrics: the need for standardised protocols; extending metrics to loading and sizing; open source data on systems and whole buildings; measure impact of users on energy performance.

End user information: understand smart metering experience, and in-house display impacts; optimal operation of different building types; deliver user education and appropriate support media.

Technical capacities: speculating whether there are differences between OECD and other countries, the need for capacity-building programmes to be undertaken by international organisations was highlighted. However, banks and other financial institutions could also accept a responsibility to ensure that the necessary competences are available when a financial investment is being approved. The significant existing programmes were recognised, but improved co-ordination was seen as desirable. There is also a need to ensure energy issues are adequately covered in undergraduate and in professional development programmes, and that energy skills are properly certified.

For the detailed comments, given during the discussion, see the annex.

4.2 Energy Storage and Management

The workshops on Storage did not limit the scope: Both thermal and electrical storage issues were discussed.

In the first session the focus was on identifying the barriers which need to be addressed to create an energy neutral future in which storage plays an essential role. The main barriers were identified along the lines of:

- ◁ Political, social, environmental and legal barriers:
 - Planning - land ownership – boundaries for deployment
 - Lack of a legal framework for electrical storage
 - Awareness and knowledge of users is poor and awareness of benefits of storage is lacking
 - Weak linkage between these forms of technology and energy policy
 - Incentives for decentralised storage to support the electricity grid

While these barriers were not further addressed, they are of extreme importance. But, they were considered to be outside the scope of the various IEA Implementing Agreements and should be addressed via a different platform.

- ◁ Economic barriers:
 - Need for harmonised evaluation methods of benefits
 - Fragmented market structure
 - Current price of thermal energy storage
 - Split ownership at a system level
 - Deployment rate for new technologies
 - Need for educated professionals

- Need for industry investment in innovative technologies

As with the political barriers, some of these have a far reaching impact.

◁ Technical barriers:

- Management to aggregate collective energy storage systems to meet individual systems demand
- Ways to store surplus power using seasonal storage: power to the earth
- Management of surplus renewable energy / electricity production by storage systems to relieve the grid: centralised / decentralised?
- Ways to handle compact thermal storage in dwellings: distance between user and storage needs to be optimised.
- Same for how to handle electrical storage capacity in dwellings
- High cost compared to traditional systems
- Electric vehicles: storage capacity in conjunction with the grid is a limitation
- Spatial constraints: area requirements in high density building regions
- Large seasonal storage requires open source and long time investment
- Technological readiness: no large scale production as yet
- Lack of compact storage for retrofit
- Heating / cooling systems being used in different time scales to meet different loads

These technical barriers were identified as the main input for the next session in which the directions for possible solutions were identified.

The output from the 1st workshop led to identification of a series of potential solutions in the 2nd workshop to suggest possible new directions for research. The main areas identified were:

The development of a methodology for impact analysis and related benefits and side effects. This should set the basis for better understanding, both of the technical issues and communicating the effects of storage to a wider community of potential stakeholders. The gap between technical and economic issues relating to storage can be addressed by bridging this through dynamic system modeling on mesa, micro and nano levels (not macro).

In conjunction with this, the need to *improve the R&D cycle* was identified. This implies focus and attention following a pre-determined sequence of activities and involvement of researchers, industry and users to follow the innovation chain from Discovery (fundamental research) to Development (products and systems) to Demonstration and Deployment. Storage can never be seen as an isolated solution and will need to be a part of an integrated system.

At a physical level, solutions need to be found for:

- The integration and multi-functionality of facades and roofs to include thermal storage
- Control strategies to manage and optimize storage capacity in systems
- Time-independent and compact storage for use in existing buildings (with little space)
- Combinations and integration of short term and seasonal storage
- Development of electricity to thermal storage systems (i.e. "power to earth" and "power to gas") in order to make use of electrical overcapacity periods
- Learning from natural systems (i.e. by imitating nature)

In the 3rd workshop a number of concrete proposals were developed. These were:

System Dynamic Modeling: The methodology needs to be based on system dynamics, simulations and should incorporate technical and economic parameters, as well as addressing the overall management and control strategies of the storage as part of the system. This will build on existing building physics models and will incorporate the technical knowledge about specific storage solutions. The main contribution will be that these models will identify the potential, as well as the limitations, that storage will bring for certain applications. It will further increase the insight and knowledge of the functionality of storage within a comprehensive system.

Multiple Storage Systems: To enhance the use of thermal capacity in the underground for heating and cooling purposes for the built environment, more research is required to develop sound storage systems whereby the interaction (thermal, chemical, or biological) with adjacent functions in the underground can be mapped out. This will lead to a better use of underground hot and cold storage and potential buffering of excess energy flows by thermal storage. In itself, this could lead to thermally autonomous districts.

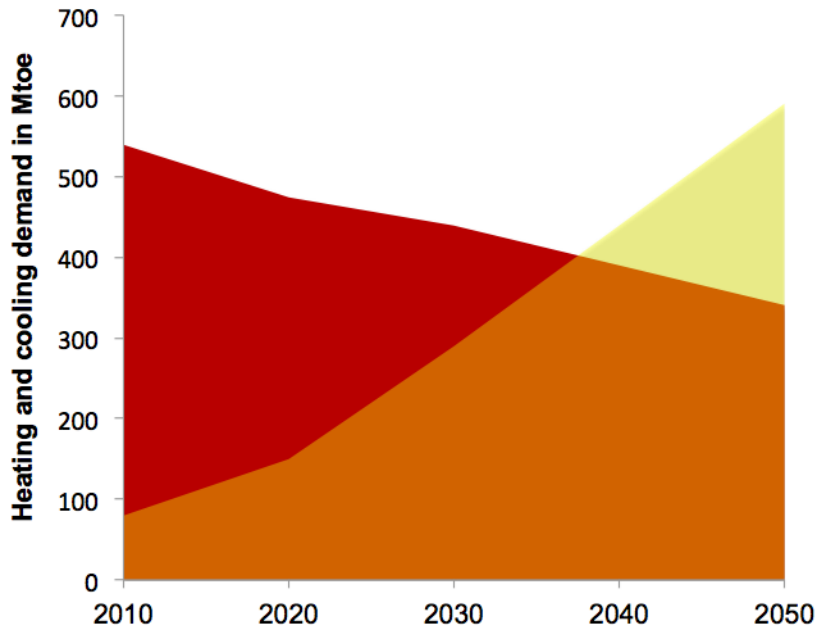
Seasonal Storage: This is used to balance the electricity grid with unpredictable renewable energy production such as that from wind and solar energy. This is potentially to be addressed in conjunction with multiple storage systems. It could use UTES, CAES (compressed gas storage, H₂ storage) and other storage technologies. This will contribute to a 100% renewable energy system over time and will continue to build on knowledge on energy production, storage and energy management.

