How far can buildings take us in fighting climate change? Results of 3CSEP-GEA Model

CENTER FOR CLIMATE CHANGE AND SUSTAINABLE ENERGY POLICY

CENTRAL EUROPEAN UNIVERSITY

GEA

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Building Envelope Technologies and Policy Workshop

About 3CSEP@CEU
Center for Climate and Sustainable Energy Policy

- 3CSEP is an **interdisciplinary** research and educational center at **Central European University** (CEU) whose mission is
  - to foster solutions to climate change and sustainable energy challenges
  - while advancing the implementation of development agendas.
- **Platform** for academic, outreach and educational activities at CEU in these fields
- **Director - Prof. Diana Ürge-Vorsatz**
  - Lead author of **IPCC** WGIII (mitigation)
  - Involved in internstional initiatives: UN SEG on climate change, UNEP-SBCI, Global Energy Assessment, etc.

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IIASA

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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 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 December 2011 – January 2012
- Within its framework, visionary scenarios (pathways) produced for GEA that meet all GEA objectives

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GEA – UNEP SBCI – 3CSEP
Model design

Center for Climate Change
and Sustainable Energy Policy

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GEA

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Sustainable Buildings
& Climate Initiative

Approach, methodology, assumptions and data

A novel approach to global building energy modeling

- Considers buildings as complete systems rather than sums of components -> performance-based approach
- 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

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Main philosophy and assumptions

- Assumes that the world's building stock will transform over to today's known (and built) cutting edge in architecture
  - At the most affordable cost
  - At the natural rate of building construction and retrofit
  - Taking into account capacity and other limitations, but assuming ambitious and supportive (not financially but legally) policy environment.
- The main pillars of the model are existing best practices
  - Best practice from and energy and INVESTMENT COST perspective as well
- The world's building stock is broken down by regions, climate zones and 3 building types
- Model eradicates energy poverty well before 2050, i.e. everyone has appropriate thermal comfort energy services by 2050
- Model includes two main scenarios:
  - Sub-Optimal
  - State-of-the-Art

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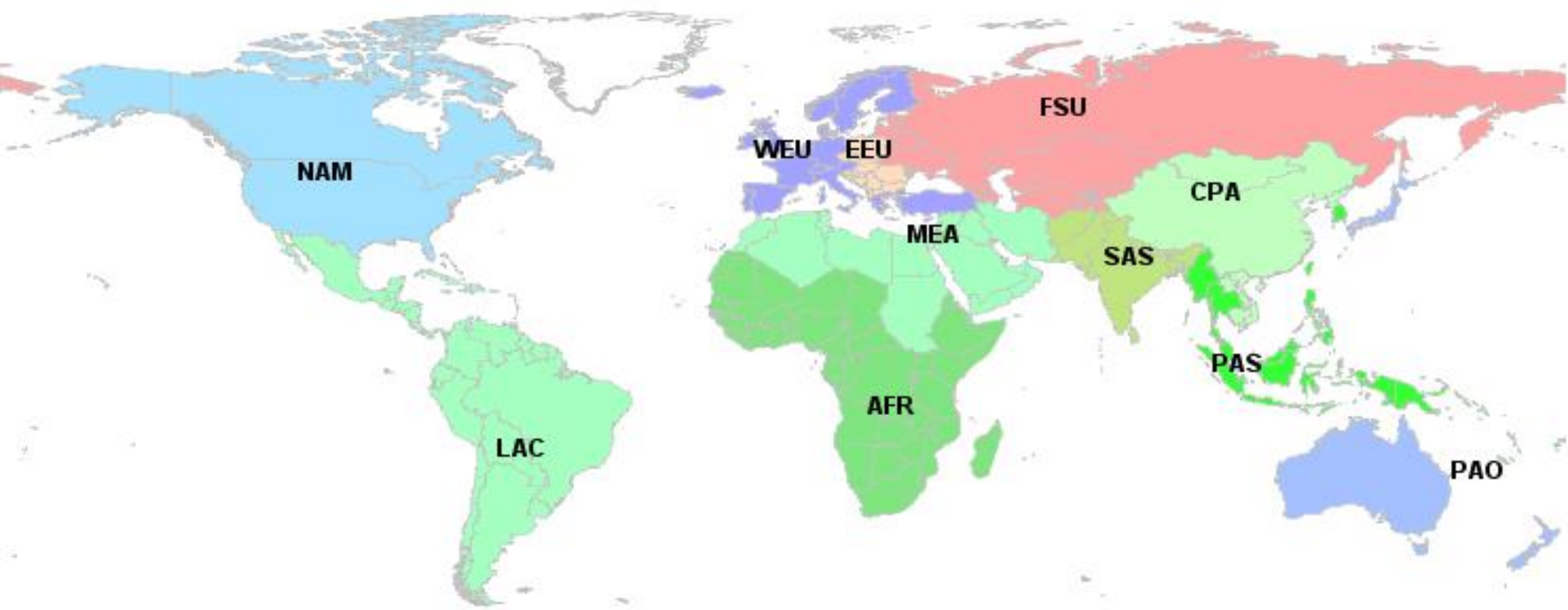
Geographical boundaries

