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Steering through the maze #2

Nearly zero energy buildings: achieving the EU 2020 target

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Steering through the maze #2

Nearly zero energy buildings: achieving the EU 2020 target

Your eceee guide to issues related to the recast of the EPBD. Updated 8 February 2011

Background

Following the European Commission's proposal in November 2008 for an update of the 2002 Energy Performance of Buildings Directive (EPBD), the recast was adopted by the European Parliament and the Council of the European Union on 19 May 2010. One of the highlights of the recast is a strengthening of the energy performance requirements of new as well as existing buildings across the EU.

For new buildings, the recast fixes 2020 as the deadline for all new buildings to be "nearly zero energy" (and even sooner for public buildings – by the end of 2018). For existing buildings, Member States are required to draw up national plans to increase the number of nearly zero energy buildings, though no specific targets have been set. However, the Directive does not clearly define what a "nearly zero energy building" is, either for new build or refurbishment of existing buildings. Article 2(1a) gives a purely qualitative definition:

> A "nearly zero energy building" is a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

The timescales are further amplified in Article 9 of the Directive, which states that Member States shall ensure that:

> (a) by 31 December 2020, all new buildings are nearly zero-energy buildings; and
>
> (b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.

This paper considers the practicalities of various low/zero energy targets and illustrates where a number of Member States are on their journey towards nearly zero energy buildings. The position in Europe is compared with other countries/regions. A case study on the UK's path to defining zero carbon buildings is also provided.

A set of appendices is included:

- Appendix 1 discusses some of the issues pertaining to terminology and definitions around buildings that consume very low or zero energy (or carbon), including those with net energy production ("energy positive")
- Appendix 2 reproduces Article 9 of Energy Performance of Buildings Directive
- Appendix 3 contains a selection of relevant information sources
- Appendix 4 provides miscellaneous publications and articles
- Appendix 5 is a commentary on UK's Zero Carbon Target
- Appendix 6 provides abstracts on low/zero energy buildings from recent eceee and ACEEE summer studies

Is Zero Energy Achievable?

In determining the level of ambition to set in the recast of the EPBD, the European Commission undertook an Impact Assessment.[1] Several options were assessed, including *Option D4: Setting up EU–wide low or zero energy/carbon buildings/passive house requirements.* Compared to the other options for improving the energy performance of buildings assessed by the Commission, this option gave by far the largest energy and carbon savings and resulted in the largest number of jobs created (240,000-580,000). It also had a low administrative burden. However, they considered it may not be practical to introduce low energy building requirements in the short-term in all Member States, due to the pertaining low penetration rates, higher costs, lack of trained professionals and low readiness of the construction industry to deliver large quantities of low energy buildings in all EU Member States.

In conclusion, the Commission felt that such a requirement would pose a significant challenge to the construction industry to build such homes and would increase prices by 7% to 15%. It would also not respect the subsidiarity and proportionality principles, as it would require investments that are not in all cases cost-efficient and would create burdens for national budgets as they would have to support households that could not afford to build such low energy homes. Therefore, a softer approach was recommended, which was to include an obligation for the development of 'roadmaps,' wherein Member States would show their commitment toward achieving low energy/emission houses in the future and the concrete measures they plan to undertake.

Progress Towards Low & Zero Energy Buildings in EU Member States

A comprehensive description of the progress toward very low energy buildings across all Member States (together with Croatia, Norway and Switzerland) can be found in "*European National Strategies to move Towards Very Low Energy Buildings,*[2]" published by SBi, the Danish Building Research Institute at Aalborg University in 2008. A more detailed analysis in five Member States (Denmark, France, Germany, The Netherlands, and United Kingdom) can be found in "*Towards very low energy buildings*[3]", also published by SBi, in February 2009. The table below shows those countries with existing commitments, or proposals, to adopt low/zero energy building codes. Note that the level of aspiration, the way in which it is defined and the steps and timescales in which it is to be achieved vary considerably from country to country.

Selected National Targets for New Buildings

Country	**Target**
Denmark	75% by 2020 (c.f. base year 2006)
Finland	Passive house standards by 2015
France	By 2020 new buildings are energy-positive
Germany	By 2020 buildings should be operating without fossil fuel
Hungary	Zero emissions by 2020
Ireland	Net zero energy buildings by 2013
Netherlands	Energy-neutral by 2020 (proposed)
Norway	Passive house standards by 2017
UK (England &Wales)	Zero carbon as of 2016 (see box overleaf)

Adapted from: SBi (Danish Building Research Institute), "European National Strategies to move towards very low energy buildings", 2008

[1] http://ec.europa.eu/energy/strategies/2008/doc/2008_11_ser2/buildings_impact_assesment.pdf

[2] http://www.euroace.org/EuroACE%20documents/080313%20SBI%20Survey%20-%20European%20national%20strategies%20to%20move%20towards%20very%20low%20energy%20buildings%20-%20March%202008.pdf

[3] http://www.sbi.dk/miljo-og-energi/lavenergibyggeri/towards-very-low-energy-buildings

As one of the first countries to have committed to a "zero carbon" target for buildings, the UK presents an interesting example of the process towards this goal. This is presented in the box below (see also commentary in Appendix 5).

UK CASE STUDY – Towards a Definition of Zero Carbon

In 2006, the Government declared its ambition of **"a target for all new homes to be zero carbon within a decade".**

Since then, a raft of consultation documents, task groups, workshops and discussions have ensued to determine what the target means in practice. A high level "2016 Taskforce" was set up by Government, together with a "Zero Carbon Hub[4]" to support and report to the Taskforce. In 2009, the Zero Carbon Hub set out a 3-stage hierarchical approach to achieving 'zero carbon' for dwellings in England & Wales[5]. This approach has largely been accepted by Government:

1. Ensuring an energy efficient approach to building design;
2. Reducing CO_2 emissions on-site via low/zero carbon technologies and heat networks;
3. Mitigating the remaining carbon emissions with a selection of *Allowable Solutions*.

Originally, the proposal was that at least 70% of the target must be achieved in "regulated CO_2 emissions," covered by items 1 and 2 above. The balance, namely the *Allowable Solutions,* (set out in a Ministerial Statement in July 2009) includes:

- further carbon reductions on site beyond the regulatory standard
- energy efficient appliances installed as fittings within the home
- advanced building control systems which reduce the level of energy use in the home
- exports of low carbon or renewable heat from the development to other developments
- investments in low and zero carbon community heat infrastructure
- other allowable solutions remain under consideration

The Department for Communities & Local Government (CLG) issued consultations in 2009 on the definition of zero carbon for domestic[6] and non-domestic[7] buildings. In response, the Zero Carbon Hub's published its interim recommendations on carbon compliance in December 2010[8]. They found that the proposal from July 2009, to tighten the carbon compliance standard from 2016 by 70**%** (equivalent to 6 kg $CO_{2(eq)}/m^2$/year), may not be achievable in all cases. The latest recommendations are that the "built performance" emissions from new homes should not exceed:

- **10 kg $CO_{2(eq)}/m^2$/year for detached houses;**
- **11 kg $CO_{2(eq)}/m^2$/year for other houses;**
- **14 kg $CO_{2(eq)}/m^2$/year for low rise apartment blocks**

They also recommend an option for carbon compliance to be assessed across the whole of a development site, instead of by individual dwelling. A further key recommendation is to ensure that the gap between "as designed" and "as built" standards is closed.