Multi-functional Facades: Façades provide climate and acoustic protection, daylight penetration, ventilation and potentially (renewable) energy production and storage. Simultaneously, they need to contribute to an optimal indoor climate to accommodate the people living or working in the building. By incorporating storage in this multi-functional approach, they will reduce the need for active heating and cooling.

Time Indifferent / Compact Storage: The objective is to reach a factor of 7-8 compactness compared to water using thermo/chemical materials and reactors (TCM / TCR). The time-indifferent character is reached by separating the TCM materials for later use. The main applications are likely to be in the existing building stock due to requirements for compactness. There is preliminary work done within a combined ECES and SHC Annex. This would require further development, mainly on the materials and the reactors.

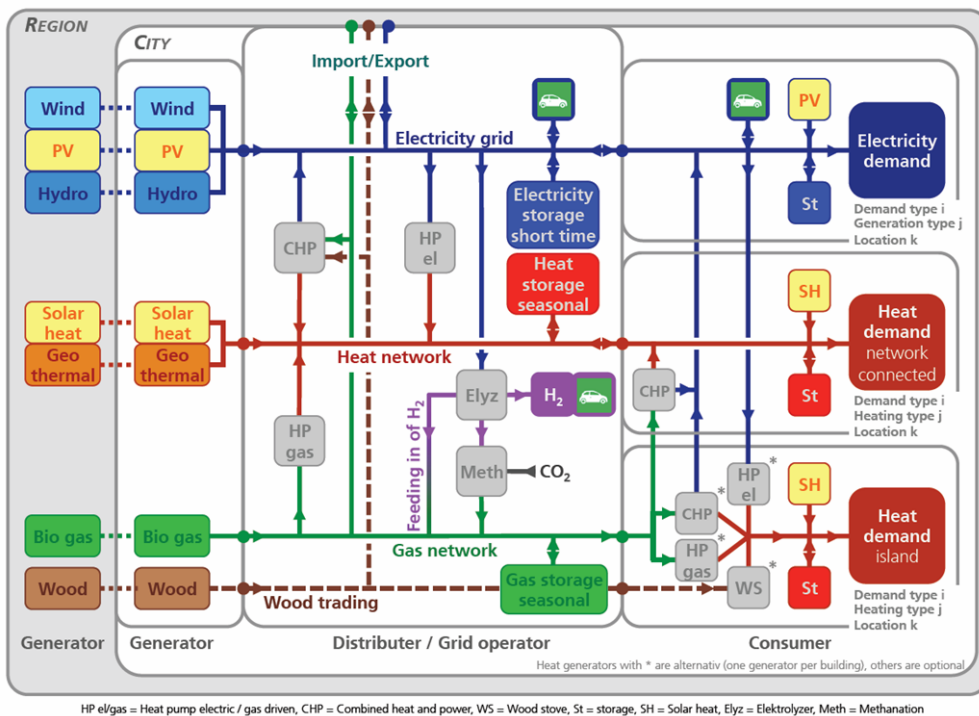
4.3 Energy Production

In the introduction, Gerhard Stryi-Hipp focused on the possibilities to generate energy on site and in communities. He showed that if the energy demand is reduced, the total heating and cooling demand in Europe can be reached by renewables, according to the European RHC-platform. This is also valid for the world RHC demand. He also stressed the importance of local grids and the interactions between buildings, local grids and national grids. Storage will play a role in adapting the demand to the available renewable sources. The future could be an urban energy system based on 100% renewables and interactions between grids and between the building level, the local level and the regional level as shown in figure urban Energy systems bases on 100% renewable Energies”.



Heating and cooling demand and RHC \dot{E} potential in EU 27

Urban Energy System based on 100% Renewable Energies



The scope in the discussion covered all energy producing technologies, but in the future renewable technologies will be most important for the built environment. These are: Solar PV, Solar thermal, biomass + waste and heat pumps. In heat grids, waste heat from industry or others sources could also play a role.

The focus in the discussion was on energy, but in the future the demand for (scarce) materials could be more important. Also, the participants stressed that an overall solution will be achieved by combining energy reduction, energy production and energy storage.

The discussion led to the identification of three clusters: (i) data and methods for decision making, (ii) business models, and (iii) system integration.

Data and methods for decision making

- ◁ Support tools to help cities to make better decisions on energy systems for districts

Business models

- ◁ Evaluations of business models and identification of success factors
- ◁ Risk assessment of different renewable energy technologies

System integration

- ◁ System approach to local production by “prosumers” and the grids (electric, gas, heat / cold)
- ◁ Open source tools for the balancing of production and use in smart districts for planning, decision making and monitoring

These future activities were not limited only to R&D. For example, working on business models is not a scientific R&D activity, but is essential to reach the goals for 2035. It is the responsibility of the Implementing Agreements to agree if international collaboration under the IEA umbrella is useful for these activities.

5. Roadmap for future R&D Items

Based on the discussions, the following R&D items have been formulated.

5.1 Future R&D Items for Energy Reduction

Cost effective, novel technologies

Detailed case studies and business models varying on energy systems, energy prices / climate, etc.

Highly insulated windows

Optimized ventilation systems with heat recovery

Improved insulation (less CO₂) including reference to LCA

Solar thermal cooling and heating

Evacuated tube collectors; high temperature collectors

Appropriate sensors (and correct interpretations)

Performance monitoring tools for components and systems

System integration

R&D on (simplified) tools for complex energy systems

R&D on optimal integration of HVAC, RES and storage for the targeted building types: design tools for complex systems, etc

R&D on control strategies for comfort & grid interaction & operational costs

R&D on sensor techniques and ICT

Metrics

R&D on real data and validation of energy use of buildings

R&D on knowledge of metrics, relevant for environmentally friendly energy efficiency

Knowledge and technical capacity

◁ R&D on optimal operation of different building types looking at building /user / system interactions, including optimal performance of energy generation / smart grids

Development of monitoring /assessment protocols

Standards and policies

Identify some "best available technologies", worth disseminating through capacity building and training programmes.

Identify the existing programmes in the field and, if necessary, establish new training materials and programmes

◁ Implement the programmes, putting the information online to broaden access.

Knowledge of user behavior

◁ R&D on user behavior and predicting energy use in buildings.

