How much can sustainable buildings help the climate?

A global building thermal energy model

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UNEP-SBCI Symposium

UNEP Sustainable Buildings and Climate Initiative

Central European University

Center for Climate Change and Sustainable Energy Policy

About CEU
Overview

- Background: the Global Energy Assessment and its scenarios
- The fundamentals of the GEA-SBCI-3CSEP building energy use scenarios
- Results:
  - How far can buildings take us?
  - And how far will they take us if we compromise? i.e. how far will they not allow us to go further? => the lock-in effect
- Conclusions
Background: the Global Energy Assessment and its scenarios

IIASA
International Institute for Applied Systems Analysis
Towards a more Sustainable Future

- Energy problems are broader than just climate change: access, development, poverty, security, environment, health – all key problems

- CC is well assessed but without in isolation from related issues

- GEA Initiated in 2006 and involves >300 CLAs and LAs and >200 Anonymous Reviewers

- Final report (Cambridge Univ. Press) in June 2011; (pre-) release at the Vienna Energy Forum with 64 Energy Ministers confirmed
All Analysts and Executive Committee

- OECD Europe, 90, 31%
- OECD North America, 64, 22%
- OECD Asia and Oceania, 31, 11%
- Latin America and the Caribbean, 22, 8%
- Sub-Saharan Africa, 16, 5%
- non-OECD Asia and Oceania, 49, 17%
- non-OECD Europe, 14, 5%
- Middle-East and North Africa, 4, 1%

TOTAL 300 LAs, CAs and REs
The GEA pathways

- All meet the GEA objectives
  - On access, security, environment, climate change, health and development
- Demonstrate the feasibility of the multiple pathways towards the transformative change that is needed
- The novel philosophy is of transformative change vs. incrementalism (e.g. no baseline)
- Integrates end-use sector models closely
- Building model created by 3CSEP (CEU), in collaboration with UNEP SBCI
GEA – SBCI – 3CSEP Model design

Approach, methodology, assumptions and data
A novel approach to global building energy modeling

- Considers buildings as complete systems rather than sums of components

- Recognizes that
  - state-of-the-art building energy performance can be achieved through a broad variety of designs and component combinations
  - Systemic gains are important when buildings are optimised to very high energy performance, not typically captured by modeling buildings by components

- Assumes that existing best practices become the standard (both in new construction AND renovation) after a certain transition time

- Costs also follow best practice philosophy rather than averages
Energy Use Calculation

Final Energy = \sum_{i=1}^{11} \sum_{j=1}^{3} \sum_{k=1}^{4} \sum_{l=1}^{5} \text{Floor Area}_{i,j,k} \times \text{Energy Intensity}_{i,j,k} \left( m^2 \times \frac{kWh}{m^2 \cdot \text{year}} \right)

- **Energy Calculation:**
  - \( i = 1 \) to 11 Regions
  - \( j = 1 \) to 3 Building Types
  - \( k = 1 \) to 4 Climate Zones
  - \( l = 1 \) to 5 Different Building Thermodynamic Classes

- **The five Thermodynamic Classes of buildings are:**
  - Existing
  - New (Built to code)
  - Retrofit (Built to code or 30% less than existing)
  - Advanced New (Best Practice for region and climate zone)
  - Advanced Retrofit (Best Practice for region and climate zone)
Scenarios Considered
Key Scenario Assumptions (1/3)

- Global 1.4% Retrofit rate
- Switch to 3.0% Retrofit rate in 2020
- All floor area is fully conditioned and 100% access to commercial energy is achieved by 2050
  - i.e. fuel poverty eliminated
- Developing countries see large increase in floor area per capita, synonymous with full development
Detailed findings

Findings of the buildings scenario exercise
State of the Art scenario: global heating&cooling energy consumption if today’s best practices proliferate

Thermal Energy

Floor Area

-46.4%

+126%
Lock-in Effect
World

![Graph showing energy efficiency improvements over time.](image-url)
Scenario Results
Western Europe – Energy Use