[4] http://www.zerocarbonhub.org/

[5] http://www.zerocarbonhub.org/resourcefiles/FEES_ExecSummary_Final_for_Web.pdf

[6] http://www.communities.gov.uk/publications/planningandbuilding/futureofcodeconsultation

[7] http://www.communities.gov.uk/publications/planningandbuilding/newnondomesticconsult

[8] http://www.bdonline.co.uk/Journals/60/Files/2010/12/21/Carbon_Compliance_Interim_Report_16_12_10.pdf

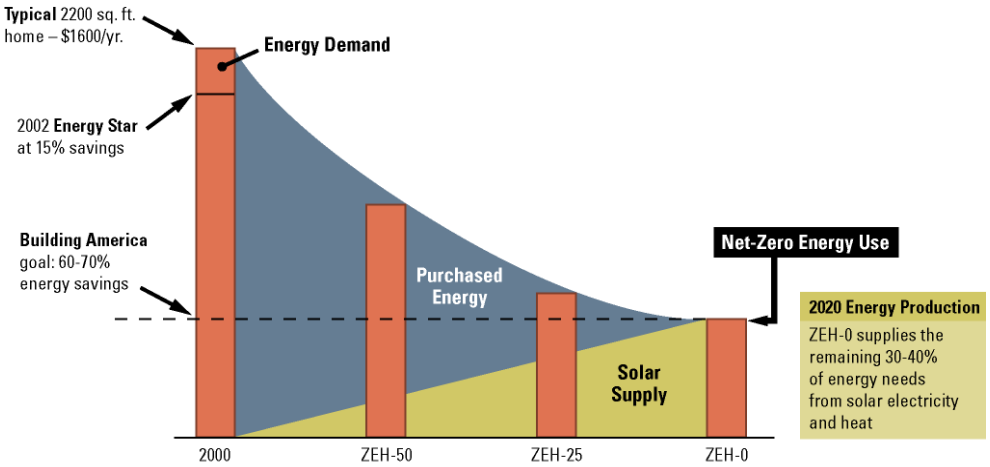
How does Europe Compare with other IEA Countries/Regions?

Laustsen,[9] in his 2008 IEA report on building codes, assessed the overall u-value performance of IEA member countries. He found a big difference in the requirements in the four main IEA regions (Europe, North America, Japan, Australia/New Zealand). Also, he found that in Europe, there are substantial differences between the northern and the southern parts. Conversely, in North America, the requirements seem to be more homogenous, probably because of the adoption by different states of model codes for energy efficiency: International Energy Conservation Code (IECC)[10] and ASHRAE.[11]

The strictest code at the time of writing (2008) in terms of overall u-value was found in Sweden with an overall value close to 0.7, followed by Denmark (0.77), Norway (0.84), Ontario (for the coldest part of the climate) (0.93), and Finland (0.94).

He concludes that the main level for prescriptive values in the building codes in Central Europe and North America are broadly similar. Levels in Japan and Australia/New Zealand are much less stringent (i.e. higher u-values). However, in terms of future standards, Europe is leading the way, with many countries having already set targets for zero energy or zero carbon by 2020.

In the United States, the Government's Building America[12] programme is focused on research and promotion of the drive towards zero energy buildings. The schematic below sets out the pathway envisaged by Building America towards a Zero Energy Home. Some states have begun to set out their ambitions towards NZEB: California has committed to achieving zero net energy for all residential construction by 2020, and for all commercial construction by 2030[13], while Massachusetts plans to achieve NZEB for all buildings by 2030.[14]



Source – Laustsen (IEA)

[9] Laustsen, J. (2008). Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings. International Energy Agency (IEA) http://www.iea.org/g8/2008/Building_Codes.pdf

[10] http://www.iccsafe.org/Store/Pages/Product.aspx?id=3800X09

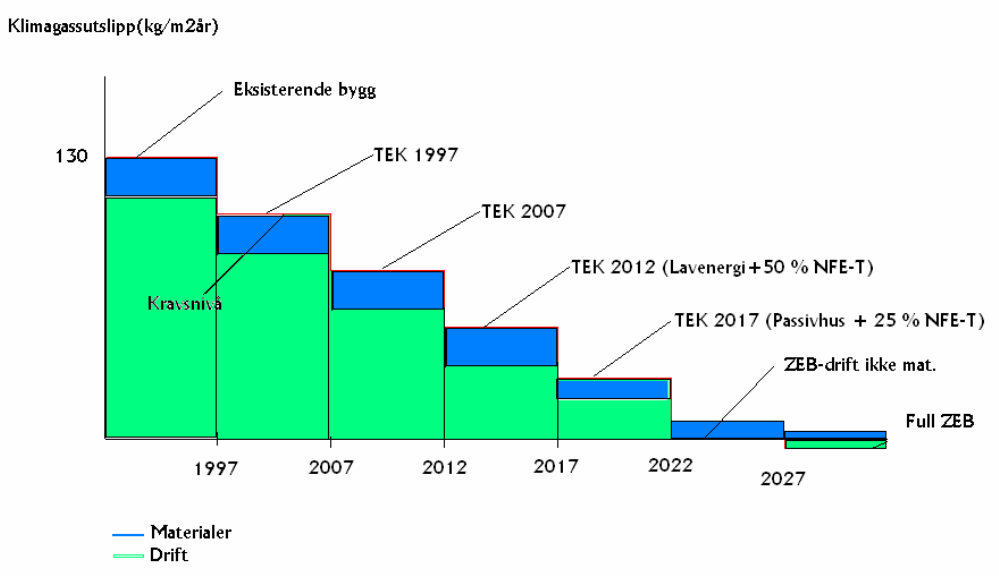
[11] http://www.ashrae.org/

[12] http://www1.eere.energy.gov/buildings/building_america/about.html

[13] http://www.californiaenergyefficiency.com/index.shtml

[14] http://www.mass.gov/Eoeea/docs/eea/press/publications/zneb_taskforce_report.pdf

Meanwhile, in Norway, the "Low Energy Commission" report of August 2009 proposes a stepwise tightening of the Building Code. The primary objective is to develop solutions for existing and new buildings, both residential and commercial, in order to bring about a breakthrough for buildings with **zero greenhouse gas emissions associated with their construction, operation, and demolition**[15].