5.2 Future R&D Items for Energy Storage and Management

Material investigation (geological layers/ thermo – chemical storage/ PCM)

Define boundaries and perspectives of storage systems: for DH-stations or for single buildings or small clusters

Define available technologies or newly developed technologies

Demonstration projects and monitoring

Review state of the art multi-functional facades

Applying Annex 43/24/42 approach to modeling

Optimal integration with BEMS

System dynamic modeling of technological and economic interactions, including different modes of energy grids, local sources and buildings as so-called "prosumers" – producers and consumers at the same time – as well as storage (drivers / requirements / targets; scenarios; validation with case studies

Multiple storage: insight about how to model / manage these systems (desired temperature levels / how achievable; business case, governance models

5.3 Future R&D Items for Energy Production

◁ Decision making tools for smart cities: tools and reference data sets for the decision making process on sustainable energy systems for districts

◁ Identify technology to make production units compatible and make the system more efficient

◁ New technology for retrofit solar facades

◁ Bring together real actors of building and solar industry; make them work together

- ◁ Case studies: identify ambitious projects , conceive extended monitoring, evaluate operation and optimization process
- ◁ Develop standards
- ◁ Business models: targeted grouping of existing results; fill gaps of knowledge; targeted dissemination
- ◁ Set up guidelines for early stage design (PV sizing / orientation)
- ◁ Distinguish hourly / daily or monthly / seasonal balancing

6. Conclusions

Collaboration is key: the Implementing Agreements of the IEA Technology Network are technology driven by their nature. Policy options, economics (including financing), environmental impacts of energy reduction measures and behavioral aspects are mentioned as “problem areas”. But, it is up to others to address these. Examples are the 25 policy recommendations of the IEA Secretariat and the Closing the Loop task of the DSM Implementing Agreement. The presence of an IEA Desk Officer and colleagues from IPEEC at the FBF Workshop is certainly a step in the right direction.

Also, it is clear that an integrated approach is needed. And, of course, the last step in the chain is an optimal (energy efficient) product or device.

System integration is important on several levels: the integration of energy systems within building elements, the integration of different installation technologies, the integration between local energy production and local or regional grids.

Considering the most energy efficient measures and products, we must realize that embodied energy plays an important role. The need to give more attention to the use of materials is increasingly important, rather than only taking in account energy aspects. Integrated approaches must also deal with life cycle assessment.

In the future, materials use in buildings could be more limiting than the energy use. This might lead to an optimum based on more energy use, but less materials use.

Capacity building in the professional workforce is another item that has to be addressed. The IEA End Use Working Party, and in particular the Buildings Co-ordination Group should play a role to coordinate collaboration of necessary actions to achieve a sustainable built environment by 2035.

The real performance of systems, especially combination of systems is currently poorly understood. Metrics to obtain information about real performance are essential for prediction of performance and the development of supporting design and decision tools.

Storage systems will play a role in smart buildings and smart districts to balance supply and demand in a 100% renewable region.

Final Conclusion

It is clear there are many R&D items to be addressed by the various IEA Implementing Agreements. But an additional conclusion must be that there are many non-technical problems to solve, otherwise we will not reach our targets: to build an energy neutral environment by 2035. Not only financial problems, but also legal aspects and human behavior must be taken into account.

A few issues raised during the FBF Workshop sessions did not make it to the final selection. In part this is because they are not typical R&D issues for IEA Implementing Agreements. However, it is important that they should be taken up by other networks.

7. Annexes

Annex 1

Programme of the FBF Think Tank Workshop

Future Buildings Forum Think Tank Workshop 11th - 12th April 2013 "Transforming the Built Environment by 2035"

| Thursday 11 th April | | | | |
|---------------------------------|---|---|---|---|
| 09.00 - 09.20 | Welcome by - Host : Bert Stuy, NL Agency, member of CERT - ECBCS: Andreas Eckmanns, chairman ECBCS - FBF Chair: Rob Kool | | | |
| 09.20 - 10.00 | Key note | | | Ronald Rovers |
| 10.00 - 10.40 | Input speech: Emerging technologies and existing roadmaps concerning Energy Reduction | | | Dr. Morad R. Atif, National Research Council, Canada |
| 10.20 - 10.40 | Input speech: Emerging technologies and existing roadmaps concerning Energy Storage and Management | | | Prof. Dr. Halime Paksoy, Cukurova University, Adana, Turkey |
| 10.40 - 11.00 | Input speech: Emerging technologies and existing roadmaps concerning Energy Production | | | Gerhard Stryi-Hipp Fraunhofer Institute for Solar Energy Systems |
| 11.00 - 11.30 | <i>Coffee break</i> | | | |
| 11.30 - 13.00 | Parallel workshops: What are the problems? | | | Moderators / Reporters |
| room: | Workshop 1: Energy reduction Steyl | Workshop 2: Energy production Kenia | Workshop 3: Energy storage Mozambique | |
| 13.00 - 14.00 | Lunch | | | |
| 14.00 - 15.30 | Parallel workshops: What is needed to solve the problems? Which directions of technologies, behaviour, social aspects, adaptation, etc. | | | Moderators / Reporters |
| Room | Workshop 4: Energy reduction Steyl | Workshop 5: Energy production Kenia | Workshop 6: Energy storage Mozambique | |
| 15.30 - 16.00 | <i>Coffee break</i> | | | |
| 16.00 - 16.30 | Summing up results first day | | | Reporters and |

| | | |
|---------------|------------------------------|-----------------------------|
| | | Chair |
| 16.30 - 17.15 | Trends: Revolution Justified | Roger Cox |
| 17.15 - 18.00 | <i>Get-together, drinks</i> | <i>all</i> |
| 20.00 | <i>Dinner</i> | <i>Offered by NL Agency</i> |

| Friday 12 th April | | | | |
|-------------------------------|--|--|---|----------------------------|
| 09.00 - 09.30 | Plenary opening | | | Rob. Kool |
| 09.30 - 11.00 | Parallel workshops: How does IEA R&D contribute to solve the problems? | | | Moderators / Reporters |
| | Room | Workshop 7: Energy reduction St. Jan | Workshop 8: Energy production Kenia | |
| 11.00 - 11.30 | <i>Coffee break</i> | | | |
| 11.30 - 12.15 | Summing up results from parallel session | | | Chair and Reporters |
| 12.15 - 13.00 | Final discussion and conclusions | | | Ronald Rovers |
| 13.00 - 13.05 | CLOSING | | | Chair and Andreas Eckmanns |
| 13.05 - 14.00 | <i>Lunch</i> | | | |

Annex 2 Presentations

During the FBF the following presentations are presented and already sent to the participants. For the presentations, see the www.ecbcs.org

- ◁ What built environment do we want by 2050? by Professor Ronald Rovers, Zuyd University, Heerlen, The Netherlands.
- ◁ Consolidation of Technology Roadmaps for Energy Reduction in Buildings: Overview, by Dr. Morad R. Atif, National Research Council, Ottawa, Canada.
- ◁ Energy Storage and Management, by Professor Halime Ö. Paksoy, Çukurova University, Adana, Turkey.
- ◁ Energy production in future buildings, by Dr. Gerhard Stryi-Hipp, Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany.
- ◁ Revolution Justified – why only the law can save us now, by Roger Cox, lawfirm Paulussen advocaten, Maastricht, The Netherlands.