State-of-the-Art Scenario

Sub-Optimal Scenario

![Graphs showing energy use over time in Western Europe under different scenarios.](image-url)

- **State-of-the-Art Scenario**
  - Adv New
  - New
  - Adv Ret
  - Retrofit
  - Standard

- **Sub-Optimal Scenario**
  - New
  - Retrofit
  - Standard
Scenario Results
Centrally Planned Asia – Energy Use

State-of-the-Art Scenario

Sub-Optimal Scenario

PWh/year

Year

0.0 1.0 2.0 3.0 4.0 5.0 6.0

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

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Adv New
New
Adv Ret
Retrofit
Standard

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New
Retrofit
Standard
Lock-in effect and potential energy savings for different regions
Investment costs and energy cost savings for different regions

14-18 trl.USD of investment vs. 58 trl.USD of energy cost savings globally
Comparison of the results to other global scenarios

![Graph comparing energy consumption across different scenarios]

- GEA
- 3CSEP
- GE A
- Laustsen
- WEO10
- Harvey Low GDP
- Harvey High GDP
- ETP10
- ETP08
- WEO06

<table>
<thead>
<tr>
<th>Year</th>
<th>Scenario</th>
<th>Energy Consumption (PWh)</th>
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<tbody>
<tr>
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<td>2050 &quot;SUB&quot;</td>
<td>25</td>
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<tr>
<td>2005</td>
<td>2050 &quot;LOW&quot;</td>
<td>30</td>
</tr>
<tr>
<td>2005</td>
<td>2050 &quot;Supply&quot;</td>
<td>35</td>
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<td>2005</td>
<td>2050 &quot;Mix&quot;</td>
<td>30</td>
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<tr>
<td>2005</td>
<td>2050 &quot;BAU&quot;</td>
<td>25</td>
</tr>
<tr>
<td>2005</td>
<td>2050 &quot;Factor.4&quot;</td>
<td>20</td>
</tr>
<tr>
<td>2005</td>
<td>2050 &quot;Current&quot;</td>
<td>15</td>
</tr>
<tr>
<td>2005</td>
<td>2050 &quot;Slow&quot;</td>
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<td>2005</td>
<td>2050 &quot;Fast&quot;</td>
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<td>2005</td>
<td>2035 &quot;Base&quot;</td>
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<td>2005</td>
<td>2050 &quot;Blue Map&quot;</td>
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<td>2005</td>
<td>2030 &quot;REF&quot;</td>
<td>25</td>
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<tr>
<td>2005</td>
<td>2030 &quot;ALT&quot;</td>
<td>30</td>
</tr>
</tbody>
</table>

Sustainable Buildings & Climate Initiative

3CSEP

Work in progress – do not distribute or quote
Conclusions

- If existing holistic best practices for space conditioning are implemented, it will almost halve today’s final thermal energy use in buildings worldwide by 2050, which roughly corresponds to a 16-26% reduction of total global emissions.

- Such an energy use reduction can be achieved despite the considerable increase in floor area (app. 126%) and thermal comfort.

- Significant investments are needed: app. USD 17 trillion cumulative inv. Needs; vs. Close to 60 bln energy cost savings.

- However, there is a huge risk of locking in unnecessarily high energy consumption and thus emissions if suboptimal, piecemeal solutions are promoted.

- Almost 80% of energy savings may be lost by 2050 or postponed and, consequently, climate mitigation targets are unlikely to be met.

- In dynamically developing regions what happens in the next 5 – 10 years fundamentally determines energy use in 2050 – action NOW is vital.