Next Steps

Member States have obligations to prepare national plans on promoting nearly zero-energy buildings. These national plans may include targets differentiated according to the category of building. Full details of the requirements are provided in Article 9 of the Directive (see Appendix 2).

Numerous government bodies, research institutes and other organisations are actively investigating practical aspects relating to the delivering of the EU target for nearly zero energy buildings. Appendix 3 lists a selection of other sources of information, both from within the EU and internationally. Among these is the Buildings Performance Institute Europe (BPIE),[16] which was established in 2010 with a mission to improve the energy performance of buildings across Europe.

An ongoing BPIE study entitled "**Mandatory low-energy buildings from 2020"** will facilitate implementation of the ambitious efficiency target for all EU member states by developing a common and cross-national understanding of definition criteria, possible technical solutions and implications for national building markets (building materials, equipment, labour force). The study is expected to be available in summer 2011. Further information on the study will be available on the BPIE website.

This eceee briefing paper will be updated periodically when new material becomes available.

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[15] http://files.portal.aau.dk/filesharing/download?filename=aau/nvc/zeb/~/pub/konference2010/praesentationer/Anne_Grete_Hestnes_The_Norwegian_Approach.Aalborg.pdf

[16] http://www.bpie.eu/

Appendix 1

Definitions for Low/Zero Energy Buildings

A wide range of terms and descriptions is used in discussions on low and zero energy buildings. The definition of a net zero energy building (NZEB) used by the Industry Committee during the negotiations on the recast is provided below, though ultimately, the final document adopted the less stringent requirement of "nearly zero energy building" (see Appendix 2) as opposed to "net zero energy building":

> "a net zero energy building is where, as a result of the very high level of energy efficiency of the building, the overall annual primary energy consumption is equal to or less than the energy production from renewable energy sources on site".

Torcellini et al (ACEEE 2006) identified the following main definitions of zero energy buildings (ZEB)[17]:

Net Zero Site Energy: A site ZEB produces at least as much energy as it uses in a year, when accounted for at the site.

Net Zero Source Energy: A source ZEB produces at least as much energy as it uses in a year, when accounted for at the source. Source energy refers to the primary energy used to generate and deliver the energy to the site. (NB this is equivalent to the Industry Committee's definition.)

Net Zero Energy Costs: In a cost ZEB, the amount of money the utility pays the building owner for the energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.

Net Zero Energy Emissions: A net-zero emissions building produces at least as much emissions-free renewable energy as it uses from emissions-producing energy sources. (In other words, a **Zero Carbon Building.**)

The pros and cons of these four definitions are summarised in the table overleaf.

Two further definitions have been extracted from **"***A literature review on ZEB definitions - Draft report for discussion*" A. Marszal, P. Heiselberg; Aalborg University, Denmark 2009 (unpublished):

- The U.S. Department of Energy (DOE) Building Technologies Program defines ZEB thus: "A net zero-energy building (ZEB) is a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies." However they also point out that: "Despite the excitement over the phrase "zero energy," we lack a common definition, or even a common understanding, of what it means."

- Laustsen, in the 2008 International Energy Agency report on buildings[18], gives the following definition: **Zero Net Energy Buildings** are buildings that over a year are neutral, meaning that they deliver as much energy to the supply grids as they use from the grids.

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17 Zero Energy Buildings: A Critical Look at the Definition P. Torcellini, S. Pless, and M. Deru National Renewable Energy Laboratory D. Crawley U.S. Department of Energy To be presented at ACEEE Summer Study Pacific Grove, California August 14−18, 2006 http://www.nrel.gov/docs/fy06osti/39833.pdf

18 Laustsen, J. (2008). Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings. International Energy Agency (IEA) http://www.iea.org/g8/2008/Building_Codes.pdf

Table 1. ZEB Definitions Summary (Torcellini et al)

Definition	Pluses	Minuses	Other Issues
Site ZEB	• Easy to implement. • Verifiable through on-site measurements. • Conservative approach to achieving ZEB. • No externalities affect performance, can track success over time. • Easy for the building community to understand and communicate. • Encourages energy-efficient building designs.	• Requires more PV export to offset natural gas. • Does not consider all utility costs (can have a low load factor). • Not able to equate fuel types. • Does not account for non-energy differences between fuel types (supply availability, pollution).	
Source ZEB	• Able to equate energy value of fuel types used at the site. • Better model for impact on national energy system. • Easier ZEB to reach.	• Does not account for non-energy differences between fuel types (supply availability, pollution). • Source calculations too broad (do not account for regional or daily variations in electricity generation heat rates). • Source energy use accounting and fuel switching can have a larger impact than efficiency technologies. • Does not consider all energy costs (can have a low load factor).	• Need to develop site-to-source conversion factors, which require significant amounts of information to define.
Cost ZEB	• Easy to implement and measure. • Market forces result in a good balance between fuel types. • Allows for demand-responsive control. • Verifiable from utility bills.	• May not reflect impact to national grid for demand, as extra PV generation can be more valuable for reducing demand with on-site storage than exporting to the grid. • Requires net-metering agreements such that exported electricity can offset energy and nonenergy charges. • Highly volatile energy rates make for difficult tracking over time.	• Offsetting monthly service and infrastructure charges require going beyond ZEB. • Net metering is not well established, often with capacity limits and at buyback rates lower than retail rates.
Emissions ZEB	• Better model for green power. • Accounts for non-energy differences between fuel types (pollution, greenhouse gases). • Easier ZEB to reach.	• Need appropriate emission factors.	

Appendix 2

Article 9 of Energy Performance of Buildings Directive

1. Member States shall ensure that:

(a) by 31 December 2020, all new buildings are nearly zero- energy buildings[19]; and

(b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.

Member States shall draw up national plans for increasing the number of nearly zero-energy buildings. These national plans may include targets differentiated according to the category of building.

2. Member States shall furthermore, following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings, and inform the Commission thereof in their national plans referred to in paragraph 1.

3. The national plans shall include, inter alia, the following elements:

(a) the Member State's detailed application in practice of the definition of nearly zero-energy buildings, reflecting their national, regional or local conditions, and including a numerical indicator of primary energy use expressed in kWh/m^2 p.a. Primary energy factors used for the determination of the primary energy use may be based on national or regional yearly average values and may take into account relevant European standards;

(b) intermediate targets for improving the energy performance of new buildings, by 2015, with a view to preparing the implementation of paragraph 1;

(c) information on the policies and financial or other measures adopted in the context of paragraphs 1 and 2 for the promotion of nearly zero-energy buildings, including details of national requirements and measures concerning the use of energy from renewable sources in new buildings and existing buildings undergoing major renovation in the context of Article 13(4) of Directive 2009/28/EC and Articles 6 and 7 of this Directive.

