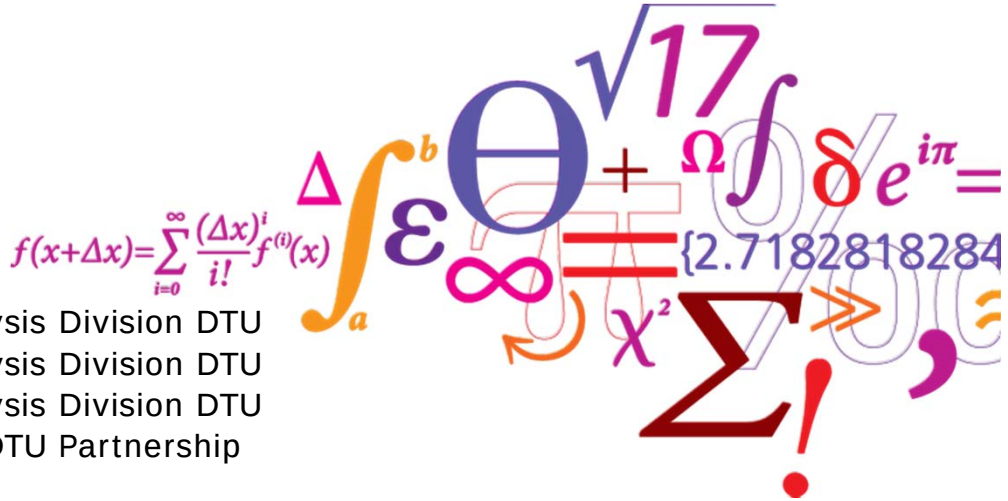
Global economic potential from moderate and deep retrofit of building envelopes in residential and service sectors from an energy system perspective



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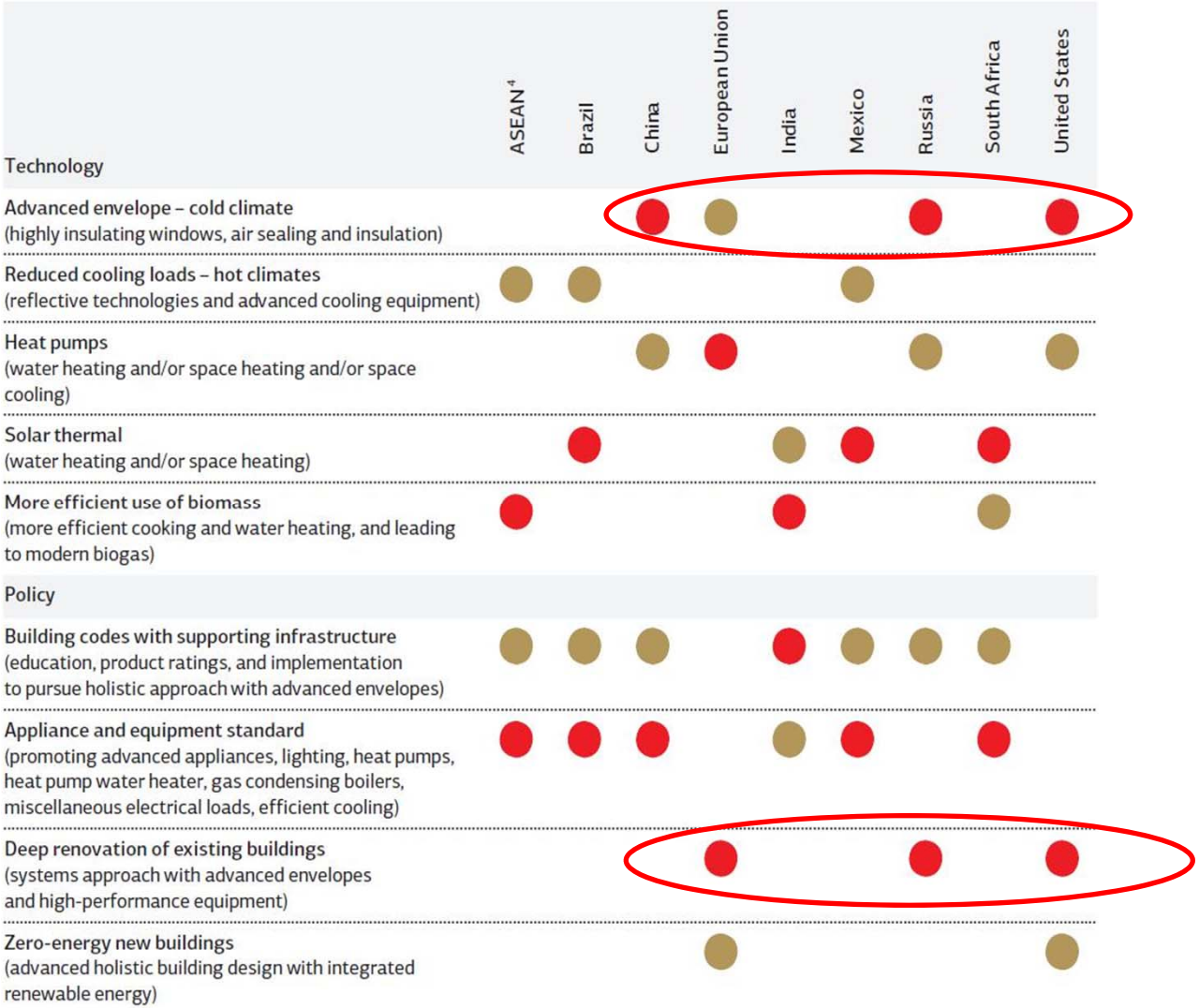
Introduction