Annex 3 Discussion papers : based on the discussions in workshop sessions 1 and 2

REDUCTION

| Barriers (1) | Political, social environmental, and legal barriers | Economic barriers | Technical barriers |
|---------------------|---|---|---|
| | energy prices are low; difficult for policymakers to impose long term solutions | industry only in for long term investment; no changes in short time | complexity of solutions |
| | lack of awareness (public and officials) | financing community wants less risk | existing buildings are complicated |
| | cost / benefits varies greatly by region / climate /country | energy prices directly impact consumer benefits | technical solutions are there; integration needed |
| | individuals must understand how to drive politicians | lack of detailed case studies for deep retrofit versus economics; no business model | fragmented industry |
| | lacking long term planning (macro-economic perspective) no long term vision | split incentives on cost; lack of incentives; incentive for investors | lack of knowledge energy saving measures and CO ₂ consequences of total building |
| | Minister: WE know what we have to do; we just don't know to do it and get re-elected | Cost effectiveness is hard to calculate; need accurate numbers | technology is proprietary expensive |
| | environmental benefits not monitored by most of the world | Need for initial investments | risk of new technologies; changes and failures |
| | different conditions (climate, economics, market development) that makes cost effectiveness different in different places | no proof that return on investment is valid | infrastructure too complex; many partners |

| Barriers (2) Reduction | Political, social environmental, and legal barriers | Economic barriers | Technical barriers |
|-----------------------------------|---|---|--|
| | hidden agendas | naive economics; big business does not understand the opportunity | researchers are not so responsible for their results |
| | outreach; awareness of the cost effectiveness | percentage of cost for evaluating products will become higher | lack of building physics knowledge |
| | fear of change | energy prices too low | lack of benchmarking; no real performance data |
| | lack of knowledge of building stock and its dynamics; how it changes over time, when to retrofit, how much, how to control it | cost effectiveness is not synonymous to 'making money' | large gap between predicted and actual energy consumption of buildings |
| | problem ownership? liability for success | payback too short | lack of technical capacity / educated personnel |
| | political decisions based on public awareness is lacking | profit at society level, not at individual level | lack of knowledge of users |
| | many actors, many levels | different value of money among actors | evaluation is dependent on use conditions which we do not know enough |
| | people in general don't understand the importance of (building) CO ₂ emissions | too few creative entrepreneurs who see the opportunities | most people don't understand how to use buildings |
| | people like to invest in new technologies, many of which fail | | |
| | delicate problem when evaluating accurately existing products | | |

| Solutions (1) Reduction | System integration / integrated solutions | Knowledge CO₂ impact / LCA knowledge users | New technology / cost effective | Practitioners / technical capacity | Metrics |
|------------------------------------|--|--|---|--|---|
| | R&D on integrated optimized, functional, easy to use controlling and monitoring systems (e.g. HP / storage / solar, etc) | Scientific approach for reliable LCA based decisions | pursue pre-competitive R&D with multiple solutions (market players) | capacity building programmes | standardized protocols for assessment and monitoring of energy use / performances of products / systems/ whole building |
| | R&D on controlling and monitoring system interactions with smart grids | metrics for embodied energy of materials | examples of highly insulated windows, cold climate heat pumps, gas heat pumps, small scale , COP > 12, low embodied energy high performance insulation, small scale solar cooling, urban building heat pump | involve national energy agencies, NGOs, international organisations in training programmes | metrics of performance extended to load & sizing |
| | definition of new components for better efficiency (or improvements of existing) components | LCA method is okay, lack of good data sources | defining efficiency benefits beyond existing technology & also non-energy benefits | involve financial institutions in training programmes | measured impact of building occupants on energy use |
| | systems for monitoring and control performance of complex energy infra structures | require that LCA techniques be used in all applications for energy regulation approval | policy makers need to define critical high priority technologies versus largest saving potentials | coordination of existing capacity building programmes | building energy use data via open source of the systems & whole building |
| | integration of thermal storage technologies to heating and cooling systems to make these more efficient | require that that all manufactures provide LCA data | new technology driven for systems, not for products | introduce energy issues in built environment courses at the beginning to building people | include requirements of performance monitoring into building regulation |
| | multi-functional building envelope components | lack of mapping of energy resources; fuel types from different regions | new technology needs to have equivalent generic version for affordability | certification programmes for people | |

| Solutions (2) Reduction | System integration / integrated solutions | Knowledge CO₂ impact / LCA knowledge users | New technology / cost effective | Practitioners / technical capacity | Metrics |
|------------------------------------|--|---|---|---|----------------|
| | | info about product / system / building | new technology has to be proven | prepare standards | |
| | | user behavior: handbooks / applications | focus on viability (economic, user interface, installer for new technologies | | |
| | | improve smart metering | need for local materials and low cost for developing countries | | |
| | | optimise operation smart grids | support needed to move technology from concept to point that is ready for investors (loan guarantee, R&D funding) | | |
| | | study of optimum operation of different building types looking at interaction of building / user including energy system | connections / converters of current standards for communication | | |
| | | | smart phone integration of energy data and comfort conditions | | |

| Steps needed within R&D programmes (1) Reduction | System integration | Knowledge | New technology | Practitioners | Metrics |
|--|---|--|---|--|--|
| | R&D integration building components and services installations especially for retrofit | R&D of the optimal operation of different building types looking at building / user / system interactions including optimal performance of energy generation / smart grids | sensor technology for new applications in monitoring and BEMS systems | identification of Best Available Technologies from the (IEA) roadmap worth disseminating through capacity building and training programmes | knowledge development metrics for real energy performance (environmentally friendly energy efficiency) |
| | demonstration | modelling of building stock dynamics to indentify relevant type - age and 'natural' renovation cycles; then assess how to accelerate it | | identify and co-ordinate existing programmes in this field | assessment and monitoring protocols for buildings and systems |
| | performance monitoring integrated in all systems | deep retrofit: detailed case studies and business models varying on energy prices, climate, etc | | when development of best available technologies is needed | real data / validation open innovation |
| | R&D for tools for BEMS for complex systems (connected with smart grids for electricity, heat and gas) at urban level | work on current low carbon city programmes; case studies | solid state lighting | implement the programmes; put the information online to broaden the access | knowledge development for standards and policies |
| | | | | | |

| Steps needed within R&D programmes (2) Reduction | System integration | Knowledge | New technology | Practitioners | Metrics |
|--|--|---|---|----------------------|--|
| | advanced facades (dynamic windows / lighting / HVAC) interacting with building technologies | define standardized user profiles (statistically meaningful for user related loads (DHW, lighting, appliances, cooking with hourly values | improved insulation, less material, less CO ₂ | | follow up in addition to DSM Task 16 |
| | user friendly monitoring systems for dwellings | | highly insulating windows / suitable glazing (reflectivity, PV contribution | | new metrics to characterize benchmark building grids interaction |
| | optimal integration of HVAC, RES and storage for different building types; optimal control strategies for comfort / grid interaction | more R&D on solar thermal | | | need for material testing and rating of infrastructure for developing countries |
| | | | evacuated tube collectors | | archetype building by breaking down its characteristic for the purpose of adequate comparison / benchmarking of energy consumption |
| | | | high temp collectors and use gas HP breakthrough | | high performance product sale metrics (low-γ glass, condensing boilers, HP, etc |
| | | | cold climate HP / gas thermal Annex | | optimize existing monitoring set ups of meters for each energy service; set up of temperature sensors, |