4. The Commission shall evaluate the national plans referred to in paragraph 1, notably the adequacy of the measures envisaged by the Member State in relation to the objectives of this Directive. The Commission, taking due account of the principle of subsidiarity, may request further specific information regarding the requirements set out in paragraphs 1, 2 & 3. In that case, the Member State concerned shall submit the requested information or propose amendments within nine months following the request from the Commission. Following its evaluation, the Commission may issue a recommendation.

5. The Commission shall by 31 December 2012 and every three years thereafter publish a report on the progress of Member States in increasing the number of nearly zero-energy buildings. On the basis of that report the Commission shall develop an action plan and, if necessary, propose measures to increase the number of those buildings and encourage best practices as regards the cost-effective transformation of existing buildings into nearly zero-energy buildings.

6. Member States may decide not to apply the requirements set out in points (a) and (b) of paragraph 1 in specific and justifiable cases where the cost-benefit analysis over the economic lifecycle of the building in question is negative. Member States shall inform the Commission of the principles of the relevant legislative regimes.

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[19] 'Nearly zero-energy building' means a building that has a very high energy performance, as determined in accordance with Annex I "**Common general framework for the calculation of energy performance of buildings"**. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, either produced on-site or nearby;

Appendix 3 – Selected Information Sources

(a) EU Initiatives and Sources of Further Information

- The **Buildings Performance Institute Europe (BPIE)** http://www.bpie.eu/ is dedicated to improving the energy performance of buildings across Europe, and thereby helping to reduce CO_2 emissions from the energy used by buildings.

- European Commission page on Energy Efficiency in Buildings: http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm

- **BUILD UP -** The web portal was established by the European Commission in 2009 to support EU Member States in implementing the Energy Performance of Buildings Directive (EPBD). www.buildup.eu

- The **Concerted Action (CA) EPBD** was launched by the European Commission to promote dialogue and exchange of best practice on the Buildings Directive. http://www.epbd-ca.org/

- **Intelligent Energy Europe (IEE)** – a number of ongoing projects relate to the development of highly energy efficient and zero energy buildings:
    - − **PASS-NET**, Co-operation network of passive house promoters (http://www.pass-net.net).
    - − **INTENSE**, Supporting municipalities with energy saving measures throughout Central and Eastern Europe
    - (http://www.intense-energy.eu).
    - − **CEPH**, Training and certification of European Passive House Designers (http://www.passivehousedesigner.eu).
    - − **NORTHPASS**, Putting the Passive House concept on the North European map (http://www.northpass.eu).
    - − **ILETE**, Low Energy Training in European regions (http://www.ilete.eu).

    - More details on the IEE programme and the EACI are available on-line (http://ec.europa.eu/intelligentenergy).
    - More information on the projects funded by IEE can be found in the on-line project database (http://ec.europa.eu/energy/intelligent/projects).
    - Useful tools and guidebooks resulting from IEE and other projects can be also downloaded from the Intelligent Energy e-library (http://www.iee-library.eu)

(b) European national initiatives and Sources of Further Information

- **Passivhaus Institut** – The German Passive House Institute - http://www.passiv.de/

- **MINERGIE®** - a Swiss sustainability brand for new and refurbished buildings - www.minergie.ch

- **EFFINERGIE** - French standard for low energy buildings - www.effinergie.org

- **Norwegian** Research Centre on Zero Emission Buildings www.zeb.no

- **Zero Carbon Hub** is a UK public/private partnership established to take operational responsibility for co-ordinating delivery of low and zero carbon new homes. http://www.zerocarbonhub.org/

- The **EPBD Implementation Advisory Group** - established to advise the UK Government upon the Directive's effective and timely implementation http://www.diag.org.uk/

- Dutch **Energy Innovation Agenda** – see Built Environment chapter http://www.senternovem.nl/mmfiles/Energy%20Innovation%20Agenda%2009-09-2008_tcm24-281800.pdf

- **The built environment of the Netherlands** - 'An outlook on energy-neutral new construction and sustainable existing buildings' http://www.senternovem.nl/mmfiles/Energy%20Innovation%20Agenda%20-%20The%20built%20environment%20of%20the%20Netherlands_tcm24-306299.pdf

- Dutch **Energy Transition in the Built Environment** Platform http://www.creative-energy.org/

- The Dutch "**WAELS**" research project aims to demonstrate that an energy-supplying home is one of the possibilities for the future. This is being done through research in three distinct fields: development of a building system; efficient conversion of sunlight; and compact heat storage http://www.ecn.nl/nl/nieuws/newsletter-en/february-2009/energy-source-dwelling/

- **Active House** is a vision of a future paradigm for construction. It is a holistic design model, reflecting the balance between energy design and living, thus creating optimal indoor climate through a dynamic building envelope which is CO_2 neutral.http://www.activehousing.net/

- "**Energy Balance - Optimal System Solutions for Renewable Energies and Energy Efficiency**" German research project to identify and present real system solutions at which renewable energies and efficiency have been successfully linked for an optimal energy balance – see chapter on buildings http://www.wupperinst.org/en/projects/proj/index.html?projekt_id=192&bid=43&searchart=projekt_uebersicht

- A new **knowledge centre for energy savings in buildings** was inaugurated in April 2009 by the Danish Minister for Climate and Energy Connie Hedegaard. The centre, located at the Technological Institute in Tåstrup near Copenhagen, highlights the importance of training and skills needed to achieve near zero energy buildings and low carbon refurbishment. http://www.denmark.dk/en/servicemenu/news/environment-energy-climate-news/knowledgecentrepresentsenergysavingsolutions.htm

(b) International Initiatives and Sources of Further Information

- **IEA Joint Project:** Solar Heating & Cooling Programme:
    - Towards Net Zero Energy Solar Buildings (Task 40) www.iea-shc.org/task40/index.html;
    - Energy Conservation in Buildings & Community Systems (Annex 52) www.ecbcs.org/annexes/annex52.htm#p

- **World Business Council for Sustainable Development's** Energy Efficiency in Buildings (EEB) project is a leading industry-only group working towards a world where buildings consume zero net energy. http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?type=p&MenuId=MTA5NQ&doOpen=1&ClickMenu=LeftMenu

- **World Green Building Council** (WorldGBC) is a union on national Green Building Councils (GBCs) whose mission is to accelerate the transformation of the built environment towards sustainability. The website contains links to existing and emerging GBCs in various countries. http://www.worldgbc.org/

(d) North American Initiatives and Sources of Further Information

- **R-2000** - Developed in partnership with Canada's residential construction industry, R-2000 is an initiative of the Office of Energy Efficiency to promote the use of cost-effective energy-efficient building practices and technologies. http://oee.nrcan.gc.ca/residential/personal/new-homes/r-2000/About-r-2000.cfm?attr=4

- Canadian **Net-Zero Energy Home (NZEH) Coalition** aims to advance the benefits of the more efficient use of zero or very low impact resources. http://www.netzeroenergyhome.ca/

