CHALLENGES IN COMBINING DIFFERENT METHODS AND TOOLS FOR IMPROVING PERFORMANCE MONITORING IN BUILDINGS

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Introduction – Our Common Challenge

- **Reduction of energy consumption in buildings** is a vital element in the long-term transition towards low-carbon society
- The EU has identified **buildings as being the most promising target for improving energy efficiency** and has quantified a significant energy-saving potential associated with infrastructure and equipment investments
- **Challenge** - How the region/city/state can promote greater adoption of new and efficient technologies by consumers?
- Plan-Do-Check-Act (Adjust) – **Sounds simple but…**
- **Copy-paste planning - the most frequent mistake!**

Assessment of Energy Performance – Do We Really Know What We Are Doing?

- At the beginning there was a **lack of data**!
- **Energy Auditing** was logical **step forward**
- The ultimate aim of energy audit is clear – **identifying opportunities for reducing energy consumption and related costs**
- From the end-user perspective there is a need for a robust instrument for reliable **verification of energy savings** and **active support** for **building operators** to perform necessary activities for systematic reduction of the energy consumption!

Assessment of Energy Performance – Do We Really Know What We Are Doing? (2)

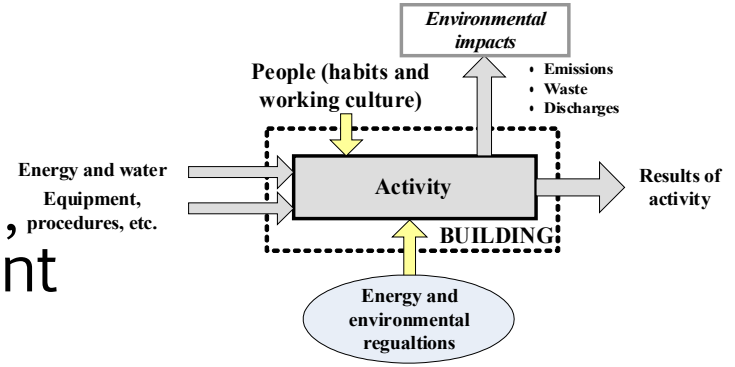
- **The house is a machine for living in!** (Charles-Édouard Jeanneret, better known as Le Corbusier)
- It is **not dehumanisation**, it simply means that the establishment of performance standards becomes necessary element of modern living
- … When you can **measure what you are speaking about**, and express it in numbers, you know something about it … (Lord Kelvin)
- Are there universally applicable solutions?
- **Context of energy use!** It is not possible to expect successful implementation of the initially defined energy efficiency programs without the proper understanding of the implementation environment

Energy Performance Monitoring and Energy Certification of Buildings

- **Key performance indicators** – the purpose of benchmarking, measured energy consumption and proposed recommendations
- Policy point of view - there is a challenge to **link real energy consumption data** with **governmental financial support** programs, **training for building managers** and **tailor-made information** campaigns for building users
- Operational point of view - it is crucial to **properly present real consumption data** to **ordinary people** which in many cases **do not understand** differences between calculated and measured energy consumption
- **There is a need to combine different methods and tools!**

Energy Cost Centre Based Modelling

- **Integration of energy within the activity flow charts**, basis for decisions on setting up the structure of ECC
- On the conceptual level, this method belongs to the **family of process integration methods**
- It provides methodological approach for **connecting energy and activity diagrams** into overall framework for improving energy performance
- **Completely in line with ISO 50001!!**
- Different key performance indicators were selected, the most important - Energy Performance Coefficient ratio of actual to predicted or benchmark energy consumption