- Thus, actions are to be taken without any further delay: the building energy revolution needs to start today.
“the stone age did not end for the lack of stones….”
Thank you for your attention

Trust me – they just keep promising this global warming; they just keep promising; but they won’t keep this promise of theirs either…

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http://3csep.ceu.hu   www.globalenergyassessment.org
Email: vorsatzd@ceu.hu
Confirmed Reviewers

- OECD Europe, 80, 39%
- OECD N. America, 63, 30%
- non-OECD Asia and Oceana, 30, 15%
- non-OECD Europe, 9, 4%
- OECD Asia and Oceana, 9, 4%
- Latin America and Caribbean, 8, 4%
- Middle East and N. Africa, 5, 2%
- Sub-Saharan Africa, 4, 2%

TOTAL 200 confirmed
Integration of Knowledge Clusters

- **Cluster I** characterizes nature and **magnitude** of challenges, and express them in selected indicators
- **Cluster II** reviews existing and future resource and technology options
- **Cluster III integrates** cluster II elements into systems, and links these to indicators from Cluster I
  - This will include energising of rural areas, land use, water, urbanisation, life-styles, etc.
  - Scenarios, using numerical models and storylines, will be used for the **integration**, in an iterative fashion
- **Cluster IV** assesses policy options, and specifically identifies **policy packages** that are linked to scenarios meeting the needs, again in an iterative fashion.
The climate change challenge

“How on Earth do we turn it off?”

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In order to limit the impacts of CC, GHG emissions have to be reduced significantly

- Stabilizing global mean temperature requires a stabilization of GHG concentrations in the atmosphere -> GHG emissions would need to peak and decline thereafter (SPM 18 WG III)
- The lower the target stabilisation level limit, the earlier global emissions have to peak.
- Limiting increase to 3.2 – 4 C requires emissions to peak by 2020-2060.
- Limiting increase to 2.8 – 3.2 C requires global emissions to peak by 2000-2020.
- Limiting global mean temperature increases to 2 – 2.4 C above pre-industrial levels requires global emissions to peak by 2000-2015 and then fall to about -50 to -85% of 2000 levels by 2050.
The later emissions peak, the more ambitious reductions needed

Source: Meinshausen et al 2009
Buildings offer large mitigation potentials (at low costs)

Figure SPM.6: Estimated sectoral economic potential for global mitigation for different regions as a function of carbon price in 2030 from bottom-up studies, compared to the respective baselines assumed in the sector assessments. A full explanation of the derivation of this figure is found in Section 11.3.
Few sectors can deliver the magnitude of emission reduction needed for climate stabilisation

- know-how has recently developed that we can build and retrofit buildings to achieve 50 – 90% savings as compared to standard practice in all climate zones (providing similar or increased service levels)

However, most of the buildings around the world are still highly energy-consuming
Total final building energy consumption per capita by region and building type in 2007 (kWh/capita/yr)

Data Source: IEA online statistics (2007)
Final heating and cooling specific energy consumption by region and building type in 2005 (kWh/m²/yr)

This energy use can be significantly reduced...
...as long as optimal technologies are applied instead of sub-optimal ones

Solar thermal coll.  (optional)

Super

triple pane
double low-e glazing

summer sun

winter sun

light coloured roof
with insulation

louvred vent

summer cooling breezes

deciduous trees

screen planting
against winter winds

maximum glazing to north

thermal mass flooring

ground heat exchanger

PASSIVE HOUSE

Annual heating requirement less than 15 kWh/(m²a)

Combined primary energy consumption (heating, hot water and electricity) less than 120 kWh/(m²a)
Buildings utilising passive solar construction ("PassivHaus")

Source: Jan Barta, Center for Passive Buildings, www.pasivnidomy.cz
Example of savings by reconstruction

Before reconstruction

-90%

Reconstruction according to the passive house principle

15 kWh/(m²a)

over 150 kWh/(m²a)

Can we afford this?