11 GEA regions



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Key Assumptions on Building Types

- Buildings are split into three primary types
  - Single Family (SF): either attached or detached single family homes.
  - Multifamily (MF): multi apartment complexes from high-rise structures to low rise and terrace structures
  - Commercial and Public Buildings (C&P): everything else.

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Key Assumptions on Building Vintages

- There are 5 building vintages:
  - Existing
  - New (Built to the 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)
- There are different energy intensities used in the model for different regions, building vintages, building types and climate zones

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Thermal final energy intensities assumed in the scenarios for different building types, vintages and regional climate zones

Region	Climate Type	Single Family					Multi-Family					Commercial and Public				
		Existing	New	Adv New	Retrofit	Adv Retrofit	Existing	New	Adv New	Retrofit	Adv Retrofit	Existing	New	Adv New	Retrofit	Adv Retrofit
NAM	Warm Mod.	150	65	15	105	20	170	65	10	119	15	220	65	15	154	17
	Cold Mod.	191	65	20	134	30	200	65	15	140	20	340	65	15	238	20
	Tropical	75	65	17	53	25	75	65	17	53	25	131	65	25	92	30
	Arid	87	65	12	61	20	87	65	12	61	20	114	65	20	80	25
WEU	Warm Mod.	160	50	12	112	15	155	50	10	109	15	130	50	10	91	17
	Cold Mod.	261	50	14	183	20	225	50	14	158	20	209	50	14	146	20
PAO	Warm Mod.	100	55	15	70	20	95	60	10	67	15	90	66	15	63	17
	Cold Mod.	150	65	20	105	30	130	80	15	91	20	90	66	15	63	20
	Tropical	65	55	17	46	25	63	55	17	44	25	131	65	25	92	30
	Arid	155	65	12	109	20	155	60	12	109	20	114	65	20	80	25
EEU	Warm Mod.	240	145	14	168	15	205	120	10	144	15	180	120	10	126	17
	Cold Mod.	280	123	20	196	20	245	150	15	172	20	280	111	14	196	20
FSU	Warm Mod.	240	150	15	168	25	205	130	15	144	20	180	120	10	126	17
	Cold Mod.	280	180	20	196	20	246	150	20	172	25	353	150	14	247	20
	Arid	210	100	12	147	20	210	100	15	147	20	210	65	18	147	25
CPA	Warm Mod.	65	42	15	46	20	65	42	10	46	15	96	62	15	67	17
	Cold Mod.	140	91	20	98	30	120	78	15	84	20	150	98	15	105	20
	Tropical	60	39	17	42	25	55	36	17	39	25	96	62	25	67	30
	Arid	70	46	12	49	20	55	36	12	39	20	96	62	20	67	25
SAS	Warm Mod.	65	42	15	46	20	65	42	10	46	15	96	55	15	75	17
	Tropical	35	23	17	25	25	35	23	17	25	25	96	65	25	75	30
	Arid	35	23	12	25	20	35	23	12	25	20	96	65	18	75	18
PAS	Warm Mod.	65	42	15	46	20	65	42	10	46	15	96	55	15	75	17
	Tropical	35	23	17	25	25	35	23	17	25	25	96	65	25	75	30
MEA	Arid	87	50	12	50	20	62	60	12	60	20	62	65	20	75	25
LAC	Warm Mod.	81	50	15	50	20	81	60	10	60	15	91	55	15	55	17
	Cold Mod.	196	50	20	50	30	170	60	15	60	20	209	65	15	65	20
	Tropical	63	50	17	50	25	63	55	17	55	25	131	65	25	65	30
	Arid	87	50	12	50	20	155	60	12	60	20	114	65	20	65	25
AFR	Warm Mod.	120	50	15	50	20	100	60	10	60	15	100	55	15	55	17
	Tropical	63	50	17	50	25	63	55	17	55	25	65	65	25	65	30
	Arid	87	50	12	50	20	62	60	12	60	20	62	65	20	65	25