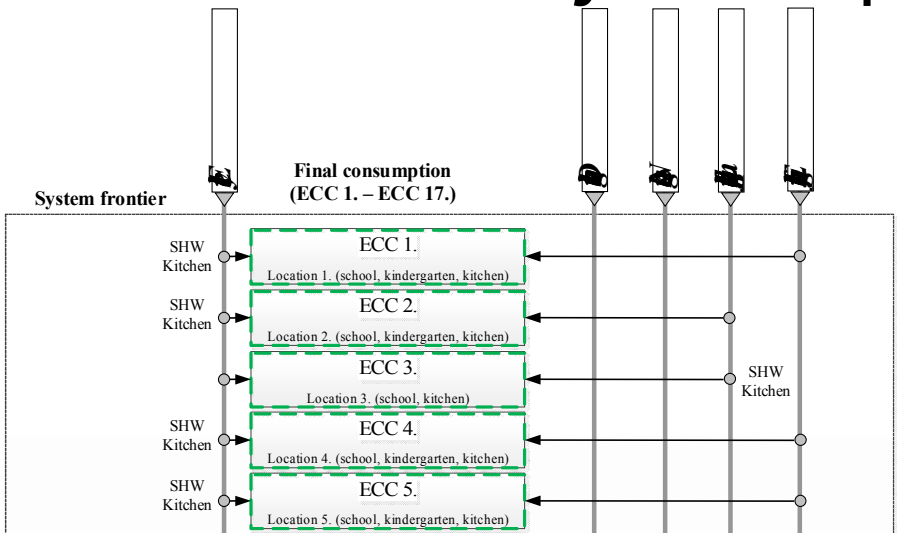


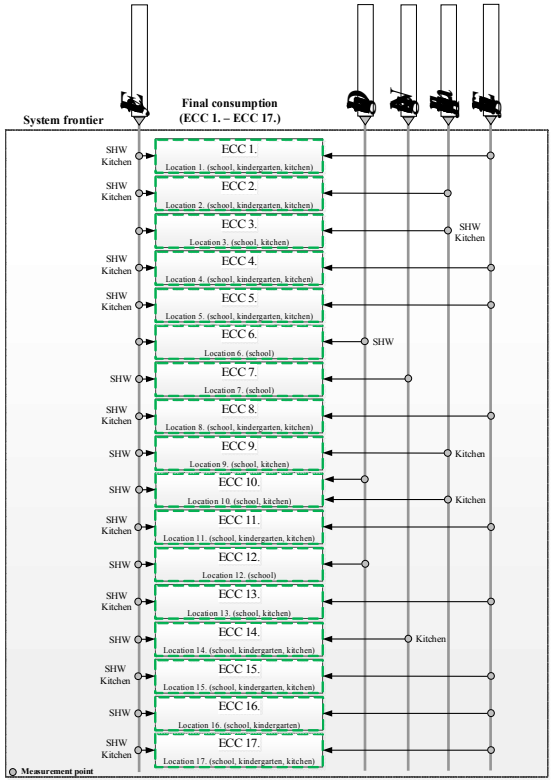
Data Envelopment Analysis

- DEA is a **non-parametric method** based on postulates of mathematical programming and it is used to measure the performance or effectiveness of private sector companies or public sector entities
- It is used to **compare decision-making units** (alternatives) in terms of their efficiency in converting inputs into outputs
- It is not possible to **explicitly relate and mathematically formulate relationship** between selected input elements that are participating in the creation of the desired output values - weighting factors for inputs and outputs are not determined by the end user, but they are calculated by a linear optimization procedure for each individual business entity
- DEA can be implemented on a set of **comparable business entities** belonging to the **same sector**