- **Building America** is an industry-driven research program, sponsored by the U.S. Department of Energy, designed to accelerate the development and adoption of advanced building energy technologies in new and existing homes. http://www1.eere.energy.gov/buildings/building_america/about.html

- **Energy Star** is the largest US initiative defining low-energy homes. In 2008 the US Department of Energy launched a programme with the ultimate goal to spread zero energy housing over the US. Currently, participating builders commit to constructing new homes that achieve 30% savings on a home energy rating scale. http://www.energystar.gov/index.cfm?c=new_homes.hm_index

- **The Zero Energy Commercial Buildings Database** features profiles of commercial buildings that produce as much energy as they use over the course of a year. The database highlights projects from across the US and provides ideas that can be applied to any new building. http://zeb.buildinggreen.com/

- **Massachusetts Zero Net Energy Buildings Task Force** sets out on an aggressive agenda to address global climate change, reduce greenhouse gas emissions, and develop a vital clean energy sector that provides both energy security and economic prosperity. http://www.mass.gov/?pageID=eoeeatopic&L=3&L0=Home&L1=Energy%2c+Utilities+%26+Clean+Technologies&L2=Energy+Efficiency&sid=Eoeea

- **Zero Energy Building Research Alliance (ZEBRAlliance)** is a research project and an education campaign. Energy efficient components integrated into the construction of new homes will be tested in order to provide homeowners with information on how to buy the best energy efficient technologies for their homes. http://www.zebralliance.com/

- **Seven Steps to a Zero Energy Home,** developed by ToolBase Services, the US housing industry's resource for technical information on building products, materials, new technologies, business management, and housing systems. http://www.toolbase.org/Home-Building-Topics/zero-energy-homes/seven-steps-zeh

- **ASHRAE: Guidance for Net-Zero Energy Design -** A series of Advanced Energy Design Guides as a step in the process toward achieving a net zero energy building. http://www.ashrae.org/technology/page/938 See also Net-Zero & Beyond conference, 2009 http://www.ashrae.org/events/page/2182

- **California's Long Term Energy Efficiency Strategic Plan** includes two "Big Bold Strategies" on zero energy buildings:
  - All new residential construction in California will be zero net energy by 2020; and
  - All new commercial construction in California will be zero net energy by 2030.

http://www.californiaenergyefficiency.com/index.shtml

Zero Energy Building Award (US) - To help spur the market for zero energy buildings in the Northeast, the Northeast Sustainable Energy Association (NESEA) has developed the ZERO-Energy Building Award to recognize net-zero-energy buildings designed for the unique northeast climate. Winners will be announced at the Building Energy Conference and Trade Show in March, every year. http://www.zeroenergybuilding.org/

Zero Energy Commercial Buildings Database (US) - features profiles of commercial buildings that produce as much energy as they use over the course of a year. It is part of the High Performance Buildings Database which lists many additional projects. Visit the High Performance Buildings Database to discover more energy efficient building techniques. http://zeb.buildinggreen.com/

Massachusetts Zero Net Energy Buildings Task Force - The north-eastern US state of Massachusetts has set out on an aggressive agenda to address global climate change, reduce greenhouse gas emissions, and develop a vital clean energy sector that provides both energy security and economic prosperity for its citizens. State Governor has established a Task Force of experts and local leaders who can examine the prospect of zero net energy buildings, both commercial and residential.
http://www.mass.gov/Eoeea/docs/eea/press/publications/zneb_taskforce_report.pdf
http://mazneb.org/

The Zero Energy Building Research Alliance (ZEBRAlliance) is both a research project and a residential efficiency education campaign. It enables new energy-efficient components to be tested in order to provide homeowners with information on how to buy the best energy efficient technologies for their homes. http://www.zebralliance.com/

Appendix 4

Miscellaneous Publications and Articles

Zero Energy Buildings: A Critical Look at the Definition
http://www.nrel.gov/docs/fy06osti/39833.pdf

Federal R&D Agenda for Net-Zero Energy, High-Performance Green Buildings, National Science & Technology Council, October 2008 (US)
http://www.bfrl.nist.gov/buildingtechnology/documents/FederalRDAgendaforNetZeroEnergyHighPerformanceGreenBuildings.pdf

A Cold-Climate Case Study for Affordable Zero Energy Homes
http://www.nrel.gov/docs/fy06osti/39678.pdf

Countdown to a Sustainable Energy Future...Net-Zero and Beyond conference, March 2009 This ASHRAE conference provided a forum to discuss the role of policy and regulatory involvement in addition to providing application knowledge for the various aspects of net-zero-energy buildings,both residential and non-residential.
http://www.ashrae.org/events/page/2182

ASHRAE Guidance for Net-Zero Energy Design
http://www.ashrae.org/pressroom/detail/16503

Building-a-Better-Future – Moving toward zero pollution with highly efficient homes and businesses, *PennEnvironment Research & Policy Center, April 2009*
https://www.pennenvironment.org/uploads/fX/sa/fXsaxyJXXs6Ky_6ILJMKAg/Building-a-Better-Future.pdf

Are Zero Energy Buildings a Bridge too Far? Discusses the pros and cons on onsite, offsite and community based solutions. http://www.leonardo-energy.org/are-zero-energy-buildings-bridge-too-far

Zero Energy Buildings in the EU by 2019? Is it realistic to make zero energy buildings mandatory and impose zero energy standards to a certain percentage of refurbished buildings by 2019? http://rhein.blogactiv.eu/2009/04/27/zero-energy-buildings-in-the-eu-by-2019/

Seven Steps to a Zero Energy Home http://www.toolbase.org/Home-Building-Topics/zero-energy-homes/seven-steps-zeh

SINGAPORE'S nascent green building industry
http://wildsingaporenews.blogspot.com/2009/05/green-buildings-can-cost-less-if-design.html

Seminar on Zero Energy Building, Singapore, July 2008
http://www.dhbvn.com/main/conservation/zeroenergy.pdf

GE Targets Net Zero Energy Homes by 2015 (14th July 2009) **-** GE announced that by 2015 it is developing a turn-key product portfolio that will enable an overall net zero annual energy cost.
http://www.genewscenter.com/content/detail.aspx?releaseid=7272&newsareaid=2

The largest Passivhaus development in the UK - the Perryfields development in Dorset will have 66 energy efficient homes and provide a mixture of private and social housing. It is being built by Lomand Homes and will feature energy saving and environmentally friendly insulation systems.
http://www.edie.net/news/news_story.asp?src=nl&id=19163

european council for an energy efficient economy

Appendix 5

Commentary on UK's Zero Carbon Target

(i) UK position on the Definition of Zero Carbon - feedback from workshops organised by the Zero Carbon Hub[20] held in February 2009 on the CLG consultation "Definition of Zero Carbon"[21]

The overall majority of delegates (over 90%) agreed or strongly agreed that the Government should legislate for higher energy efficiency in homes. This view was consistent across all parties represented. The overall perception of the challenge posed by high energy efficiency standards (which were described broadly as EST Advanced Practice[22]/PassivHaus standards) was very mixed. Some features, such as provision of high efficiency windows and highly insulated floors, walls and roofs, were generally seen as less challenging, whereas achieving very low air leakage rates and eliminating thermal bridges were regarded as much bigger challenges. The achievement of design standards on site, however, was considered by delegates to be the most demanding challenge.

