Methodology to estimate energy savings in buildings within ETSAP-TIAM

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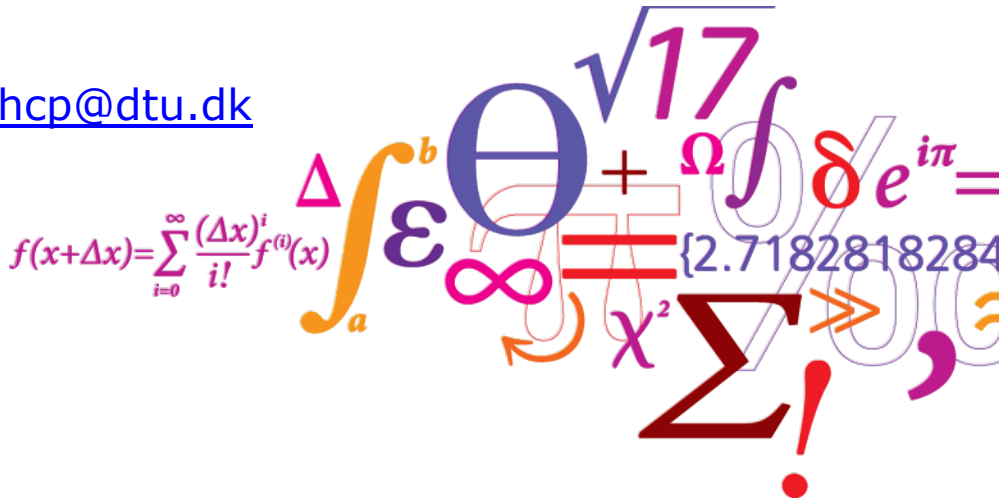

DTU Management Engineering
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Outline

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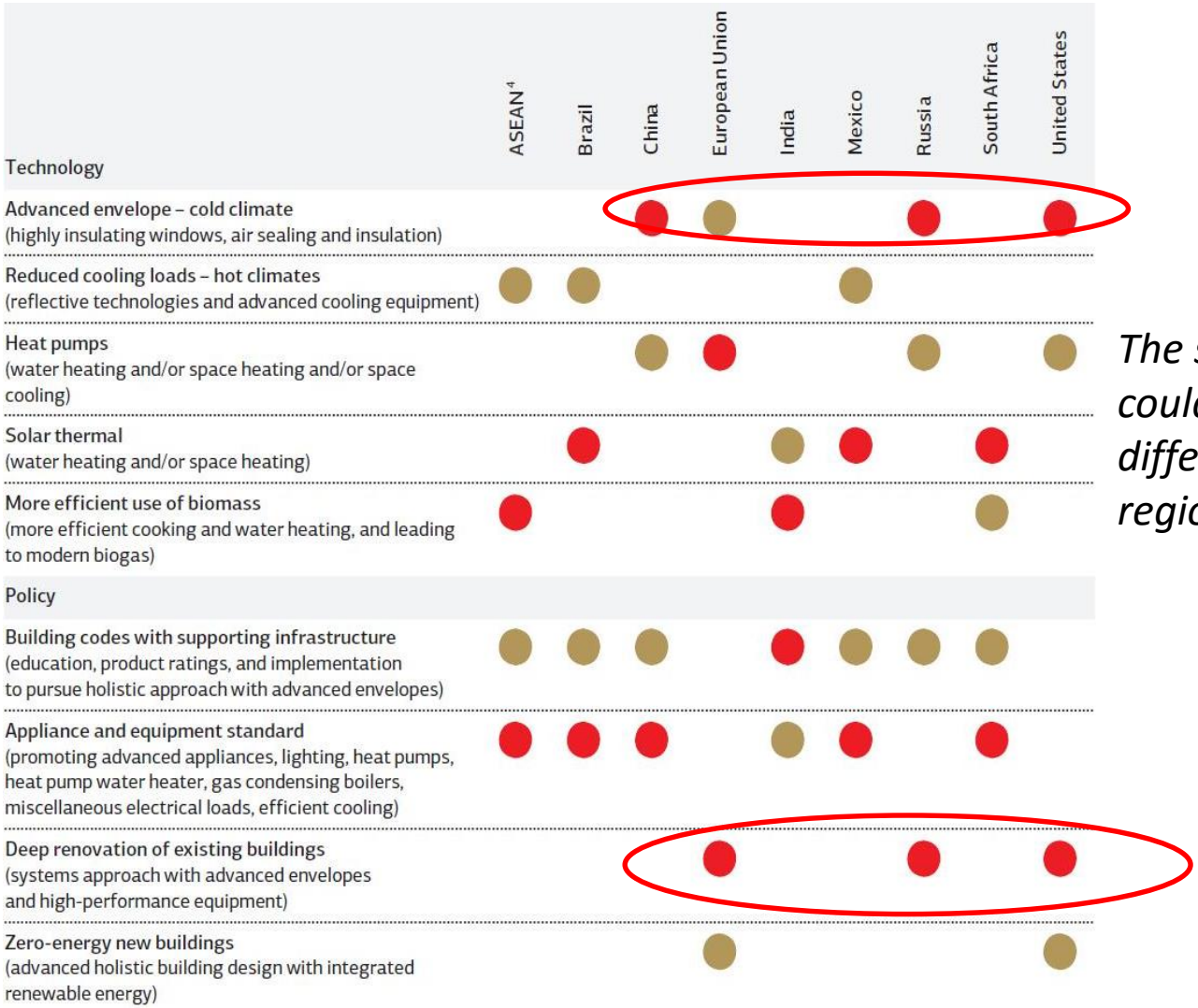
Introduction