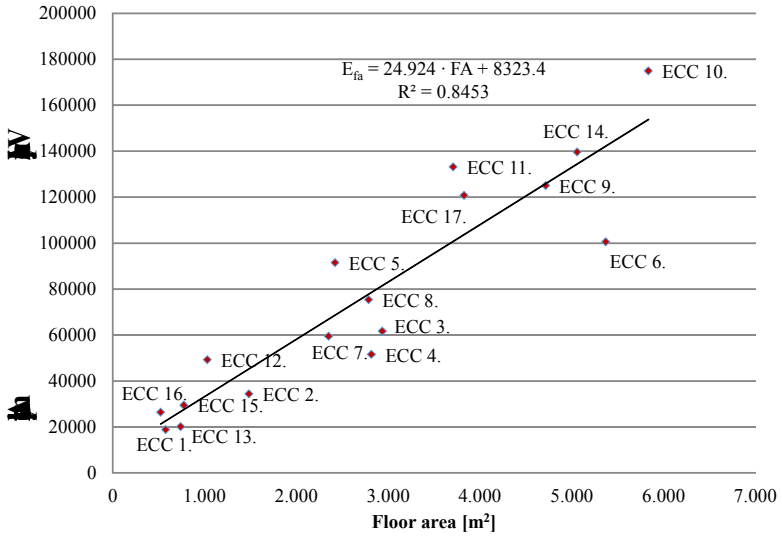
Results and Discussion

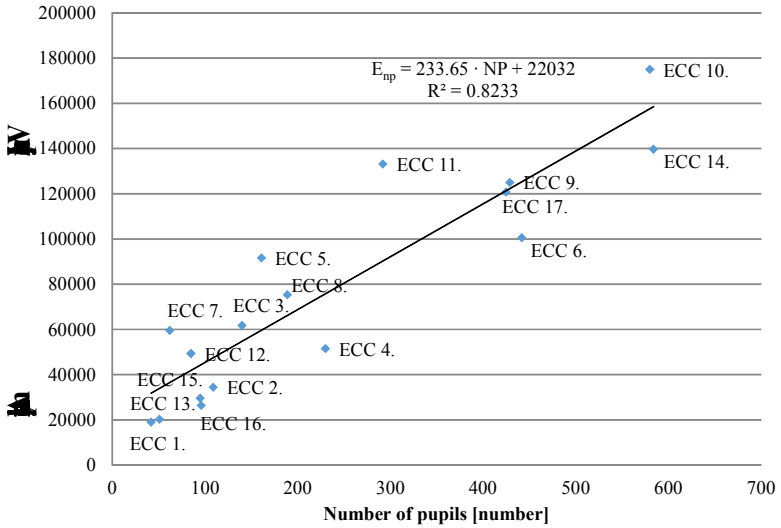
- ECC based modelling and DEA were used for the **assessment of the energy performance** of different buildings belonging to educational sector
- **Decision support for energy manager!**
- Point of interest – **electricity consumption**!

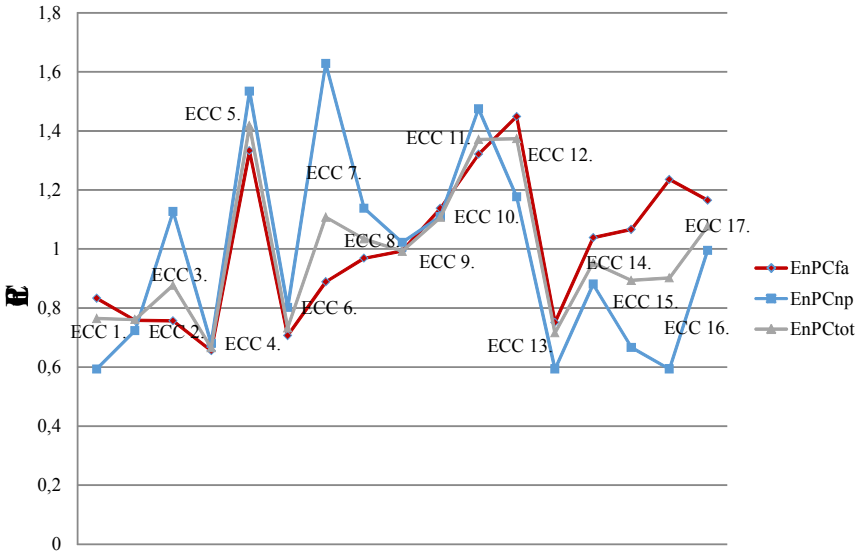




Results and Discussion (2)







Results and Discussion (3)