On the timing of advice on energy efficiency, the majority of people wanted to see the requirements for 2016 specified with the 2010 update of Part L. Carbon compliance (energy efficiency plus on-site low and zero carbon technologies) is a central issue in the consultation. The consultation explains that achieving zero carbon through carbon compliance alone is impractical for individual developments in most situations. The consultation therefore invited views on three alternative carbon compliance levels: reductions of 44%, 70% and 100%. Once the pros and cons of these options were clarified, the **70% option was most favoured by delegates** at the Zero Carbon Hub events. Nearly 80% of consultants were in favour of carbon compliance set at 70% or above. With developers/housebuilders, there was a split vote with about 51% preferring carbon compliance set at 70% or above and 49% preferring carbon compliance set at 44%.

A high proportion of delegates (78%) voted in favour of a variable-level carbon compliance that would result in an equally challenging target across different dwelling types. On the cost of carbon compliance, 45% of delegates with experience of low carbon homes felt that the cost figures in the consultation document were underestimating the true costs that would be incurred in 2013 and 2016. A system of 'allowable solutions' is offered in the consultation, to give the industry and its clients flexibility over how to step up from the carbon compliance level to achieve the zero carbon target. The allowable solutions are essentially ideas at this stage and are offered in the consultation to gauge their potential. Delegates were therefore contributing feedback without the benefit of specific information on how each might work in practice. Typically, three quarters of delegates acknowledged high potential or some potential for each idea. The allowable solution considered to have most potential at this point was the one that gave credit for energy efficient appliances and controls. The one considered to have least potential was the idea that gave credit for export of low/zero carbon heat to existing local buildings.

Feedback from delegates at the events, and from a range of visits attended by the Zero Carbon Hub during the consultation period, indicated considerable concern over the

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[20] http://www.zerocarbonhub.org/downloads/ZCH-C55-Feedback-v3.pdf

[21] http://www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition

[22] Available at http://www.energysavingtrust.org.uk/corporate/Global-Data/Publications/Demonstrating-Compliance-Advanced-Practice

complexity of the overall framework for the allowable solutions approach and how the individual allowable solutions would be delivered in practice. The large majority of delegates favoured 2012 or earlier as the date for carrying out a review of the allowable solutions.

On who should enforce the zero carbon targets in homes, there was broad consensus that building control should be responsible for overseeing the energy efficiency and carbon compliance levels. For the enforcement of the allowable solutions, some of which are effectively off-site or sometimes remote activities, the consensus favoured the establishment of a new accredited body.

Delegates felt very strongly that the definition being developed through this consultation should also be applied to the energy section of the Code for Sustainable Homes. Although not detailed in this report, delegates felt very strongly that the definition and framework for zero carbon homes should be carried over and applied to non-domestic buildings. Feedback from the events is highly instructive and provides clear messages for the Zero Carbon Hub in its facilitation role. It identifies consensus on certain issues and differing opinions in others. It also identifies areas where industry has concerns about delivery and areas where it is more confident.

For further information on the costs of achieving zero carbon, please see the report "Costs and Benefits of Alternative Definitions of Zero Carbon Homes: Project report"[23]

(iv) Feasibility of zero carbon homes in England by 2016: A house builder's perspective.

A new study has surveyed major house builders in the UK to understand what is needed if all new homes are to be zero carbon by 2016. The house builders generally felt that it is not an impossible challenge, but a comprehensive approach with clear guidelines, supported by necessary legislation is required. The results provide important lessons for sustainable construction programmes in other countries.

The UK has set itself a 'world-beating' target: aiming for all new homes to be zero carbon by 2016 in its 'Code for Sustainable Homes', published in 2006. In order to be zero carbon, buildings must generate as much energy as they consume. The Code for Sustainable Homes uses environmental impact rating system of 1 to 6 to indicate overall sustainability of a new house: a rating of 6 equates to a zero carbon home, which specifies that required domestic energy must be generated from renewable sources. This exceeds other international housing standards. For example, Germany's 'PassivHaus' sets a maximum level of energy usage (15 kWh/m2 a year for heating and cooling), but does not specify the source of energy.

The house builders' responses to the survey suggest:

- The Code for Sustainable Homes is a significant driver of zero carbon homes.
- New technologies and products would also significantly help builders achieve the target. Zero carbon homes are not considered possible with today's technologies and so the supply chain is seen as a major barrier. Sufficient resources are needed for the government and building industry to research and develop appropriate and cost effective technologies.
- There are no financial incentives for producing zero carbon homes. Additionally, there is much uncertainty about how much it will cost to build a zero carbon building, but it is generally considered to be more than a standard house.
- The most significant legislative barrier was an unclear definition of 'zero carbon'. Builders were unsure of the requirements, for example, the need to provide onsite renewable energy. Appropriate guidelines would be beneficial. For instance, does

[23] http://www.communities.gov.uk/publications/planningandbuilding/definitionszerocarbonhomes

renewable energy distributed at a district level by Energy Service Companies (ESCOs), rather than onsite, count towards zero carbon status?
- There was concern over the reliability of renewable technologies. An alternative and more cost-effective solution to providing onsite renewable energy would be to distribute renewable energy from ESCOs.
- Consumers need to be made aware of the benefits of zero carbon homes, although there have been recent signs of increased demand for such homes. As such, the house builders called for the government to act upon this growing demand and legislate to create a national market for zero carbon homes.

http://europa.eu/scadplus/leg/en/lvb/l27042.htm
http://www.planningportal.gov.uk/england/professionals/en/1115314116927.html

Source: Osmani, M. and O'Reilly. (2009). Feasibility of zero carbon homes in England by 2016: A house builder's perspective. *Building and Environment*. 44:1917-1924.
Contact: m.osmani@lboro.ac.uk

(v) Could Community Energy Fund drive UK to zero carbon homes? (23 Dec 10)
Industry groups are calling for the creation of a Community Energy Fund to boost the UK's progress in making all new homes zero carbon by 2016. Housing minister Grant Shapps confirmed on December 20th that the government is examining ways that housebuilders can reduce emissions in homes by supporting such renewable energy schemes in their area. He said that a Community Infrastructure Levy will give councils the power to build new housing developments and contribute funds towards local renewable energy generation.