Source: Jens Lausten, IEA

Frankfurt/M Germany Sophienhof
FAAG/ABG Frankfurt Architect Fuessler

Blocks of Flats

160 dwellings
14 767 m²
Passive House Technology
15 kWh / m² per year

Extra costs
= 3-5% of the total costs
Payback = 9 – 10 years
Base Year Floor Area and Projections Residential

- Floor Area per building type per capita main indicator
- GEA Population Projection Database
- Assumed that developing regions will increase their floor area per cap to that of the OECD by 2050 or some fraction of OECD levels (South Asia 50% of 2005 OECD Levels)
- Previous demolition trends continue throughout modeling period
- A fraction of existing building stock for both Residential and C&P is considered “Historical” and cannot be retrofitted to Advanced Status

\[
\text{Floor Area} = \sum_{i=1}^{11} \sum_{j=1}^{2} \text{Population}_{i} \times \left( \frac{m^2}{\text{Capita}} \right)_{i,j}
\]
Base Year Floor Area and Projections Commercial

- Floor area for first year from BUENAS model and regional reports (McKinsey, LBNL, etc.)
- GEA GDP 2005USD projections
- C&P Floor Area projection based on Floor Area per unit GDP (USD2005) in 2005
- Developing regions are assumed to reach OECD levels of this “floor area elasticity” by 2050
- Tempers otherwise exponential floor area increase if C&P floor area tied directly to GDP
Population and GDP data used in the model
### Climate Types

#### Climate Zones
- **Warm Moderate**
- **Cold Moderate**
- **Tropical**
- **Arid**

#### Köppen Climate Equivalents

<table>
<thead>
<tr>
<th>Köppen Climate Zone</th>
<th>Characteristics</th>
<th>Model Climate Zone</th>
<th>Regional examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group A - Tropical</strong></td>
<td>High temperatures all 12 months of the year. &gt;18°C</td>
<td>Tropical</td>
<td>Hilo, Hawaii, USA</td>
</tr>
<tr>
<td>Af</td>
<td>Rainforest Climate</td>
<td>Tropical</td>
<td>Miami, Florida, USA</td>
</tr>
<tr>
<td>Am</td>
<td>Monsoonal Climate</td>
<td>Tropical</td>
<td>Mumbai, Maharashstra, India</td>
</tr>
<tr>
<td>Aw</td>
<td>Wet and Dry/Savanna Climate</td>
<td>Tropical</td>
<td></td>
</tr>
<tr>
<td><strong>Group B - Dry</strong></td>
<td>Precipitation is lower than potential evapotranspiration</td>
<td>Arid</td>
<td>Cobar, NSW Australil (BSh)</td>
</tr>
<tr>
<td>BS</td>
<td>Steppe Climate</td>
<td>Arid</td>
<td>Almeria, Spain (BWh)</td>
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<tr>
<td>BW</td>
<td>Desert Climate</td>
<td>Arid</td>
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<tr>
<td>BS/BW-k</td>
<td>Coldest Month Avg. Below 0°C</td>
<td>Arid</td>
<td>Denver, CO USA (BSk)</td>
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<tr>
<td>BS/BW-b</td>
<td>Coldest Month Avg. Above 0°C</td>
<td>Arid</td>
<td>Dubai, UAE (BWh)</td>
</tr>
<tr>
<td><strong>Group C - Temperate</strong></td>
<td>Avg. temperature above 10°C in warmest months, Avg. temperature between -3°C and 18°C in coldest months</td>
<td>Warm Moderate</td>
<td>Madrid, Spain</td>
</tr>
<tr>
<td>Csa</td>
<td>Mediterranean Climates</td>
<td>Warm Moderate</td>
<td>San Francisco, CA, USA</td>
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<tr>
<td>Csb</td>
<td></td>
<td>Warm Moderate</td>
<td>Buenos Aires, Argentina</td>
</tr>
<tr>
<td>Cfa</td>
<td>Humid Subtropical - Interiors of large land masses</td>
<td>Warm Moderate</td>
<td>Hong Kong, PRC</td>
</tr>
<tr>
<td>Cwa</td>
<td></td>
<td>Warm Moderate</td>
<td>Bergen, Norway</td>
</tr>
<tr>
<td>Cfb</td>
<td></td>
<td>Warm Moderate</td>
<td>Mexico City, Mexico</td>
</tr>
<tr>
<td>Cwb</td>
<td></td>
<td>Warm Moderate</td>
<td>Reykjavik, Iceland</td>
</tr>
<tr>
<td>Cfc</td>
<td></td>
<td>Warm Moderate</td>
<td></td>
</tr>
<tr>
<td><strong>Group D - Continental</strong></td>
<td>Avg. temperature above 10°C in warmest months, Avg. temperature below -3°C in coldest months</td>
<td>Cold Moderate</td>
<td>Chicago, Illinois, USA</td>
</tr>
<tr>
<td>Dfa</td>
<td></td>
<td>Cold Moderate</td>
<td>Seoul, South Korea</td>
</tr>
<tr>
<td>Dwa</td>
<td></td>
<td>Cold Moderate</td>
<td>Tabriz, Iran</td>
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<td>Dsa</td>
<td></td>
<td>Cold Moderate</td>
<td>Minsk, Belarus</td>
</tr>
<tr>
<td>Dfb</td>
<td></td>
<td>Cold Moderate</td>
<td>Harbin, China</td>
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<td>Dwb</td>
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<td>Cold Moderate</td>
<td>Anchorage, Alaska, USA</td>
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<td>Cold Moderate</td>
<td>Irkutsk, Russia</td>
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<tr>
<td>Dfc</td>
<td></td>
<td>Cold Moderate</td>
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</tr>
</tbody>
</table>