1) The energy used for space conditioning (cooling and heating), included water heating, accounts for an estimated 55% of global building energy loads in 2013, (IEA, 2016).

2) Space heating continues to be the largest end use, accounting for roughly 35% of global building energy use in 2013, while space cooling is the fastest growing end use, having increased by more than 4% per year since 1990, (IEA, 2016).

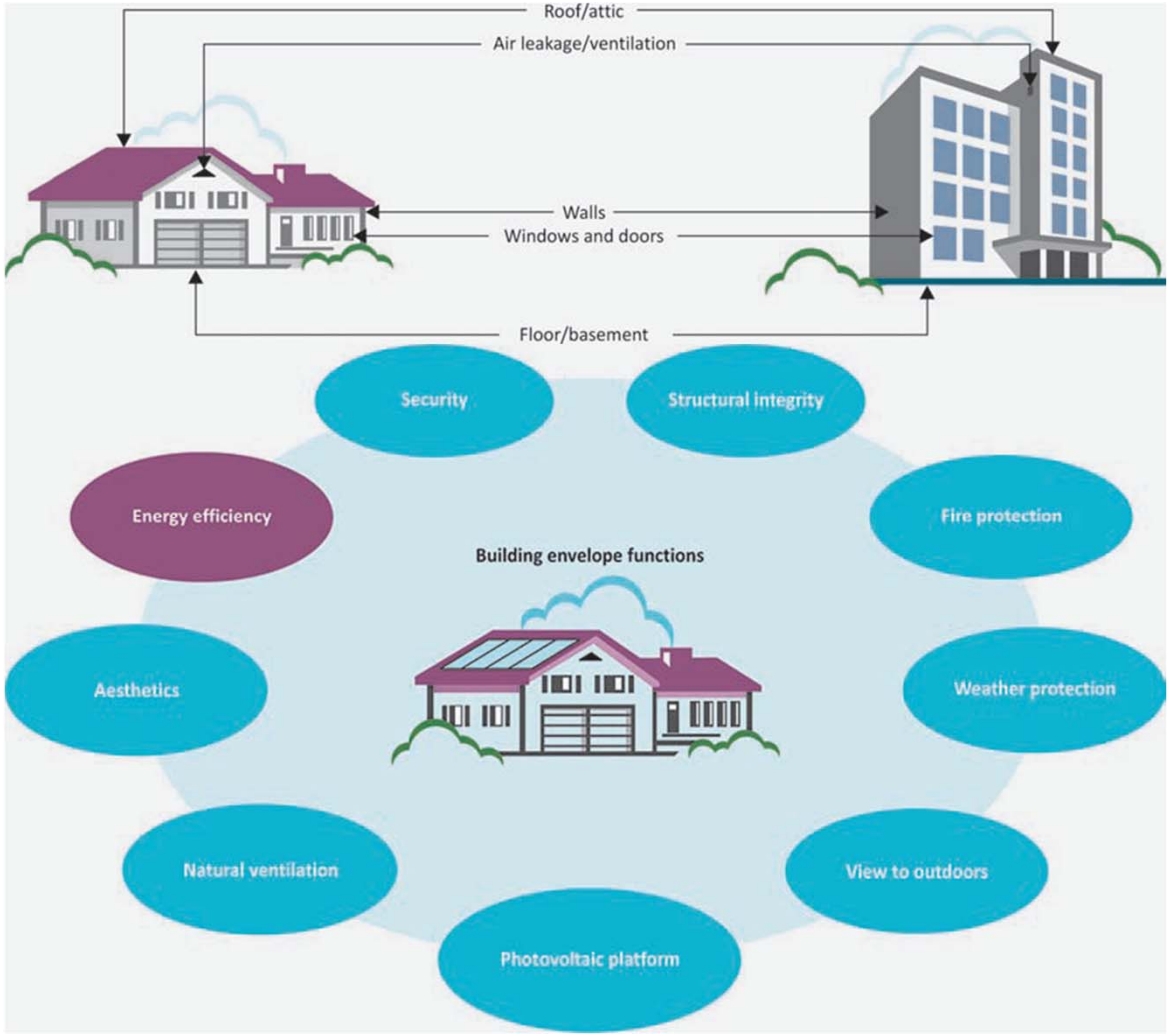
3) More than 50% of the current global building stock will still be standing in 2050; in OECD countries, that figure is closer to 75% (IEA, 2013b). **Therefore building retrofit can play an important role to reduce the future space heating and cooling demand**