| | | | | | |
|---|---------------------------|------------------|--|----------------------|---|
| | | | | | humidity sensors, airflow |
| Steps needed within R&D programmes (3) Reduction | System integration | Knowledge | New technology | Practitioners | Metrics |
| | | | building integrated photovoltaic / thermal (BIPV/T) | | select appropriate sensors and decide about correct interpretation |
| | | | CO ₂ heat pump for domestic hot water and cooling | | |
| | | | | | |

storage

| Barriers | Political, social environmental, and legal barriers | Economic Barriers | Technical barriers |
|-----------------|---|---|--|
| | systems spanning - land ownership - boundaries | evaluation methods of benefits | how to manage aggregate collective energy storage systems, to supply & individual demand system |
| | missing or poor legal framework for electrical storage | fragmented market structure | how to store surplus power in seasonal storage: power to the earth |
| | pricing mechanism of electric city; | price of TES | how to manage surplus renewable energy / electricity production by storage systems to relief the grid: centralised / decentralised? |
| | awareness building knowledge of users is poor | split ownership | how to handle compact thermal storage in dwellings; distance between user and storage needs to be optimised |
| | awareness of benefits of storage is lacking | mix up of means and goals energy / comfort / health | how to handle electrical storage capacity in dwellings |
| | weak linkage between the technology and energy policy | deployment speed of new technologies | high cost compared to traditional system |
| | incentives for decentralised storage to support the electric grid | educated professionals are few | electric vehicles: capacity of the grid is a limitation |
| | long term goals | complexity | spatial constraints; area requirements in high density building regions |
| | cost efficient incentives to renovation (one stop shop) | industry invest only in current technologies | large seasonal storage requires open source and long time investment |
| | too many options | | technological readiness: no large scale production yet |
| | lack of knowledge of TES, good practice | | lack of compact storage for retrofit |
| | lack of human and social aspect: feedback on energy and comfort | | heating / cooling systems being used at different timescales to meet different loads, using different sections of floor / ceiling at different timescale |

| | | | |
|--|------------------------|--|--|
| | consumer behavior | | |
| | drivers and motivation | | |

| Solutions | Adaptation | Small scale | Awareness / dissemination |
|------------------|---|---|--|
| Storage | develop a methodology framework for impact analyses of co-benefits and side effects | learning from natural systems (imitating nature) for the built environment (biomimicry) | evaluate models of benefits |
| | understand and improve innovation cycle R&D / demonstration / development and evaluation and permanent education | optimisation of multi-functional facades and roofs with thermal storage (what can storage add?) | appropriately trained energy assessors, e.g. system installers / performance assessors |
| | dynamic system modelling (meso / micro / nano, but not macro) to bridge technical and economic issues (guidance on modes including storage) | management & optimisation of thermal and electrical storage in meso-scale systems | consider 'unintended consequences' to wider society |
| | | time independent compact storage systems | guidance on multiple benefits (environment / energy / asset value) for multiple stakeholders |
| | consider storage as part of integrated system at all scales | micro-scale seasonal thermal storage | |
| | optimal storage packages within systems | optimisation of electro and thermo chemical storage | |
| | modelling and measuring of meso- and micro-scale electrical and thermal grids in combination with storage | global distribution of renewable surplus | |
| | reconciling bottom up with top down; market development to assess different approaches | multi-functional façade / dynamic materials; heat transfer media / green walls, micro climate | |
| | innovation cycle (RDDDE) for integrated storage systems | looking for combination of short and seasonal storage | |

| Steps needed within R&D programmes Storage | Multiple Storage system | Time independent compact storage systems | System dynamic modeling |
|--|---|---|---|
| | insight to model / manage these systems (desired temperature levels / how achievable) | material investigation | System dynamic modelling of technological and economic interactions, including different modes of energy grids, local sources and buildings as "prosumers" as well as storage |
| | what are the effects of thermal leakage | reactors | scenarios |
| | business case | continuation joint R&D with joint ECES / SHC task | case studies with validation |
| | governance models | | to define which are the drivers, requirements, targets |
| | | | |

| Steps needed within R&D programmes Storage | Multi-functional facades | Seasonal storage system |
|--|---|--|
| | review state of the art multi-functional facades | define boundaries and perspectives of storage systems: for DH-stations or for single buildings or small clusters |
| | applying Annex 43 / 24 / 42 approach to modelling | define available technologies or newly developed technologies |
| | demonstration and monitoring projects | demonstration projects |
| | optimal control and integration with BEMS | |

Production

| Barriers (1) | Political, social environmental, and legal barriers | Economic Barriers | Technical barriers |
|---------------------|---|---|---|
| | boundary of local versus central | fossil competition | system integration |
| | short term thinking of politicians | low fossil fuel prices | integration of systems, system approach; control of systems is too complex |
| | lack of knowledge for professionals (architects, installers, etc) | prices of fossil fuels may decrease | integration of solar PV and thermal in buildings, lack of solar building products, collaboration between industries |
| | fight of solar fanatics versus conservatives | effect of shale oil / gas production? | compact solar cooling is lacking |
| | lobbying for one technology | subsidies for fossil and nuclear energy | no data on real performance, need for simple feedback to end users |
| | aesthetic issues | business models (1) make 100% RE provision as business case | existing infrastructure needs different technical solutions |
| | building regulation | financial knowledge (3) business models | RES production is dynamic and not in line with demand, need for storage and integrated storage |
| | conflict about resources | Long term contracts / obligations in value chain | materials: reduce material demand |
| | lack of reliable data for decisions | built environment is slow system | energy efficient operation; no knowledge on real performance |

| Barriers (2) Production | Political, social environmental, and legal barriers | Economic Barriers | Technical barriers |
|------------------------------------|--|---|---|
| | no method for decision making process, non-integrated decision making on energy infrastructure | uncertainty or reluctance of banking system | poor performance of collective systems |
| | no demand for energy neutral dwellings, low user acceptance | financing market deployment of innovations | robustness / need for knowledge for maintenance |
| | user behavior becomes more important, end users | financing infrastructure / investor security | technical development to reduce costs |
| | there is no system/market design to set e.g. a price for local energy | availability of access to investment capital | lack of important materials increased price |
| | shale gas | material scarcity | lack of cooperation between building industry and PV / solar thermal |
| | right to solar radiation | first cost instead of LCC (2) | demand and supply are at different times |
| | | investment of RE systems not valued in building value (2) | smart controller for all HVAC systems optimizing the overall system performance |
| | | installation prices too high | lack of knowledge of appliances and maintenance |
| | | energy neutral houses are too expensive | |
| | | renewable energy systems not cost competitive with ongoing techniques | |
| | | | |