**Sources:**
1) koeppen-geiger.vu-wien.ac.at/
2) City Information from Wikipedia
Key Assumptions on Building Types

- Buildings are split into three primary types:
  - Single Family (SF): either attached or detached single family homes.
  - Multi Family (MF): multi apartment complexes from high-rise structures to low rise and terrace structures.

- The urbanization rate:
  - % of population living in an urban environment.
  - Used as a proxy for the relative proportion of SF and MF.

\[
\text{Urbanization Rate (\%)} = \frac{\text{Urban Population}}{\text{Total Population}} = \frac{\text{MF Floor Area}}{(\text{MF Floor Area} + \text{SF Floor Area})}
\]
Energy Consumption Data

- For new and renovation, case studies (standard and best practice) were collected for each region and climate type, if available
  - Final Energy performance (kWh/m²)
    - By Climate type
    - Building Type including status: Existing, New; Renovation; standard vs best practice
  - If no data found for a building and climate type, Best Practice assumed to be Passiv Haus Standard, approximately 15 kWh/m²/year
  - Values of specific energy consumption of advanced retrofit buildings are higher than the ones of advanced new buildings as it is easier to achieve very low level of energy consumption through new construction rather than renovation of existing buildings. Therefore, in advanced retrofit buildings these values are usually a bit higher.
  - Specific energy consumption values for advanced multi-family buildings are lower or the same that the ones of single-family buildings in the same region and climate zone.

- Major Challenge is Existing Building Stock energy intensity for Space Heating and Cooling (since that needs to rely on averages and provide totals)
# Summary of Building Stock Projections

## 11 Regions

<table>
<thead>
<tr>
<th>Regions</th>
<th>Residential, billions of m²</th>
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<th></th>
<th>C&amp;P, billions of m²</th>
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<tr>
<td></td>
<td>2005</td>
<td>2050</td>
<td>Change, %</td>
<td>2005</td>
<td>2050</td>
<td>Change, %</td>
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<tr>
<td>NAM</td>
<td>11</td>
<td>14</td>
<td>27%</td>
<td>8</td>
<td>12</td>
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<tr>
<td>WEU</td>
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<td>14</td>
<td>-3%</td>
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<td>13</td>
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<td>PAO</td>
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<td>4</td>
<td>-16%</td>
<td>2</td>
<td>4</td>
<td>70%</td>
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<td>EEU</td>
<td>3</td>
<td>3</td>
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<td>4</td>
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<td>54</td>
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<td>14</td>
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<td>PAS</td>
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<td>18</td>
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<td>23</td>
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<td>7</td>
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<td>MEA</td>
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<td>1</td>
<td>4</td>
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<td>AFR</td>
<td>9</td>
<td>27</td>
<td>201%</td>
<td>1</td>
<td>5</td>
<td>307%</td>
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<td>World</td>
<td>116</td>
<td>253</td>
<td>118%</td>
<td>37</td>
<td>99</td>
<td>169%</td>
</tr>
</tbody>
</table>
## Thermal final energy intensities assumed in the scenarios for different building types and regional climate zones