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Sources of data are very broad, range from national statistics through literature to personal interviews and expert judgments for regions without documented data.

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Base Year Floor Area and Projections Residential

- Floor Area per building type per capita and population are the main indicators for residential floor area dynamics
- GEA Population Projection Database
- Assumed that developing regions will increase their floor area to the OECD level by 2050 or some fraction of OECD levels (South Asia 50% of 2005 OECD Levels)
- A fraction of existing building stock for both Residential and C&P is considered "Historical" and cannot be retrofitted to Advanced Status

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Base Year Floor Area and Projections Commercial

- Floor area for first year (McKinsey, LBNL, regional reports, 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

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Energy Use Calculation

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

- 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 Vintages*

- Energy use is calculated for each region and each climate zone with the split to building types and building vintages

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Scenarios Considered
Key Scenario Assumptions

- Global 1.4% Retrofit rate
- Accelerate 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
- State-of-the-art scenario

Building best-practices are implemented worldwide

After 2020 most renovations and newly built structures are of a very low energy design

- Sub-Optimal scenario

New buildings are built to regional code standards.

Regions where passive house standards are gaining acceptance, primarily Western Europe, achieve only a 5% market share of new builds

Renovations are carried out to achieve approximately 30% energy savings

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Detailed findings

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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**

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Lock-in Effect
World heating and cooling final energy use projections in two scenarios

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Lock-in effect and potential energy savings for different regions

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Investment costs and energy cost savings for different regions

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Comparison of the results to other scenarios

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Conclusions

- A novel approach – performance-based, holistic – has been applied to develop a global building energy model that can better shed light on visionary building energy/GHG futures
- 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 during the period.
- 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 2005 heating & cooling energy use can be locked-in** by 2050 and, consequently, stringent climate mitigation targets are unlikely to be met or at much higher costs.
- 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

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New life of the model under GBPN umbrella

Best Practice Policies for Low Carbon & Energy Buildings

Scope
- + 4 big regions: US, China, India, EU-27
- EU-27 model by country
- Water heating module

Building Types
- Split between urban and rural
- Split commercial buildings into 4 types
- Including slums as a separate urban category

Climate Types
- Comprehensive GIS analysis
- Energy needs for SH&C, dehumidification
- Input: HDD, CDD, relative humidity and average T for the warmest month

Scenarios
- Pushing the frontiers renewable energy scenario
- Frozen Efficiency Scenario

Data update
- Specific energy consumption
- Floor area per capita
- Costs

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Thank you for your attention

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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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