| Solutions Production | Data and methods for decision making | System integration and optimisation during operation | Solar building products |
|--------------------------------|--|--|---|
| | identify ways to get efficient smart heat networks where renewable sources can contribute | case studies: identify ambitious projects, conceive extended monitoring, evaluate operation and optimisation process | bring together real actors of building and solar industry; make them work |
| | identify technology to make production units compatible and make the system more efficient | provide feedback to manufacturers and facilities managers | need for new technology for solar thermal |
| | | develop standards | use direct current to reduce losses (computer / phones, etc) |
| | | involve industry, housing companies, manufacturers, ESCOs | |
| | | sell services instead of energy | |
| | | business models | |
| | | home uses 3 grids (electricity, gas, heat / cool) | |
| | | | |
| | | a system approach is needed: communication- energy profile - tools - framework | |
| | | | |

| Steps needed within R&D programmes Production | Data and methods for decision making | System integration | Business models |
|---|--|--|---|
| | | feed in of heat in networks for waste heat, storage | set up co-operation for renewable energy production (financing / legal aspects/ insurance /risk) |
| | risk assessment of different renewable energy technologies | develop energy profiles: plan at an urban / collective level | adapt framework (legal / economics) |
| | distinguish hourly / daily or monthly / seasonal balancing | | |
| | set up guidelines for early stage design (PV sizing / orientation) | | support tools and reference datasets for local decision makers for the development and decision on sustainable energy systems for districts |
| | need for tools: design methods, design / construction tools (open source) for planning, communication, decision making, monitoring | | help cities make better decisions on energy systems for districts |
| | | | business models: ESCO models and financing models with reliability and risk assessment |
| | | | develop services instead of selling energy |

| Steps needed within R&D programmes Production | Products |
|---|---|
| | R&D on retrofit solar facades |
| | bring together real actors of building and solar industries |
| | |

Topic: Reduction /knowledge users

Chosen technology:

" Smart metering & user /systems / building interaction

What is reached using this technology

Improves knowledge of building user on the impact their behavior on energy consumption and comfort

Contribution to the main theme

Awareness of energy efficiency measures

What does it build upon

Task XXIV DSM

What steps are needed within the R&D programmes of the IEA:

R&D of optimal operation of different building types looking at building /user / system interactions including optimal performance of energy generation / smart grids

Identify the existing programmes in the field,

If necessary establish new training materials and programmes,

Implement the programmes, put the information online to broaden the access.

Topic: Reduction /new technology

Chosen technology:

- ~ deep renovation
- ~ business model
- ~ case studies of performance
- ~ ventilation technology
- ~ monitoring
- ~ sensor technology

What is reached using this technology

- Renovation of existing buildings
- Awareness of energy flows; feed back

Contribution to the main theme

- energy saving
- reduces ventilation losses
- supports

What does it build upon

- New technologies and existing policies
- existing monitorings activities within the IEA

What steps are needed within the R&D programmes of the IEA:

- Detailed case studies and business models varying on energy prices / climate, etc.
- Highly insulated windows
- Optimised ventilation systems with heat recovery
- Improved insulation (less CO₂)
- Solar thermal cooling and heating
- Evacuated tube collectors; high temperature collectors
- Appropriate sensors (and correct interpretations)
- Performance monitoring tools for components and systems

Topic: Reduction /Metrics

Chosen technology:

~ knowledge development for standards and certification

What is reached using this technology

validation of policies / technologies
Performance data

Contribution to the main theme

Users / government awareness
Adoption of technologies

What does it build upon

DSM task 16

What steps are needed within the R&D programmes of the IEA:

Real data and validation
Knowledge development
Monitoring /assessment protocols development
Standards and policies

Topic: Reduction /systemintegration & user/producer

Chosen technology:

- ~ ICT / communication; open source building EM
- ~ building operation / energy system integration
- ~ standard metrics & communication protocol
- ~ BEMS
- ~ energy systems for residential buildings out of DH areas

What is reached using this technology

- Planning decision making
- Informing user about energy use
- Informing energy system operator

Contribution to the main theme

- Energy efficiency, better performance of existing systems
- Better performance throughout building lifetime

Existing technologies

What steps are needed within the R&D programmes of the IEA:

- R&D for knowledge on metrics relevant for environmentally friendly energy efficiency
- R&D on (simplified) tools for complex energy systems
- R&D optimal integration of HVAC, RES and storage for the target building types
- R&D control strategies for comfort & grid interaction & operational costs
- R&D sensor and ICT

Topic: Storage: Time indifferent

Chosen technology:

- ~Thermo chemical materials (TCM)
- ~Thermo chemical reactors (TCR)

What is reached using this technology?

- " By using TCM in TCR we aim at a factor 7-8 of compactness compared to water.
- " By separating two components we allow to use them time indifferent.
- " Building based storage component for retrofit purposes to enhance renewable heat/cold production (days/weeks)

Contribution to main E=0:

This technology allows the use of storage in existing buildings in order to facilitate more renewable energy contribution.

What does it build upon:

h

@ -

Research of TCM & TCM reactors

What steps are needed within the R&D programmes of the IEA:

- . Continuation of joint research activity by joint ECES/SHC task.
- . Material investigation
- . Reactors

Topic: Storage: Seasonal storage

Chosen technology:

- ~ UTES (aquifer storage)
- ~ CAES (compressed energy storage/ H₂ storage)
- ~ Other storage technologies

What is reached using this technology

- Balancing the electricity grid
- Relying the electricity grid from unpredictable RE production, eg, wind/ PV

Contribution to the main theme

- a 100% RE system in 2050
- More use of RE in the energy system
- Reduction CO₂ emission

What does it build upon

- Knowledge energy production, storage, e-management

Which steps are needed within the R&D programmes of the IEA:

- Define boundaries and perspectives of storage systems: for DH-stations or for single buildings or small clusters
- Define available technologies or newly developed technologies
- Demonstration project and monitoring
- Distinguish hourly / daily or monthly / seasonal balancing

Topic: Storage: Multiple Storage systems

Chosen technology:

- ~Heat and cold underground storage
- ~Multiple storage units in buildings

What is reached using this technology

- Balance heat/cold demand and supply on district level on annual basis

Contribution to the main theme

- Create thermally autonomous districts through storage

What does it build upon

- Current expertise & experience on heat and cold storage

Which steps are needed within the R&D programmes of the IEA:

- Demonstration project and monitoring
- Insight to model / manage these systems (desired temperature levels/how achievable)
- business case, governance models
- R&D on leakage

Topic: Storage: System dynamic modelling

Chosen technology/ methodology

- ~ system dynamics
- ~ Techno-economic dynamic simulations
- ~ Business and economical models
- ~ Energy system analyses
- ~ Energy management and control systems