| Region | Climate Type | Single Family | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

### Sources of data
Sources of data on energy consumption are diverse but broadly range from national statistics through literature in personal interviews and expert judgments for regions without documented data.
Scenarios Considered
Key Scenario Assumptions (1/3)

- Global 1.4% Retrofit rate
- Switch to 3.0% Retrofit rate in 2020
- Access to commercial energy assumption
  - Fraction of buildings within a region have no access to commercial energy and consume 1/3 less energy than a similar building in the region
- All floor area is fully conditioned and 100% access to commercial energy is achieved by 2050
- Developing countries see large increase in floor area per capita, synonymous with full development
Scenarios Considered
Key Scenario Assumptions (2/3)
Sub-Optimal Scenario

- Best Practices are adopted to little extent
  - Only the WEU region will have 5% of New Buildings achieve “Advanced” Energy standard

- All other regions continue current (to code or equivalent) retrofit and new build energy requirements.
  - Regions without code are assumed to retrofit to 30% lower energy consumption than an existing building

- New buildings are built to current code
Scenarios Considered
Key Scenario Assumptions (3/3)
State-of-the-Art Scenario

- Steady phase in of Best Practices for each region
  - Fraction of Retrofits are “Advanced” Status starting in 2010 and ramping up to 100% in 2020
  - Most retrofits to go state-of-the-art, with 3 – 10% (historic and other non-retrofitable buildings) to less ambitious levels
  - Fraction of New Buildings are “Advanced” Status starting in 2010 and ramping up to 100% in 2020

- New buildings are built to current code
- Retrofits are built to code or 30% lower than existing buildings
Summary of key messages I.
Scenario findings

- Our scenarios demonstrate that more than 46% global final heating and cooling energy reduction is possible by 2050 as compared to 2005 by proliferating today’s best practices in design, construction and building operation technologies and know-how. This is reachable while increasing amenity and comfort; without interceding in economic and population growth trends and the applicable thermal comfort and living space demand increases. These reductions go hand-in-hand with eradicating fuel (energy) poverty and 126% increase in global floor are.

- Most regions are able to decrease final thermal energy use in buildings, with the largest drop in OECD countries (73%), followed by reforming economies (66%). Even ASIA final energy decreases, after an initial increase, ending 16.5% lower than in 2005.

- Reaching these state-of-the-art energy efficiency levels in buildings requires approximately US$14.2 trillion in undiscounted cumulative investments until 2050. However, these investments return substantially higher benefits: app. US$58 trillion in undiscounted energy cost savings alone during the same period.
Summary of key messages II.

The lock-in risk

- **Lock-in risk**: If building codes are introduced universally and energy retrofits accelerate, but policies do not mandate state-of-the-art efficiency levels, substantial energy consumption, and corresponding GHG emissions, can be “locked in” for many decades. Such a scenario results in an app. 32.5% increase in global energy use by 2050 from 2005, as opposed to a 46% decrease – i.e. an app. **79% lock-in effect** if expressed in 2005 global building heating and cooling energy use.