	CRS model	VRS model	Comparable ECCs according to VRS model and corresponding λ weight
ECC 1	0,557	1,000	ECC 1 is on the VRS efficiency frontier (peer)
ECC 2	0,789	0,913	ECC 13 (λ = 0,642) and ECC 4 (λ = 0,358)
ECC 3	0,870	0,872	ECC 4 (λ = 0,954) and ECC 6 (λ = 0,046)
ECC 4	1,000	1,000	**ECC 4 is the most efficient ECC, placed on both CRS and VRS efficiency frontier (peer)**
ECC 5	0,484	0,497	ECC 4 (λ = 0,809) and ECC 13 (λ = 0,191)
ECC 6	0,985	1,000	ECC 6 is on the VRS efficiency frontier (peer)
ECC 7	0,722	0,747	ECC 4 (λ = 0,774) and ECC 13 (λ = 0,226)
ECC 8	0,676	0,677	ECC 4 (λ = 0,985) and ECC 13 (λ = 0,015)
ECC 9	0,769	0,780	ECC 6 (λ = 0,939) and ECC 4 (λ = 0,061)
ECC 10	0,743	1,000	ECC 10 is on the VRS efficiency frontier
ECC 11	0,509	0,515	ECC 4 (λ = 0,651) and ECC 6 (λ = 0,349)
ECC 12	0,386	0,525	ECC 13 (λ = 0,703), ECC 4 (λ = 0,154) and ECC 16 (λ = 0,142)
ECC 13	0,673	1,000	ECC 13 is on the VRS efficiency frontier (peer)
ECC 14	0,937	1,000	ECC 14 is on the VRS efficiency frontier (peer)
ECC 15	0,722	0,909	ECC 16 (λ = 0,643), ECC 13 (λ = 0,273) and ECC 4 (λ = 0,084)
ECC 16	0,815	1,000	ECC 16 is on the VRS efficiency frontier (peer)
ECC 17	0,788	0,800	ECC 6 (λ = 0,920) and ECC 4 (λ = 0,080)
Mean	0,731	0,837	–

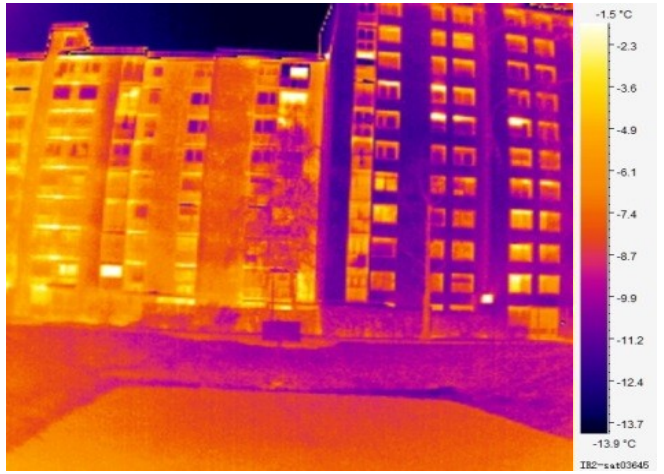
Conclusion and Future Outlook

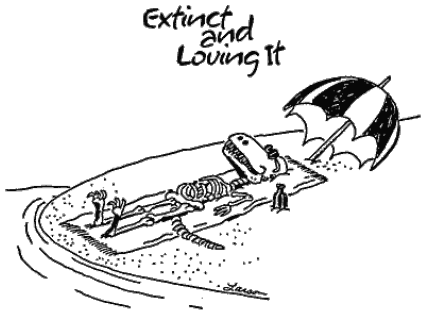
- **Performance monitoring – learning through people‘s performance evaluation**
- Assessment of energy performance of buildings (different methods and tools) + proper understanding of context of energy use + common set of key performance indicators = better energy efficiency culture
  YES, WE NEED IT!
- **Introduction of dynamic and context-sensitive indicator** called Energy Performance Coefficient, which is the **ratio of actual (measured) to predicted, estimated or benchmark energy consumption**, can be part of the solution
- **Models must incorporate the required knowledge on how to correctly interpret different values of key performance indicators**

Conclusion and Future Outlook (2)

- **Promotion of energy awareness** requires significant amount of time, efforts and experience – two main barriers resolved **(fear of change** - the addressed energy systems within the building are so complicated and can‘t be optimised

- Energy efficiency expert and building manager – **honest relationship, communication and cooperation**





Thank you for attention!

If you would like to have more information please contact

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