What is reached using this technology

-

Contribution to the main theme

- Pre-requisite to highlight potential rate and limitations of storage

What does it build upon

- Existing building physics models
- Expand existing energy systems analysis models
- Micro economics
- Specific knowledge of different storage solutions/technologies

Which steps are needed within the R&D programmes of the IEA:

- System dynamic modelling of technological and economic interactions, including different modes of energy grids, local sources and buildings as "prosumers" as well as storage (define drivers – requirements – targets – scenarios)
- validation with case studies

Topic: Storage: Multifunctional facades

Chosen technology:

"Multi-functional facades and roofs

What is reached using this technology

Facades provide climate and acoustic protection, allowing daylight penetration/natural ventilation or mechanical ventilation air supply

Contribution to the main theme

Reduction in the need for active heating and cooling

What does it build upon

- _ECBCS Annex 43, 44, 49, 50, 52
- ECES Annex 24, SHC 42 PCM, Chemical storage

Which steps are needed within the R&D programmes of the IEA:

- Demonstration projects and monitoring
- Review state of the art multifunctional facades
- Applying Annex 43/24/42 approach to modelling
- Optimal integration with BEMS

Topic: Production: business model

Chosen technology:

- ~ risk assessment for planning and operation of RE production
- ~ Planning guidelines
- ~ Know how transfer and dissemination

What is reached using this technology

utilities become active promoters of RE systems

Contribution to the main theme

accelerate to re build energy production system (especially Electricity production towards RE)

What does it build upon

existing results (risk assessment/ guidelines) for RE technologies like geothermal, CSP, PV, Solar thermal, biomass, district heating, etc,

~ Which steps are needed within the R&D programmes of the IEA:

targeted grouping of existing results;

fill gaps of knowledge;

targeted dissemination

Set up cooperation for RE production (financing/ legal aspects / insurance / risk)

- **Support tools and reference datasets for local decision makers for the development and dissemination of sustainable energy systems for districts**
- Help cities make better decisions on energy systems for districts
- ESCO models and financing models with reliability and risk assessment
- develop services in stead of selling energy
- risk assessment of different RE technologies

Topic: Production: system integration (not only heat)

Chosen technology:

~ renewable heat sources compatible with heating needs/
network and low energy sources

~ Smart monitoring of building systems involving energy
efficiency and supply measures combinations for continued
operation optimization

What is reached using this technology

system integration on combining different renewable
sources; solar, geothermal etc. converting to heat

Contribution to the main theme

Reducing at community level; system integration

What does it build upon

Smart heating networks

~Which steps are needed within the R&D programmes of the IEA:

~ identify ambitious projects , extended monitoring, evaluable operation and optimization process

Develop standards

Provide feedback to manufacturers and facility managers

Develop relevant standards

R&D on feed in of heat in networks of waste heat; storage

Develop energy profiles: plan on urban / collective level

Identify ways to get efficient smart heat networks, where renewable sources can contribute

Identify technology to make the production units compatible and make the systems more
efficient as a whole

- need for tools: design methods, design/construction tools (open source) for planning, communication, decision making, monitoring
- Set up guidelines for early stage design (PV sizing / orientation)

Topic: Production: products

Chosen technology:

- ~ PV, ST, PV-t
- ~ Direct current to reduce losses to charging computers, phone etc.
- ~ Insulation material
- ~ Prefabrication
- ~ Local building regulations

What is reached using this technology

- Minimizing storage needs
- Avoiding over production at peak time

Contribution to the main theme

Collaboration between utilities and PV and building industry

What does it build upon

Roadmaps

Which steps are needed within the R&D programmes of the IEA:

- ~ R&D on retrofit solar facades
- ~ bring together real actors of building and solar industries
- ~ Need new technology for solar thermal
- ~ R&D balancing production - consumption time lines

Annex 5 List of participants

| PARTICIPANTS WORKSHOP FUTURE BULDINGS FORUM 11TH - 12TH APRIL 2013 | | | |
|---|---|----------------------|-------------|
| No. | Organisation | Name | |
| 1 | Swedish District Heating Ass. (DHC) | Ulrika Jardfelt | |
| 2 | NRC CNRC (ECBCS) | Morad Atif | Speaker |
| 3 | Fraunhofer Institute for Solar Energy Systems | Gerhard Stryi-Hipp | Speaker |
| 4 | International Energy Agency (ECBCS) | Marc LaFrance | |
| 5 | Building Research Institute, Japan (ECBCS) | Takao Sawachi | |
| 6 | Cukurova University (ECES) | Halime Paksoy | Speaker |
| 7 | IF International (ECES) | Aart Snijders | |
| 8 | SWECO | Olof Andersson | |
| 9 | McMaster University | Samir E. Chidiac | |
| 10 | VITO | Johan Desmedt | |
| 11 | ECBCS | J. Owen Lewis | |
| 13 | Consolair NL | Teun Bokhoven | |
| 14 | OA annex 51 (ECBCS) | Reinhard Jank | |
| 15 | Paulussen | Roger Cox | Speaker |
| 16 | IA SHC & NL Agency (SHC) | Lex Bosselaar | |
| 17 | IA ECBCS & NL Agency (ECBCS) | Piet Heijnen | |
| 18 | Immediate Past President CIBSE Technical Director Mott MacDonald | Andy Ford | |
| 19 | IA ECBCS | Andreas Eckmanns | Chair ECBCS |
| 20 | IA ECBCS | Malcolm Orme | |
| 21 | Zuyd Univerity | Ronald Rovers | Speaker |
| 22 | IA DSM | Rob Kool | Chair |
| 23 | PVPS | Paul Appleby | |
| 24 | Technische Universiteit Eindhoven | Wim Zeiler | |
| 25 | DNV Kema (DSM) | Yvonne Boerakker | |
| 26 | Passivhaus Institut | Dr. Bertold Kaufmann | |
| 27 | Sintef | Igor Sartori | |
| 28 | NL Agency | Bert Stuij | Host |
| 29 | - | Miimu Airaksinen | |
| 31 | IPEEC | Thibaud Voita | |
| 32 | NL Agency | Otto Bernsen | |
| 33 | SP (HPP) | Monica Axell | |
| 34 | TEP Energy | Martin Jakob | |

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|----|-------------|-------------------|--|
| 35 | IPEEC | Sung Moon Jung | |
| 36 | EPFL (PVPS) | Christian Roecker | |
| 37 | NL Agency | Marian Poolen | |