- This points to the importance of building-shell related policies being very ambitious about the efficiency levels they mandate (or encourage), and to the major lock-in risk present policies, typically under the banner of climate change mitigation, energy security and other public goals, are taking us to.
Scenario Results
North America - Floor Area

State-of-the-Art Scenario

Sub-Optimal Scenario

bln m$^2$

[Diagram showing changes in floor area over time for different scenarios and types of buildings.]
Scenario Results
North America – Energy Use

State-of-the-Art Scenario

Sub-Optimal Scenario

PWh/year

- Adv New
- New
- Adv Ret
- Retrofit
- Standard

0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

New
Retrofit
Standard

UNEP SBCI
Sustainable Buildings & Climate Initiative

3CSEP
Comparison of the results to GEA scenarios

![Graph showing comparison of results to GEA scenarios]

- **3CSEP LOW**
- **3CSEP SUB**
- **GEA-Supply**
- **GEA-Mix**
- **GEA-Efficiency**

Index

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6

2005 2010 2020 2030 2040 2050
Thermal final energy use for two scenarios and for the five regions

State of the art scenario

Sub-optimal scenario

PWh/year

0 1 2 3 4 5 6 7 8 9

0 1 2 3 4 5 6 7 8 9

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

OECD90 ASIA REF LAC AFR
Lock-in Effect
Western Europe

PWh/year

-72%
-26%
46%

Sub-Optimal
State of the Art
Scenario Results
Western Europe – Floor Area

State-of-the-Art Scenario

Sub-Optimal Scenario

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& Climate Initiative
Lock-in Effect
Eastern Europe

-67%  +8%

75%

PWh/year

0  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8

2005  2010  2015  2020  2025  2030  2035  2040  2045  2050

Sub-Optimal  State of the Art

UNEP SBCI
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3CSEP
Scenario Results
Eastern Europe – Floor Area

State-of-the-Art Scenario

Sub-Optimal Scenario

bln m$^2$

2005  2010  2015  2020  2025  2030  2035  2040  2045  2050

2005  2010  2015  2020  2025  2030  2035  2040  2045  2050

Adv New
New
Adv Ret
Retrofit
Standard

New
Retrofit
Standard
Scenario Results
Eastern Europe – Energy Use

State-of-the-Art Scenario

Sub-Optimal Scenario

PWh/year

0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

2005
2010
2015
2020
2025
2030
2035
2040
2045
2050

PWh/year

0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

2005
2010
2015
2020
2025
2030
2035
2040
2045
2050

- Adv New
- New
- Adv Ret
- Retrofit
- Standard

- New
- Retrofit
- Standard
Lock-in Effect
Centrally Planned Asia

PWh/year

Sub-Optimal
State of the Art

Sustainable Buildings
& Climate Initiative

3CSEP

0
1
2
3
4
5
6

2005
2010
2015
2020
2025
2030
2035
2040
2045
2050

+22%
-54%
76%
Scenario Results
Centrally Planned Asia – Floor Area

State-of-the-Art Scenario

Sub-Optimal Scenario
A novel approach to global building energy modeling

- Considers buildings as complete systems rather than sums of components

- Recognizes that
  - state-of-the-art building energy performance can be achieved through a broad variety of designs and component combinations
  - Systemic gains are important when buildings are optimised to very high energy performance, not typically captured by modeling buildings by components
  - If loads are minimised, and siting, design and solar gain optimised, thermal energy performance is not a strict function of degree-days, but main climate type

- Assumes that state-of-the-art construction know-how can be transferred within climate type to different regions
- Assumes that existing best practices become the standard (both in new construction AND renovation) after a certain transition time
- Costs also follow best practice philosophy rather than averages
Sponsoring Organizations

**International Organizations**
- GEF
- IIASA
- UNDESA
- UNDP
- UNEP (incl. UNEP SBCI)
- UNIDO
- ESMAP (World Bank)

**Governments/Agencies**
- Austria - multi-year
- European Union
- Germany
- Italy
- Norway
- Sweden - multi-year
- USA (EPA, DoE)

**Industry groups**
- First Solar
- Petrobras
- WBCSD
- WEC

**Foundations**
- UN Foundation
- Climate Works Foundation
- Global Environment & Technology Foundation