Technical and political measures



Regional priorities in building sector. Red indicates immediate priority, while gold indicates second priority (IEA, 2013b)

Building envelope components and function



Building envelope components and function (IEA, 2013b)

Building envelope is the physical separator between the conditioned and unconditioned environment of a building including the resistance to air, water, heat, light, and noise.

The building envelope is critical to reduce heating and cooling loads, but this is only one of the functions it performs.

Objectives

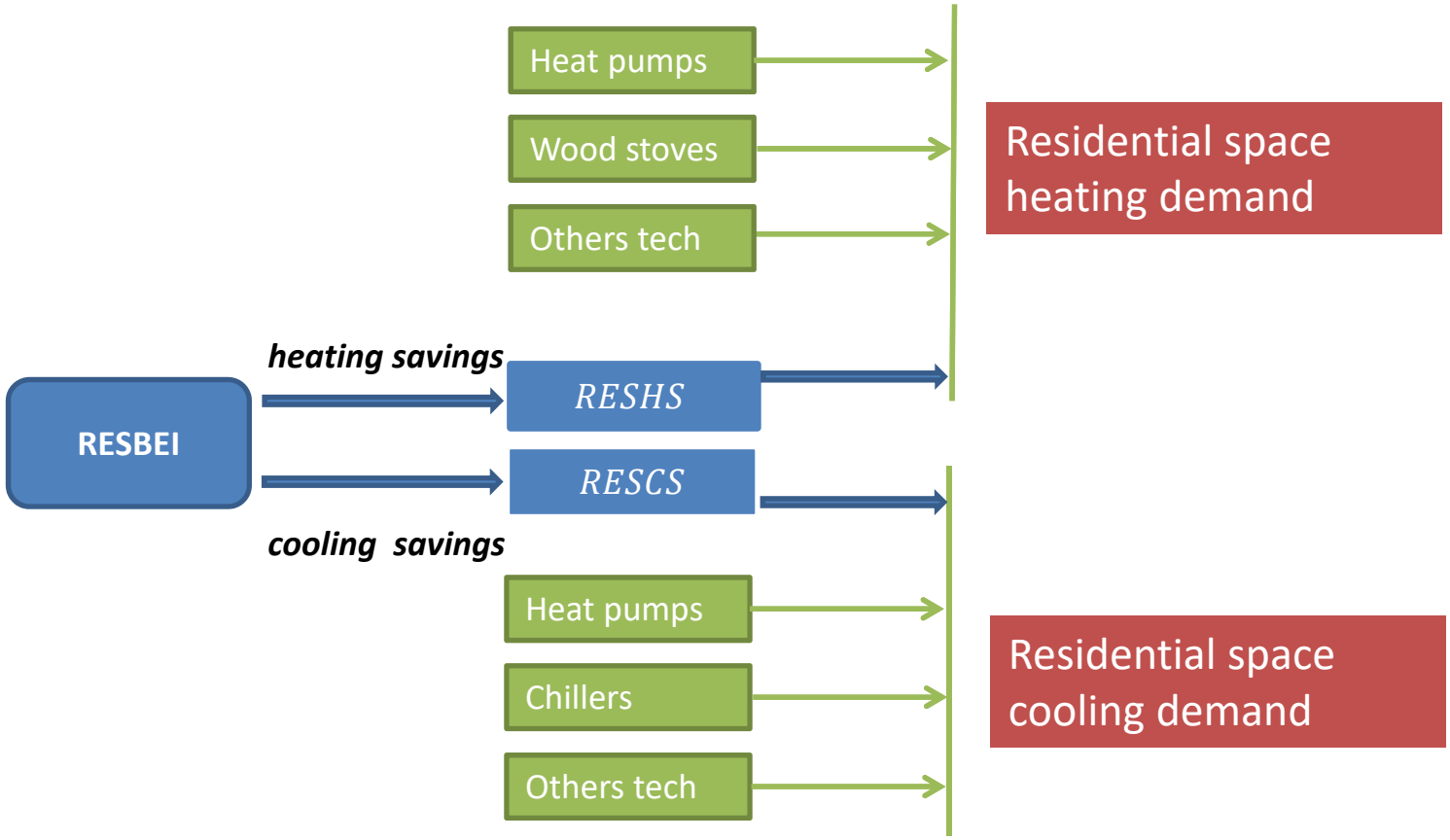
Attempt to answer the following research questions:

1) Which regions/countries have the largest economic potential for energy savings and thereby CO_2 emissions reduction from deep or moderate retrofits of building envelopes, in both residential and service sectors?
2) What are the investments required for achieving significant energy savings in residential and service buildings in the regions/countries studied?
3) How do investments in building energy efficiency compete with each other, e.g. investments in HVAC systems and building envelope retrofit compete for providing energy savings?

ETSAP-TIAM model and modelling approach

1) Architecture:
   - Developed and maintained by the Energy Technology Systems Analysis Programme (ETSAP)
   - Technology-rich, bottom-up model generator
   - Techno-economic, partial equilibrium model-generator assuming full foresight and perfectly competitive markets
   - Finds the least-cost solution for the entire energy system with flexibility in terms of time resolution and sectorial focus.
2) Regions:
   - 15 regions including **China, India, Russia, US and EU27**
3) Time frame:
   - IEA 2005 calibration year
   - 10-year steps from 2010 until 2050
   - Demand driver data were updated to 2010 data (IEA, World Bank, OECD)
4) Sectors:
   - **Residential**
   - **Commercial**
   - Transport
   - Industry

Energy Efficiency in Buildings



Data and assumptions

1) Data on specific retrofit costs and their respective energy savings potential from Ürge-Vorsatz R., et al. (2015) were used as a basis for deep and moderate retrofit costs
   - Specific costs for single and multi-family buildings were averaged. These costs correspond to specific costs for residential buildings used in the model
2) Average heated and cooled area as percentage of total floor area from IEA (2013b)