Mr Shapps also welcomed the Zero Carbon Hub's report on a national benchmark for measures of zero carbon. It recommended building homes with renewable energy on site, such as solar power and heat pumps. He stated: "We're serious about building greener homes, but also committed to finding the most practical way of doing this. And for good reasons - if we're going to be successful in reducing our carbon emissions, we need to ensure the councils and developers who are actually going to deliver these changes are on board."

A Task Group convened by the Zero Carbon Hub has delivered a report to the Minister for Housing and Local Government setting out its recommendations for carbon compliance levels for new homes from 2016. Carbon Compliance – that is, on-site reductions in emissions – form part of the Government's overall plan for achieving zero carbon homes; the other part comprises off-site "allowable solutions."

http://www.greenbuildingpress.co.uk/article.php?category_id=1&article_id=750

http://www.insidehousing.co.uk/news/development/-ministers-mull-zero-carbon-offset-scheme/6513049.article

http://www.communities.gov.uk/documents/planningandbuilding/pdf/1804259.pdf

Appendix 6 – Selected Abstracts

a) Selected Abstracts from the eceee 2009 Summer Study

Panel 4 - Residential & commercial sectors: delivering lower energy use in buildings,

Panel 7 - Innovative buildings technologies

http://www.eceee.org/conference_proceedings/eceee/2009/Panel_4/

http://www.eceee.org/conference_proceedings/eceee/2009/Panel_7/

Low-energy buildings in southern and eastern Mediterranean countries

This paper presents the experiences and conclusions from a regional project that supports the design, construction and monitoring of 10 low-energy demonstration buildings in 10 southern and eastern Mediterranean countries (see also www.med-enec.com)

Do zero carbon homes make sense?

It has been argued that it would be more sensible to focus on improving the energy efficiency of the existing housing stock rather than rushing to achieve zero carbon standards in new homes. This argument is examined by considering the cost-effectiveness of the different levels of the Code, the cost-effectiveness of energy efficiency measures that can be applied to the existing housing stock, and their respective carbon dioxide savings.

Energy Neutral House – The Danish House+ Concept

An international project contest ran from February 2009 until June 2009 to nominate the best conceptual House+ project. The House+ concept is developed in cooperation with many different parties in the building sector.

Active Houses – development of carbon neutral buildings with healthy indoor comfort

European and national strategies for low energy housing must focus on energy efficiency and CO_2 reductions, but as people spend approximately 90% of their life inside buildings, future housing also needs to be developed with a focus on healthy indoor comfort. A new approach, where energy efficiency, indoor climate and integration of renewable energy are included, is needed. A number of partners from the construction sector have initiated the first thoughts and, as they intend to move from passive systems to active systems, the network is named Active Houses.

Passive houses in Austria: the role of intermediary organisations for the successful transformation of a socio-technical system

In Austria, the first passive house was built in 1996. Since then the market for passive houses has rapidly increased. Statistics show that there were more than 4000 residential units with about 10,000 passive house residents at the end of 2006 - more per capita than in any other country of the world. Sustainability requirements, however, have led to profound shifts in the need for collaboration between the actors involved in planning, constructing and using buildings. This paper draws on a qualitative case study to analyse the development and dissemination of passive houses in Austria by focussing on the role of intermediate organisations. Empirically, the paper is based on qualitative interviews with representatives of relevant organisations as well as the analysis of various documentary sources.

A framework for selection and integration of packages of measures for low carbon dwellings

This paper presents relevant developments in UK energy policy, and outlines an optimisation-based framework for selection and integrated control of appropriate suites of technologies to meet low carbon targets in the residential sector. The framework will develop and consider factors such as technical characterisation, stakeholder rationale, spatial distribution/resolution of measures and policy, and how policy intervention can be modelled effectively. It will enable timely analysis relevant to technology developers, construction and refurbishment industries, landlords, DNOs, suppliers, and policy makers.

Energy and carbon impact of very low energy building

The main purpose of the current study is to investigate the impact associated with a wider introduction of very low energy buildings in Europe, especially for EU Member States (MS) which have elaborated plans for the future towards very low energy buildings. In the study, the resulting energy savings and CO_2 emission reduction from buildings constructed as very low energy buildings will be dealt with, taking into account the national energy-mix as well as national interpretation of very low energy buildings. In addition, the study seeks to obtain information on relevant national studies on very low energy buildings, including measures and programmes to promote such buildings and to remove barriers to their future development. In this context, education, training, and the public sector are areas of special interest.

A solutions-based simulation approach to test the technical and economic feasibility of achieving low and zero carbon homes in the UK

This paper describes the development, application and analysis of an interactive user-friendly Code for Sustainable Homes-based Sustainability Appraisal Toolkit (SAT). SAT runs on MS Excel and is used to evaluate the technical and economical feasibility of achieving Code levels 3, 4, 5 and 6 for a representative sample of new-build dwellings in UK for different scales of development (single-home, 25 homes and 250 homes). The scenarios are modelled using three standard housing types: detached house (104m^2), mid-terraced house (79m^2) and a low-rise flat (61m^2).

Passive house optimization for Southern Italy based on the "New Passivhaus Standard"

The applicability of the *Passivhaus* Standard has not yet been sufficiently tested in European areas with warm climates, where reducing cooling needs under growing summer comfort requirements poses a challenge. The IEE *Passive-On* project has drafted a proposal to adapt that Standard to the conditions that characterize Southern Europe, which is described in this paper together with its rationale. Compared with the original definition, one of the main changes is the introduction of explicit requirements on internal comfort during summer, in parallel to a limit to energy needs for cooling.

b) Selected Abstracts from ACEEE 2008 Summer Study

http://www.eceee.org/conference_proceedings/ACEEE_buildings/2008/

Residential Building Panels:

- Technologies, Design, Performance Analysis, and Building Industry Trends
- Program Design, Implementation, and Evaluation

Modellling the Impacts of Performance Components in Super Energy Efficient House Designs in Different Climate Zones

As part of Building America work, research has been conducted on how the European Passive House residential energy efficiency standard could translate to six locations in three U.S. climate zones. For each super energy efficient house design a TRNSYS

model was developed providing detailed system performance information. Modeling in a Cold climate house design showed that more comfortable conditions occur when natural air ventilation used for cooling enters at a higher air flow and the HRV is not operating.

Zero Energy Peak from Zero Energy Homes
As the Tennessee Valley Authority (TVA) dealt with record afternoon electricity demand during the August 2007 heat wave, a near zero energy home in Lenoir City was actually selling power back into the system. The affordable ZEH concept has been under design and evolution in five side-by-side Near-Zero Energy Homes, since March 2002. This paper shows how these homes can be configured and operated to supply net power during critical peaks.