- Buildings account for about a third total global final energy demand and about 30% of global energy-related CO2 emissions (Ürge-Vorsatz, et al. 2012).

- The European Union, the United States, China and India combined account for more than 60% of the 2005 final building energy use (Ürge-Vorsatz, et al. 2012).

- 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 might play an important role to reducing the future space heating and cooling demand.**

Technical and political measures



The same measure could have a different impact on regions.

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).

It 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 reducing heating and cooling loads, but this is only one of the functions it performs.

Objective

Determination of technical energy savings potential and its contribution to mitigate green house gases (GHG) emissions in residential and commercial buildings due to retrofitting of building envelopes.

Methodology

1) Create a technology capable of providing heating and cooling savings depending on specific energy demands in both residential and commercial buildings.

2) Carry out a literature review to identify which are the "big players" in terms of energy consumption in residential and commercial sectors.

3) Gather global data on building retrofit cost and its correspondent energy savings coefficient.

Input data and equations formulated

Input data

MC_i	Energy savings measure cost in [$/m2], i=1…n
S_c	Energy savings coefficient in [%]
T_{fa}	Total heated/cooled floor area in [million m2]
T_{ec}	Total annual space heating and cooling energy consumption in [PJ]

Equations

Retrofit cost:

$$R_c = \sum_{i=1}^{n} MC_i * T_{fa} \quad [1]$$

Total annual energy saved:

$$T_{es} = T_{ec} * S_c \quad [2]$$

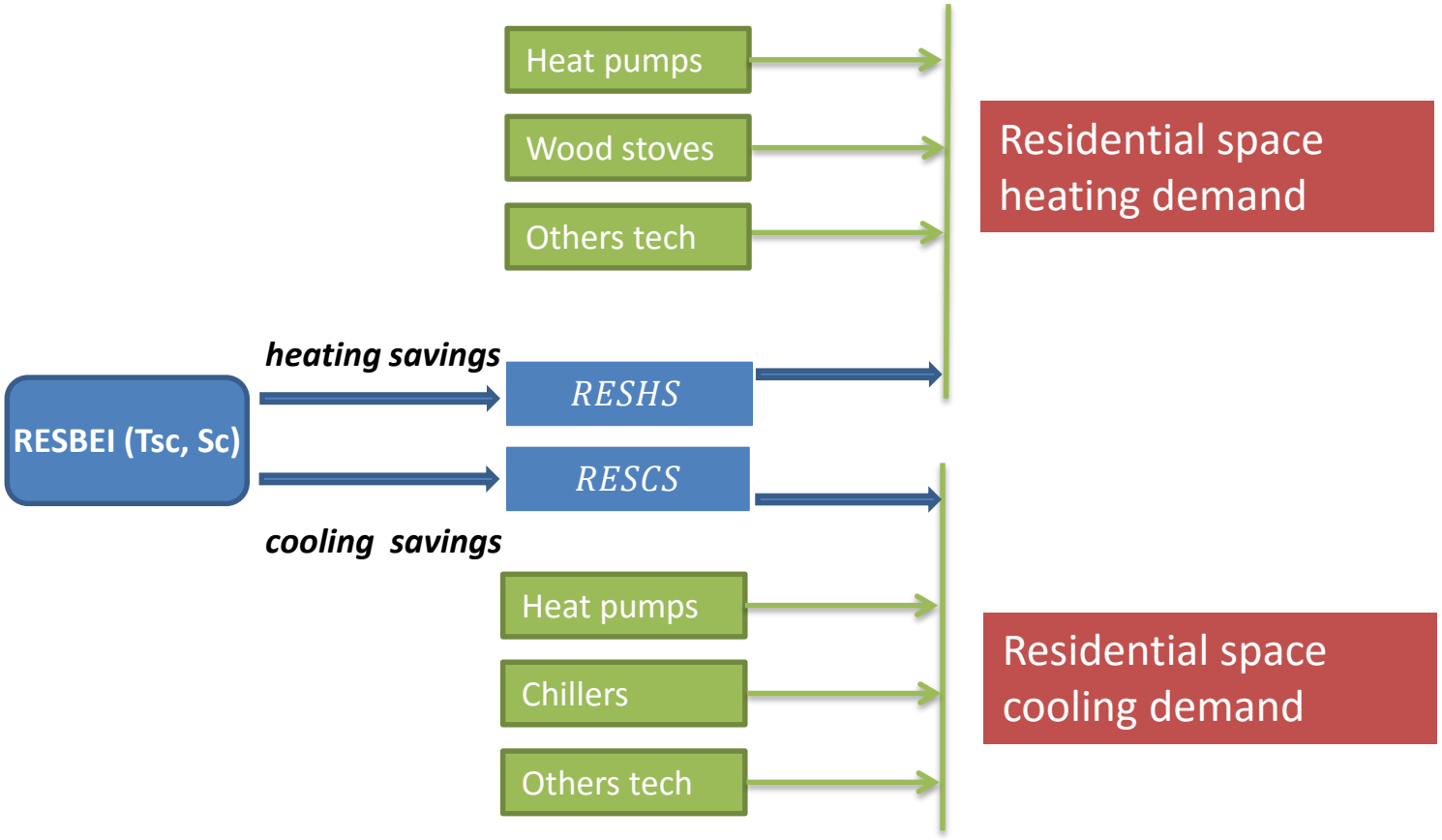
Total specific energy saving cost is:

$$\mathrm{T_{sc}} = \frac{R_c}{T_{es}} \quad [3]$$

Upper bound for annual energy savings in residential buildings:

$$RESHS + RESCS \leq T_{es} = UP_{BND} \quad [4]$$

Building envelope technology



RESBEI	Residential Building Envelope Improved	Tsc	Total specific energy saving cost
RESHS	Residential Heating Savings	Sc	Energy savings coefficient
RESCS	Residential Cooling Savings		

Energy consumption in buildings

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.

Energy savings in residential buildings example, China 2030

Building characteristics and renovation measures (Ouyang et al, 2008).

Multi family building (standard in Hangzhou city)	**Unit**	
Floor area per household	m2/house	88.75
Specific annual energy consumption	kWh/m2	112.8
Energy savings coefficient	%	50
Measures (insulated walls, improved roof and ground floor, improved windows)	$/m2	24.4

*Energy savings in residential sector **(preliminary results)**.*

Residential energy consumption (PJ)	Heating savings (%)	Cooling savings (%)	Total savings (%)
16204	2.3	0.2	2.5

Discussion

- Global data gathering process is time consuming, it is hard to find "representative data" on building envelope retrofit costs and savings associated.

- Extremely aggregated building approach, can be good as a first approximation.

- The building retrofit measures implemented in Chinese buildings stock have a larger impact on reducing space heating than space cooling demand.

Thank you for your attention!