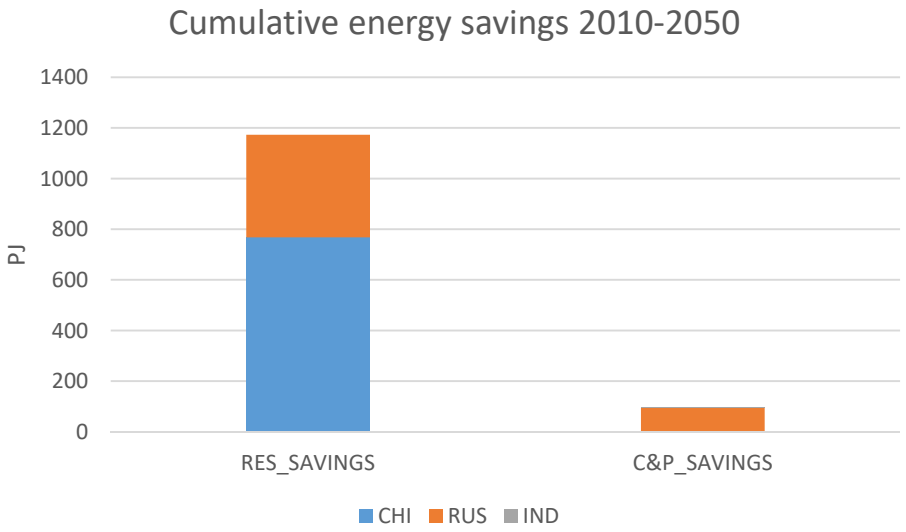
Scenarios

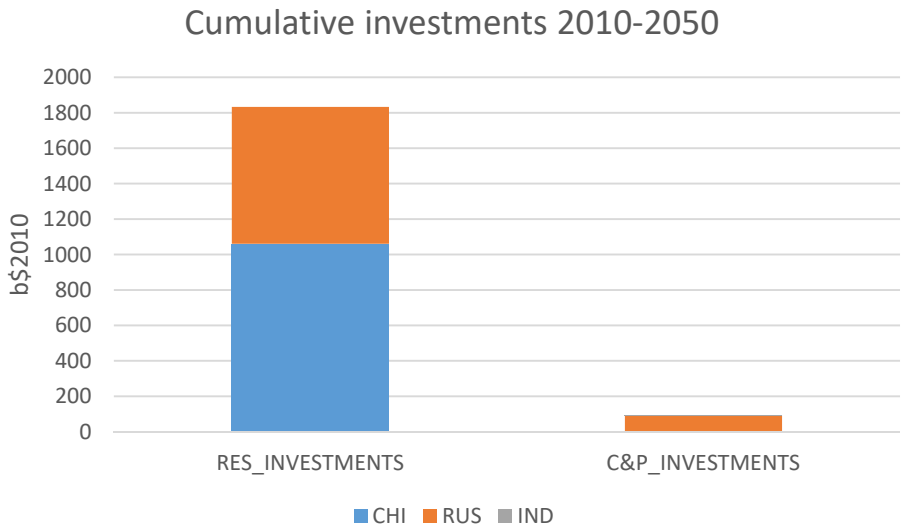
Scenario	Description	Rate of retrofit (% p.a)
Moderate Efficiency (ME)	◦ Implementation of current policies (Energy Performance Building Directive in the EU-27, building codes for new buildings in other regions); ◦ Accelerated rate of retrofit; ◦ Retrofitted buildings achieve an average energy savings of 30% as compared to the existing buildings built before 2005	Increases from 1.4% to 2.1% (EU-27, USA), 1.6% (China) and 1.5% (India) by 2020, then remains constant.
Deep Efficiency (DE)	◦ Most ambitious scenario; ◦ Best-practices are widely applied in all the regions (retrofit), achieving 60% of energy savings ◦ After 2022, most renovations will be of a very high-energy efficient design as exemplary buildings in the same climate zones and building types.	By 2020 increases from 1.4% to 3%, then remains constant.