High Performance Homes in the Southwest: Savings Potential, Cost Effectiveness and Policy Options
The Southwestern United States (specifically Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming) is a fast-growing region that is experiencing rapid growth in population and new housing construction. Increasing the energy efficiency of new homes offers a cost-effective way to help homeowners save money and lower their energy use, while reducing the energy and environmental impacts of new homes. The Southwest Energy Efficiency Project (SWEEP) recently completed a study analyzing the energy, economic and environmental benefits of improving the efficiency of new homes in the Southwest region. The study found that new homes can be built cost effectively while achieving energy savings of 50% or more through energy efficiency measures, and up to 65% savings by incorporating on-site renewable energy systems. These homes save homeowners an average of $1,600 annually on their energy bills, with positive monthly cash flow immediately. Peak electricity demand is also significantly reduced, particularly when energy efficiency and renewable energy measures are combined. This paper summarizes the results of the study findings, identifies barriers to high performance homes, and recommends programs and policies that utilities, states and local governments can implement to support increased market adoption of highly efficient homes.

c) Selected Abstracts from ACEEE 2006 Summer Study Session on Zero Energy Buildings

http://www.eceee.org/conference_proceedings/ACEEE_buildings/2006/

Panel 1. Residential Buildings: Technologies, Design, Performance Analysis, and Building Industry Trends

Panel 2. Residential Buildings: Program Design, Implementation, and Evaluation

Panel 3. Commercial Buildings: Technologies, Design, Performance Analysis, and Building Industry Trends

Panel 4. Commercial Buildings: Program Design, Implementation, and Evaluation

University of Nevada Zero Energy House Project - an example from a hot climate

New housing development in the desert southwest is causing an increasing demand for energy. To mitigate this demand the University of Nevada at Las Vegas (UNLV) with other participants have developed and built a nearly “zero net energy” (ZEH) house as a model home in a tract house setting. Both homes, which are open to the public, will be heavily monitored with a great deal of detailed instrumentation for 18 months, and during this period comparative studies will be made to determine the relative performance of the ZEH. These studies will be used to calibrate the numerical models for the thermal analysis applied during the design phase.

Zero Energy: Designing and Monitoring a Zero Energy Building that Works: The Science House in Minnesota (an example from a cold climate)

Recognized at European Council for an Energy-Efficient Economy (eceee) 2005 for innovation, the challenge of the Science House at the Science Museum of Minnesota was to create habitable, cold climate architecture that was a net zero energy building and to get it built in a "low bid" environment. This paper illustrates how measured data is used to trace the causes to unexpected equipment performance, heat pump behavior and off-line PV panels.

How to Build a Zero Electric Utility Cost House

The construction methods, building products, appliances and equipment of four single-family houses that achieve dramatic energy reductions and approach "net zero energy" use are presented. A 30-50 sensor data acquisition system constantly measures performance characteristics of each house. This data is used to develop guidelines for building a zero energy cost house. The energy performance of the test houses are compared with a "base house" — same size and location, but without advanced features of "net-zero-energy" houses.

The Winding Road Towards "Zero" Energy: Lessons from Monitoring Efficient Solar Homes

Through U.S. Department of Energy's (DOE) Building America program, Steven Winter Associates, Inc. has been working with builders of efficient, solar homes around the country. The authors have performed energy modeling of the buildings and have installed detailed monitoring of several solar homes to evaluate – and to demonstrate – the energy performance of the building systems. The results highlighted several areas (including HVAC distribution, ventilation, lighting, occupant behavior, and commissioning) which have significant impacts on home energy performance and are sometimes overlooked by builders and designers. The authors present the results from these monitoring efforts in hope that they may be useful for others moving towards "zero energy."

Utility Benefits of Homes Approaching "Zero Energy"

A tremendous number of energy efficiency measures in homes are cost-effective but don't seem to appeal to builders or homeowners. Solar energy systems, on the other hand, are quite appealing to many but their high costs tend to discourage buyers. Combining both efficiency and renewable energy – moving towards "zero energy" – offers market appeal greater than either separately; and when combined into a single package it can be cost effective. In 2003, Western Massachusetts Electric Company began this research effort. The analysis showed that life-cycle benefits associated with efficiency and renewable energy were significantly greater than the costs.

Comparative Analysis of Utility Consumption and Costs of Near-ZEHs and Comparison Homes in California

A housing development in San Diego, California, began in June 2001 to offer near-zero-energy homes (ZEHs)—highly efficient homes with solar water heating, and in some, solar electricity as standard features—the first such offering in the United States. The National Renewable Energy Laboratory (NREL) has followed this development, including the builder experience; home resale values; homeowner characteristics, decisions, and experiences; and the consumption and cost of electricity and gas in the near-ZEHs and in adjacent comparison homes.

Are Zero Energy New Homes (ZENH) Good for the Builder, Good for the Buyer, and Good for the Electric Utility?

The California Energy Commission's PIER Buildings Program is sponsoring research programs to develop new market models to promote the development of ZENHs in

California. One project team proposed a market model in which electric utilities have a role in paying for or owning photovoltaic equipment on private residences. A key research question explored in this paper is the value that ZENHs provide to the utility.

Zero-Energy Economics

The highest hurdle that a building owner faces is cost. However, when striving for a net-zero energy building, is it more cost effective to spend money on energy production or spend the capital on improved building equipment that uses less energy? This paper discusses the economics of achieving a net-zero energy building through a case study of the IDeAs Z^2 Design Facility, a remodel of an office building in San Jose, California striving to become a zero energy, zero carbon-emission (Z^2) building.

Zero Energy Buildings: A Critical Look at the Definition

A net zero-energy building (ZEB) is a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies. Despite the excitement over the phrase "zero energy," we lack a common definition, or even a common understanding, of what it means. In this paper, we use a sample of current generation low-energy buildings to explore the concept of zero energy: what it means, why a clear and measurable definition is needed, and how we have progressed toward the ZEB goal.

Assessment of the Technical Potential for Achieving Zero-Energy Commercial Buildings

The U.S. Department of Energy's (DOE) Building Technologies Program has adopted the goal of making zero-energy commercial buildings (ZEBs) marketable by 2025. The National Renewable Energy Laboratory (NREL) conducted an assessment of the entire commercial sector to evaluate the technical potential for meeting this goal with technology available in 2005 and projected forward to possible technology improvements for 2025. The analysis looked at the technical feasibility of ZEBs, limitations in market penetration and utility grid structures notwithstanding.

The results show that the ZEB goal is technically achievable for significant portions of the commercial sector. Using today's technologies and practices, the technical potential is that 22% of the buildings could be ZEBs. With projected 2025 technologies, the technical potential is that 64% of the buildings could be ZEBs. If excess electricity production could be freely exported to the grid, then with the projected 2025 technology in every building, the commercial sector could generate as much as 37% more energy than it consumes. The results suggest that the ZEB goal is feasible for the sector as a whole and that research should be implemented to overcome hurdles to achieving the goal.