Annex 6 Existing Roadmaps

- ◁ Energy-efficient Building PPP beyond 2013; Research and Innovation Roadmap. E2B, 21th November 2012); E2B Association , Avenue de Cortenbergh 52, 1000 Brussels, BELGIUM
- ◁ Solar heating Roadmap; strategy and measures of the Solar Heating Industry for accelerated Market Growth to 2030 (july 2012); BSW Solar; German Solar Industry association; Quartier 207, Friedrichstrasse 78, 10117 Berlin
- ◁ Technology roadmap Solar heating and cooling from IEA; International Energy Agency, 9 rue de la Federation, 75015 Paris, France
- ◁ Energy technology perspectives 2012; Pathway to a clean Energy System; International Energy Agency, 9 rue de la Federation, 75015 Paris, France
- ◁ A Roadmap for moving to a competitive low carbon economy in 2050; Communication from the Commission to the European Parliament, the Council, The European Economic and social committee and the committee of the regions. Brussels , 8-3-2011 (COM (2011) 112 final
- ◁ OECD Environmental Outlook to 2050: The Consequences of Inaction; OECD Paris, 2, rue André-Pascal, 75775 Paris Cedex 16.
www.oecd.org/bookshopwww.oecd.org/environment/outlookto2050

Annex 7 Curriculum Vitae speakers

Prof.Dr. Halime Paksoy

Dr Paksoy is currently a professor in the Chemistry Department, and also the Director of the Center for Environmental Research at Çukurova University, Adana, Turkey. She is a chemical engineer who has been concentrating on thermal energy storage technologies since 1992. She serves as the Turkish Delegate and current Chair of the Executive Committee of the Energy Conservation through Energy Storage Implementing Agreement. Representing Turkey, Dr Paksoy has signed the Implementing Agreement with the International Energy Agency on behalf of Çukurova University in 1995. She is associate editor responsible for energy storage in the International Journal of Solar Energy Society.

Gerhard Stryi-Hipp

Gerhard Stryi-- Hipp is a physicist and is working in the solar energy sector since 1992. Until 2008, he was managing director of the German Solar Industry Association BSW-Solar and its predecessors. In 2009 he moved to the Fraunhofer Institute for Solar Energy Systems ISE as Head of Energy Policy and Group Leader Solar Thermal Systems. Gerhard Stryi-Hipp is doing research on solar thermal energy in the field of Photovoltaic-Thermal Hybrid Collectors and Solar-Active-Houses with high solar fraction of their heating demand.

Since 2011, he is coordinating the cross-cutting topic »Smart Energy Cities« at Fraunhofer ISE. He is member of the steering committee of the Fraunhofer project »Morgenstadt: City Insights«. Morgenstadt is the name for the systemic research of Fraunhofer for the city of the future.

Gerhard Stryi-Hipp is president of the European Technology Platform on Renewable Heating and Cooling since 2009.

Professor Ronald Rovers

Ronald Rovers is professor Sustainable Built Environment at Zuyd University of applied sciences, Heerlen, The Netherlands, and leading the Research institute Built environment of Tomorrow, RiBUILT. He is also director of the private Sustainable Building support centre, an intermediate organization which contributes to the promotion and international development of sustainable building through study tours, workshops, and consultancy.

He was chairman and organizer of the first World conference on Sustainable Building 2000, in Maastricht, Founding board member of iiSBE, the international initiative for a Sustainable Built Environment, and organizer of research and program of the third pan European ministers conference on sustainable housing. He developed Chinese experience in several projects, one of them as Program leader Sino-Dutch co-operation on Sustainable Building, for MOC, China, 2004-2006. He is honorary member Chinese Academy of Science and Technology, dpt.Wuxi.

Main research is aimed at developing closed cycle approaches for the building sector, at building level and area level: "from Less Bad to Good". At this moment he is supervisor for the project "the District of Tomorrow", a pilot project for 0- energy buildings and 0-impact neighborhood development. Major research is focused at maximum exergetic potentials /quality, in existing urban areas: the MAXergy methodology (Embodied Land) and Urban Harvest + model. With a special Focus on bamboo for construction.

See www.sustainablebuilding.info

Dr. Morad Atif

Director General NRC Institute for Research in Construction (NRC-IRC)

Dr. Morad Atif was appointed Director General of the NRC Institute for Research in Construction (NRC-IRC) in March 2010.

Since 1999, Dr. Atif had been Director of NRC-IRC's Indoor Environment Research Program. In this capacity, he was a member of the NRC-IRC management team and the director responsible for the Canadian Centre for Housing Technology, a collaborative partnership between NRC, Natural Resources Canada, and the Canada Mortgage and Housing Corporation.

Dr. Atif joined NRC-IRC as a research officer in 1993, after spending two years as a faculty member at Texas A&M University's College of Architecture and Department of Construction Science, where he earned a PhD in Architecture and Construction Science. He also holds a Masters degree in Architectural Technology from the University of California.

Dr. Atif has been a Steering Committee member of two federal programs, including the Panel for Energy Research and Development and EcoEnergy. He served on the Board of the Healthy Indoors Partnership, and was the Canadian Team Leader of the Green Building Challenge (1996-98). As a researcher at NRC, Dr. Atif has managed several consortium-funded and multidisciplinary projects, combining lighting, daylighting and the energy performance of buildings.

Dr. Atif is the author of more than 80 publications and the recipient of many awards, including two NRC Outstanding Achievement Awards, a Presidential award from the Illuminating Engineering Society of North America, and two Caudill Student Research Fellowships from Texas A&M University.

Annex 8 Photos



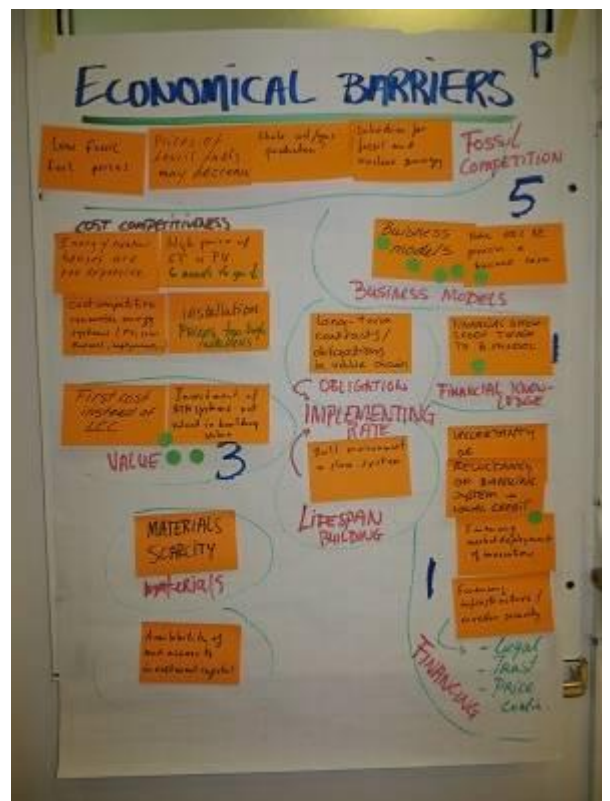
Andreas Eckmanns



Ronald Rovers



Workshop session on first day



Result of first workshop



Dinner discussions



Workshop session on second day



Workshop instructions



Presentation of workshop results