Results

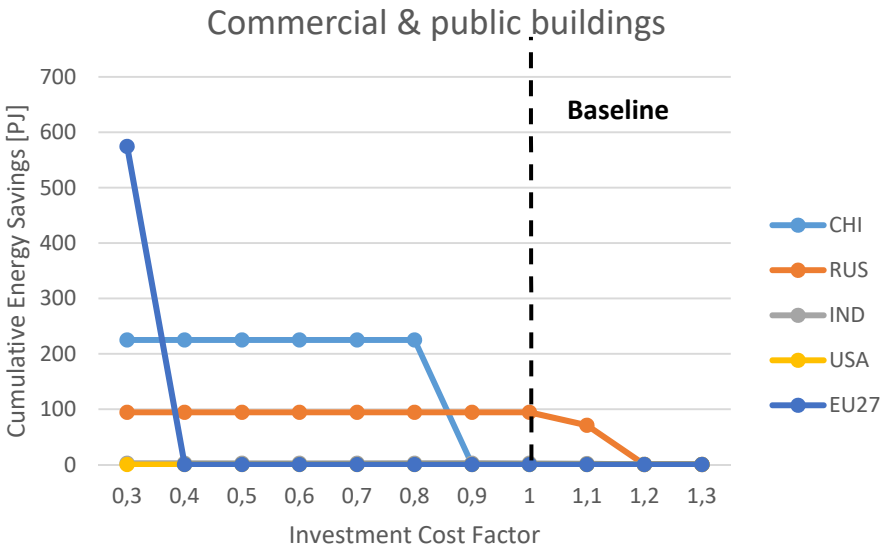
Scenario	China	India	Russia	EU27	US
Moderate Efficiency (ME)	No	No	Yes	No	No
Deep Efficiency (DE)	Yes	Yes	Yes	No	No

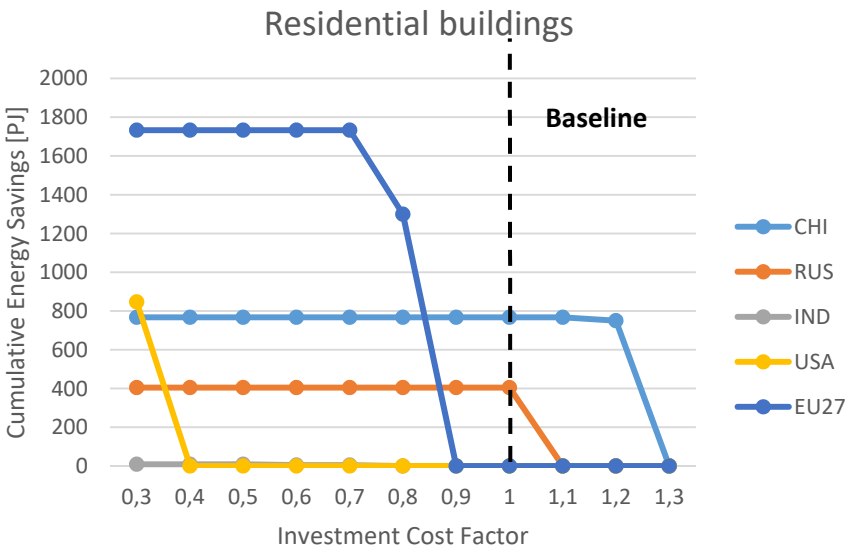
Results for DE scenario

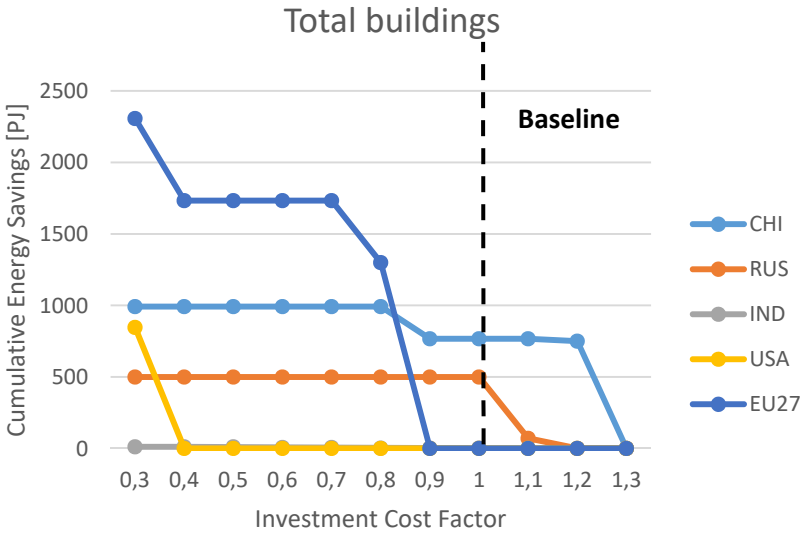




Sensitivity analysis for DE scenario







Conclusions

1) From a cost-optimization approach deep retrofit in building envelopes is more attractive than moderate retrofit, this is in alignment with other studies based on performance-based approach
2) Cumulative space heating and cooling savings from retrofit of building envelopes are very sensitive to the variation of investments cost, particularly in C&P buildings in China and residential buildings in EU27
3) The regions with the largest energy savings potential from deep retrofit of building envelopes are China, Russia and EU27
4) Deep retrofit of building envelopes replace NG burners when it rolls-out
5) Deep retrofit of building envelope is not deployed in US due to its high specific retrofit costs

Thank you for your attention!

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Data and assumptions tables

Specific retrofit costs per unit of building floor by measure in [USD_{2005}/m^2]

China	Moderate retrofit	Deep retrofit
Average SFB +MFB	197	246
C&PB	213	273
India		
Average SFB +MFB	132	166
C&PB	200	207
EU27		
Average SFB +MFB	457	571
C&PB	491	613
Russia		
Average SFB +MFB	740	925
C&PB	651	807
USA		
Average SFB +MFB	618	773
C&PB	993	1,233

Note: SFB =Single Family Buildings, MFB =Multi Family Buildings and C&PB =Commercial and Public Buildings.

Data and assumptions tables

Table 4. Average heated and cooled area as percentage of total floor area in [%].

Region	Share of heated floor area	Share of cooled floor area	Average heated/cooled area
China	22	45	33.5
India	21	21	21
Russia	90	20	55
EU27	82	66	74
US	82	66	74

Note: For RUS, the share of average heated/cooled floor area, as percentage of total floor area, is assumed to be 55%, for both residential and services sectors. For EU27, this value is assumed to be the same as for US.

Moderate vs Deep efficiency scenario

ME scenario	RES_SAVINGS (PJ)	C&P_SAVINGS (PJ)	RES_INVESTMENTS (b$2010)	C&P_INVESTMENTS (b$2010)
CHI	0	0	0	0
RUS	130	0	272	0
IND	0	0	0	0
Total	130	0	272	0

DE Scenario	RES_SAVINGS (PJ)	C&P_SAVINGS (PJ)	RES_INVESTMENTS (b$2010)	C&P_INVESTMENTS (b$2010)
CHI	768	0	1061	0
RUS	405	94	772	90
IND	0	2	0	3
Total	1173	96	1833	93

Geographical scope

Final energy consumption in residential and commercial buildings in 2010 (IEA, 2013a)

	ASEAN*	Brazil	China	EU27	India	Mexico	Russia	South Africa	USA
Residential									
Total consumption (PJ)	4600	1000	14900	12800	7200	800	4700	600	11200
Space heating	0.5%	4%	31%	66%	1%	2%	66%	8%	37%
Water heating	8%	37%	40%	14%	9%	45%	21%	25%	19%
Space cooling	2%	3%	3%	3%	2%	2%	~0%	1%	8%
Lighting	2%	5%	2%	2%	9%	7%	2%	10%	7%
Cooking	79%	33%	16%	5%	75%	29%	5%	46%	4%
Appliances and other equipment	9%	18%	8%	9%	4%	15%	6%	10%	25%
Commercial									
Total consumption (PJ)	900	400	2800	6500	600	200	1600	200	8600
Space heating	2%	1%	47%	39%	3%	17%	44%	7%	27%
Water heating	12%	14%	21%	13%	11%	11%	11%	26%	8%
Space cooling	6%	14%	6%	6%	6%	30%	1%	9%	8%
Lighting	30%	31%	13%	8%	9%	6%	9%	33%	12%
Cooking	-	-	-	-	-	-	-	-	-
Appliances and other equipment	50%	40%	13%	34%	71%	36%	35%	25%	45%

These are the bigger players!

*ASEAN stands for the Association of South-East Asian Nations and includes Brunei, Cambodia, Indonesia, Laos PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam