Jožef Stefan Institute

Session 4
Data collection and inspection of energy management systems

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Cyprus Energy Agency

Jožef Stefan Institute

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Introduction – our common challenge

- **Reduction of energy consumption in buildings** is a vital element in the long-term transition towards carbon neutral 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?

Assessment of energy performance – Do we really know what we are doing? (1/2)

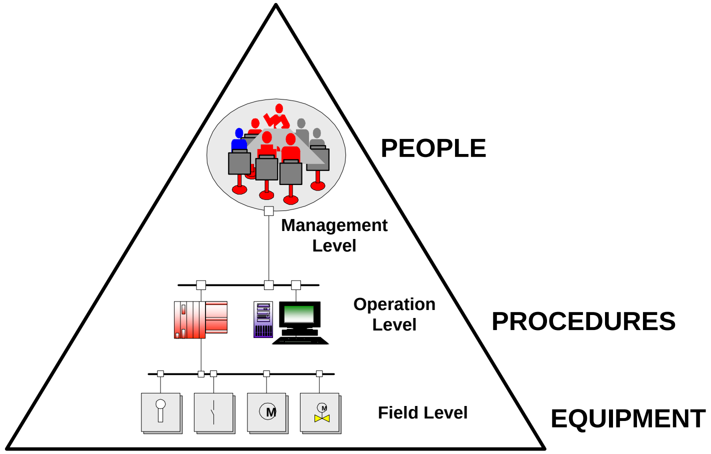
- At the beginning there was a lack of data!
- Energy Auditing was logical step forward
- The ultimate aim of energy audit is clear – identifying opportunities for reducing energy consumption and related costs
- From the end-user perspective there is a need for a robust instrument for reliable verification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

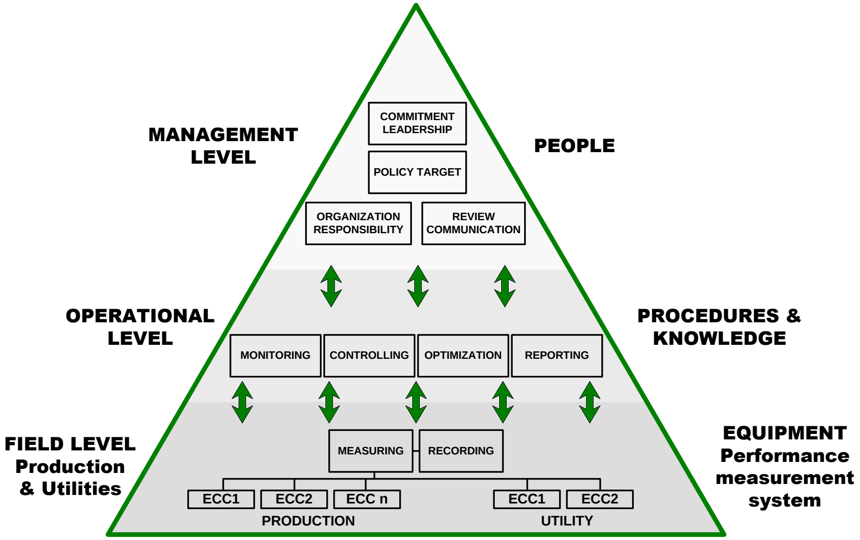
Assessment of energy performance – Do we really know what we are doing? (2/2)

- **The house is a machine for living in!** (Charles-Édouard Jeanneret, better known as Le Corbusier)
- It is **not dehumanization**, 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

What does energy management system actually mean?

- Plan-Do-Check-Act (Adjust) - Sounds simple but…
- Performance monitoring – learning through people's performance evaluation
- A common information system for the assessment of energy performance of buildings + proper understanding of context of energy use + common set of key performance indicators = better energy efficiency culture
- Copy-paste planning - the most frequent mistake!





Energy management – systematic process of change towards sustainability

EFFICIENT OPTIMISATION

- Decision Support
- Performance Measurement System
- Monitoring and Adaptation of Energy Consumption to Actual Needs
- Dynamic Benchmarking
- Verification of Achieved Savings

KNOWLEDGE

- Understanding Energy and Water Consumption
- Linking Energy Consumption and Context
- Benchmarking
- Forecasting (Estimating) Future Energy and Water Consumption

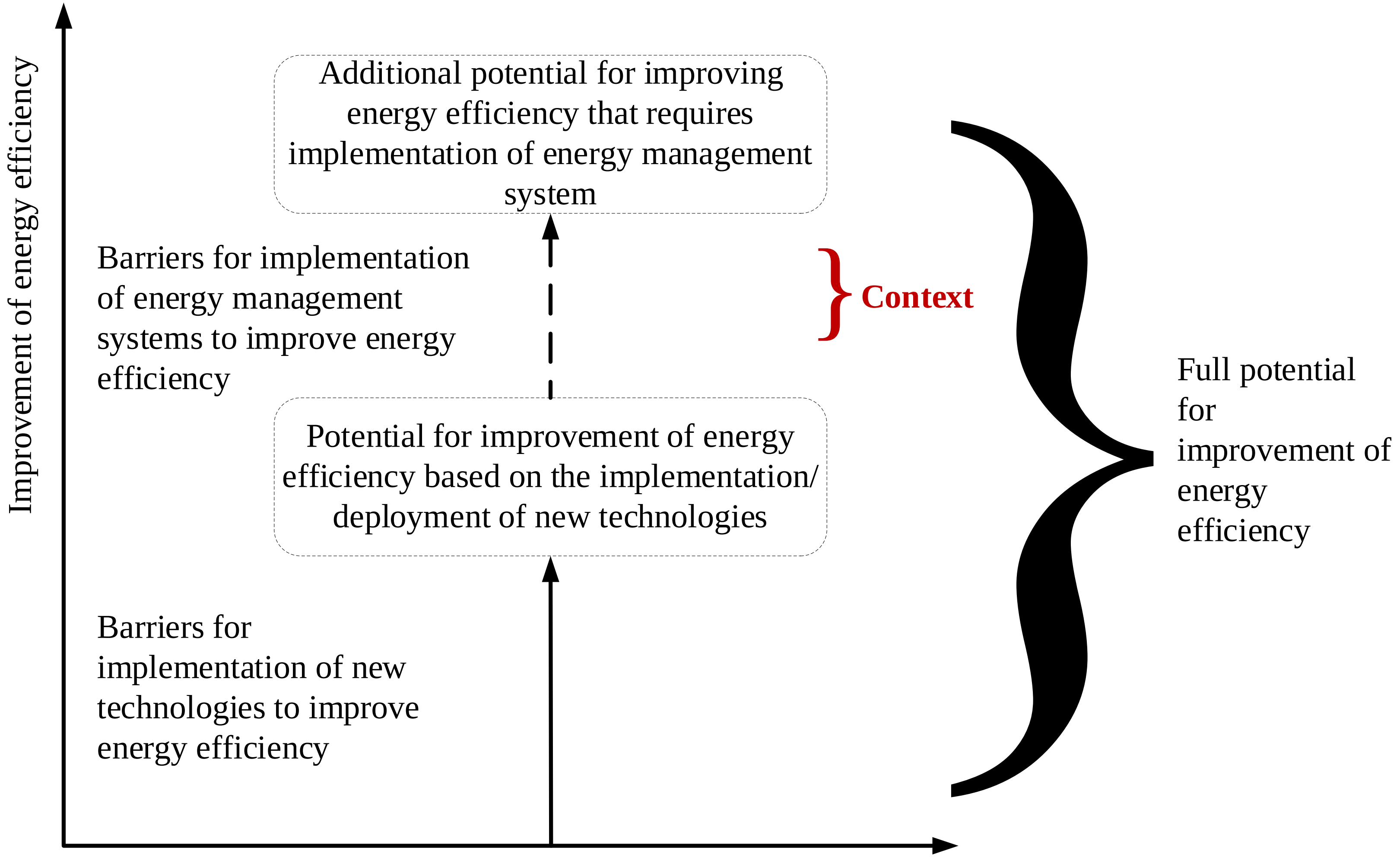
INFORMATION

- Key Perfromance Indicators
- Costs for Energy and Water
- Processed Contextual Parameters
- Various Alarms

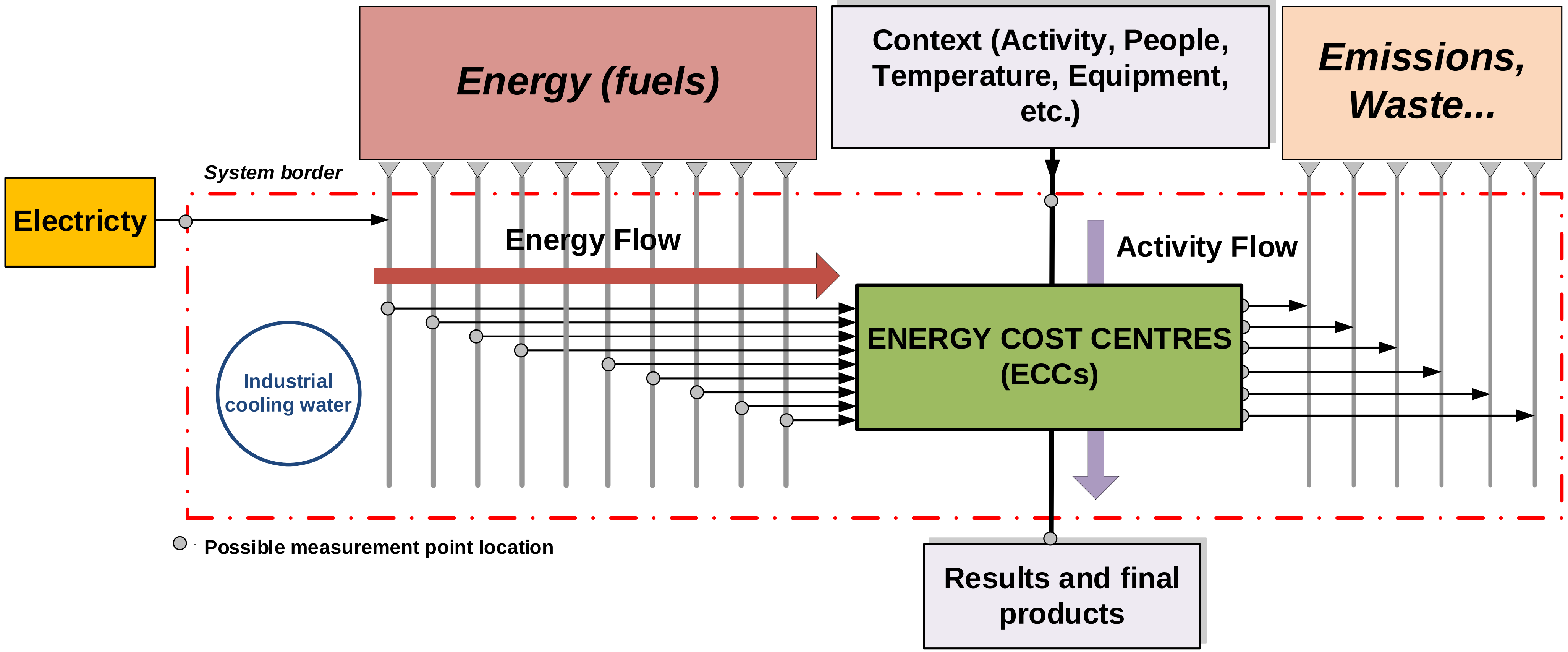
DATA

- Energy and Water Consumption
- External Temperature
- Solar Irradiation
- Internal Temperature
- Workplace Presence
- Energy Prices

Importance and role of the energy management system in the process of unlocking the full potential for improving energy efficiency

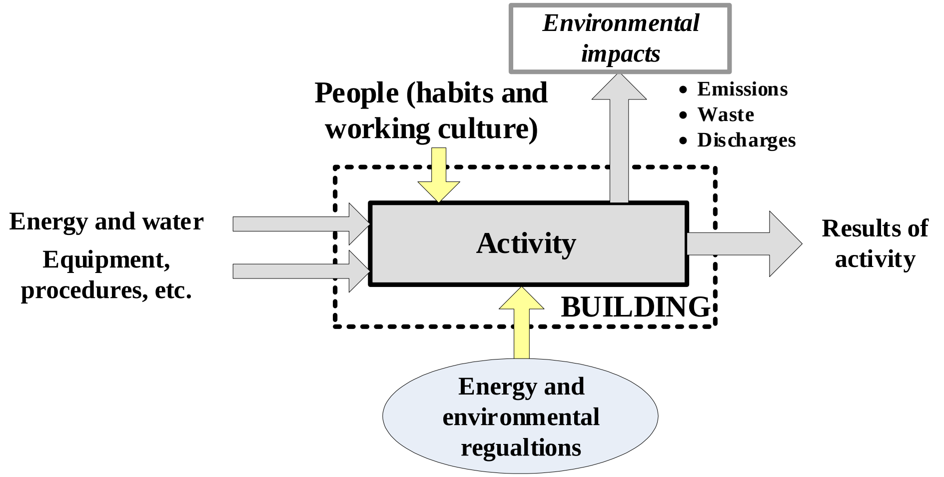


Process Integration - systematic approach to design, analyze, and optimize processes to enhance efficiency, reduce energy consumption, and minimize waste

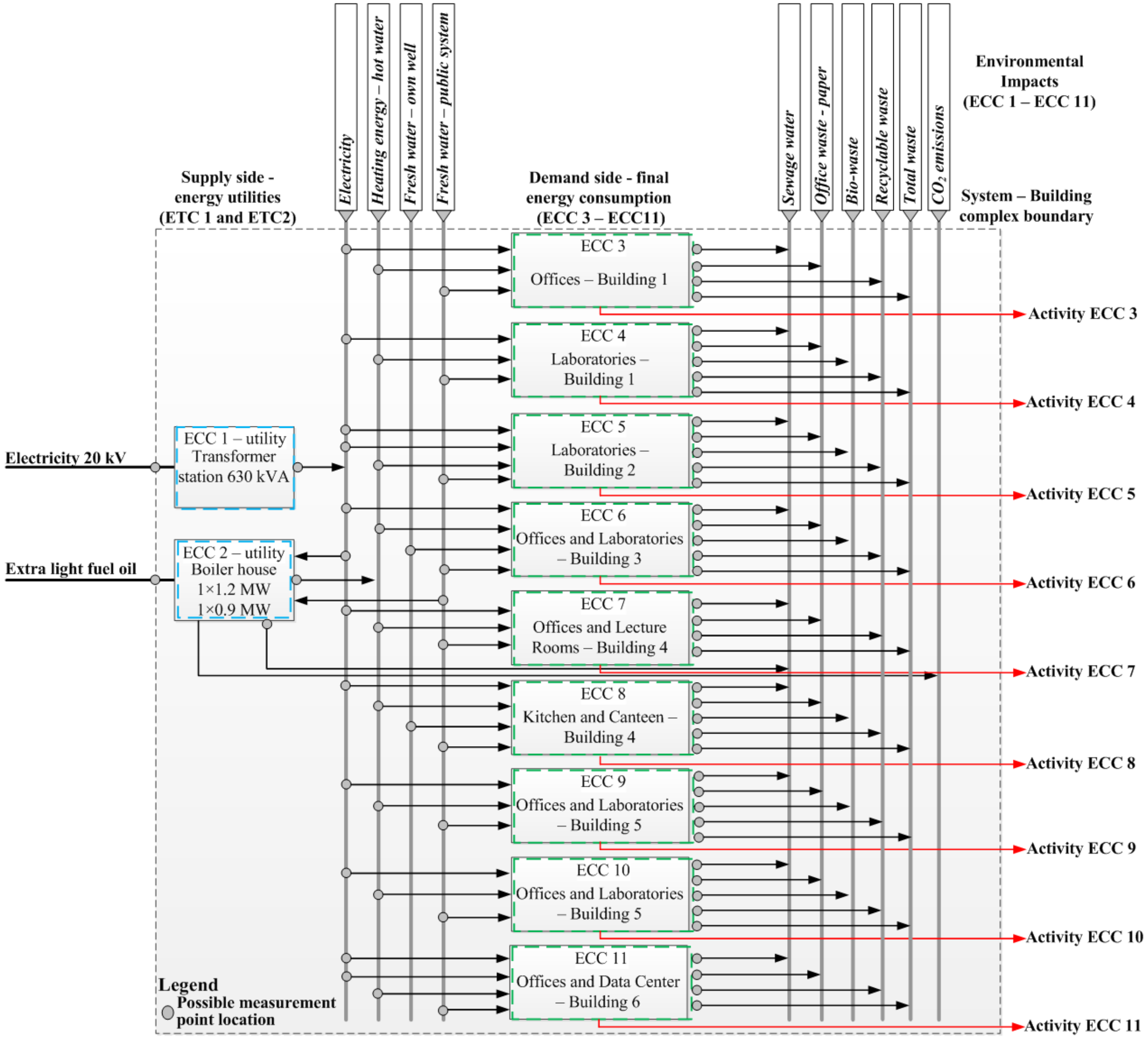


Energy cost centre based modelling

- 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

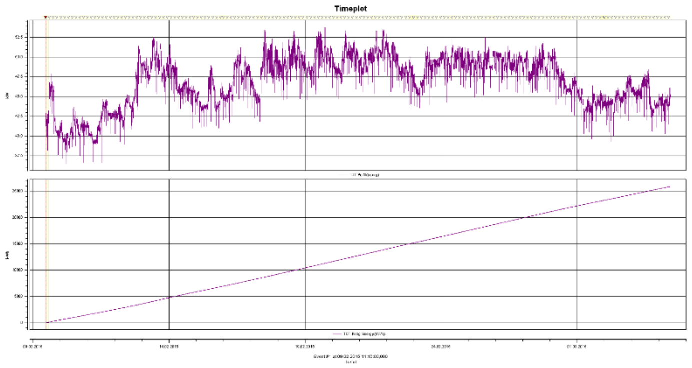


Implementation at the JSI (1/3)

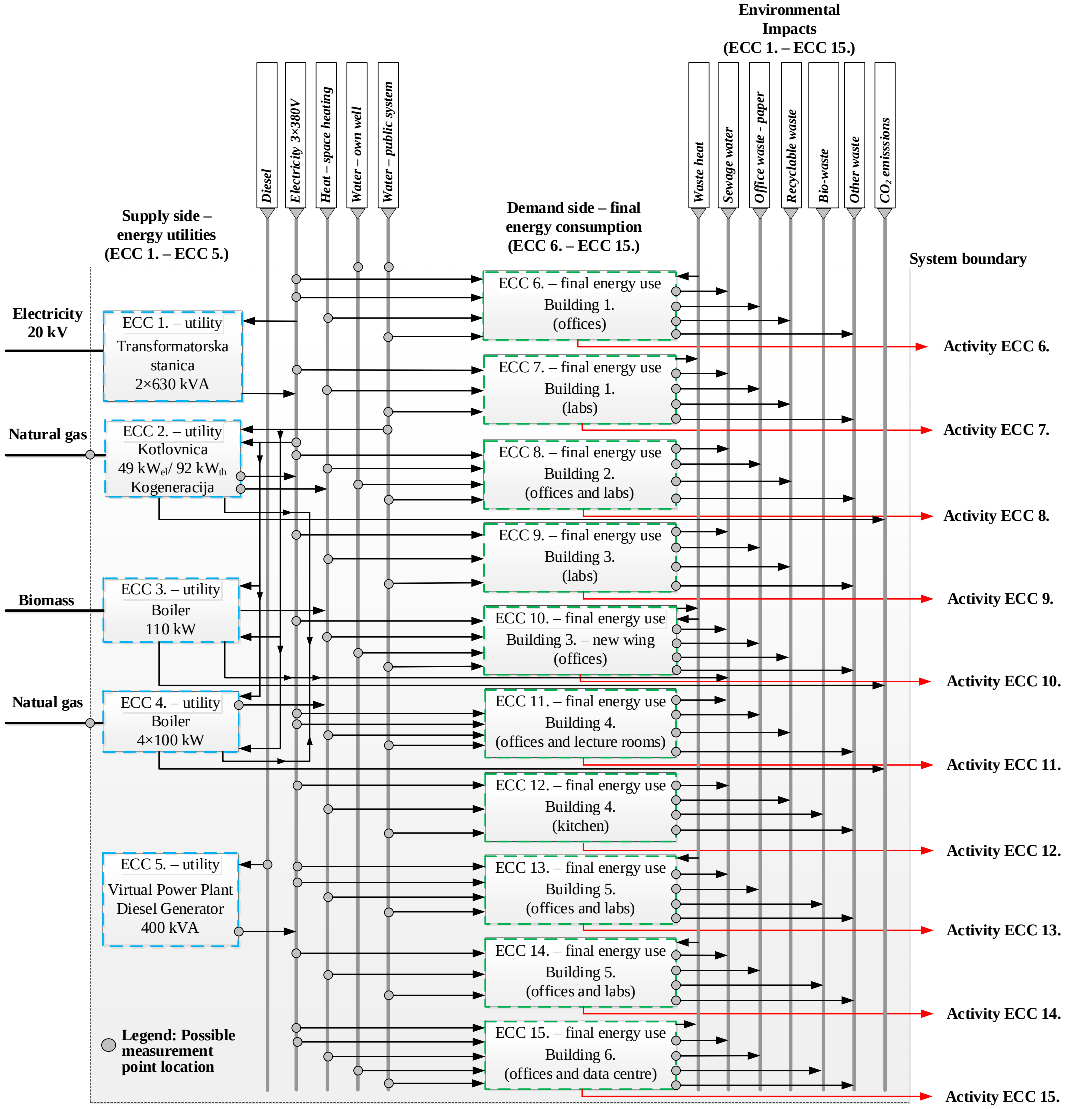


Implementation at the JSI (2/3)

- **Additional meters were installed**
- Many different metering campagins were conducted

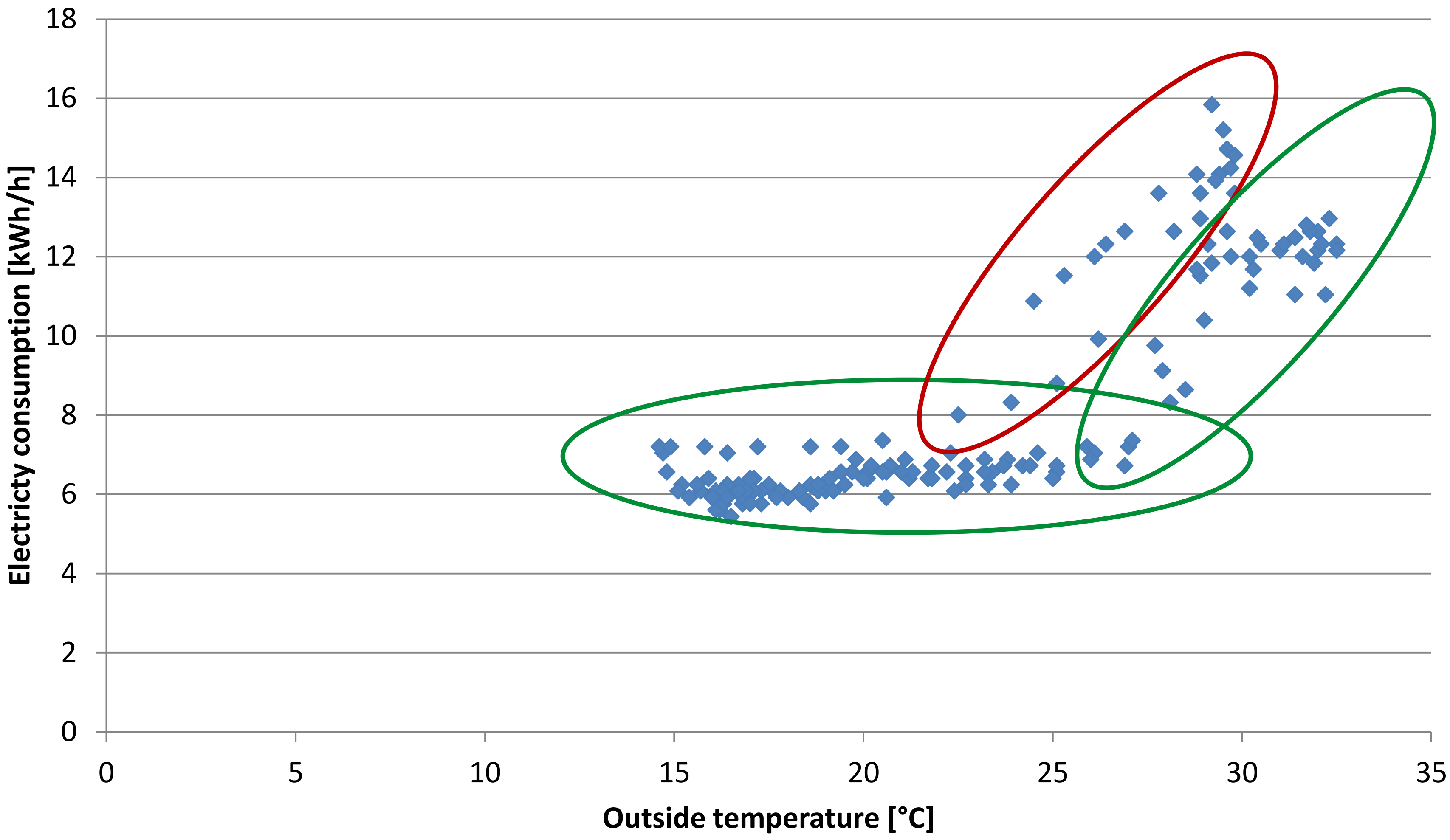
Implementation at the JSI (3/3)



Measurements without monitoring and targeting are not enough!

- The installation of appropriate additional measurements and remote reading/monitoring is only the first step!
- Many companies already monitor and measure a vast amount of flows in their SCADA systems but the real questions are:
  - Do we effectively use all collected data?
  - Does established reporting provide adequate results?
- Savings in the implementation of an energy management system usually result in minor and, above all, non-permanent savings!
  - Without an appropriate set of indicators and reporting
  - Without establishing an appropriate monitoring and targeting system

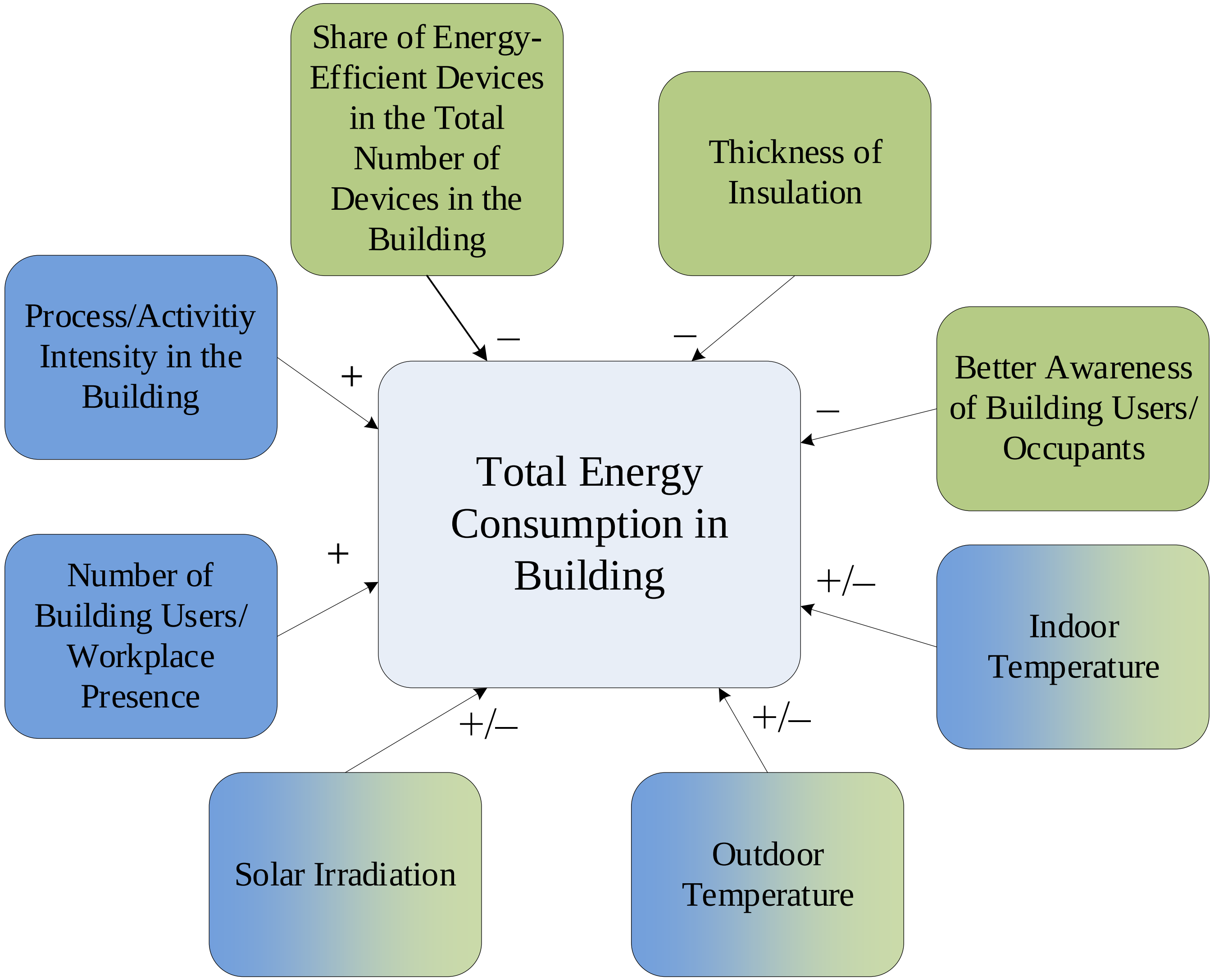
Understanding data patterns



Understanding measured data

Data needed for the optimal operation of modern buildings

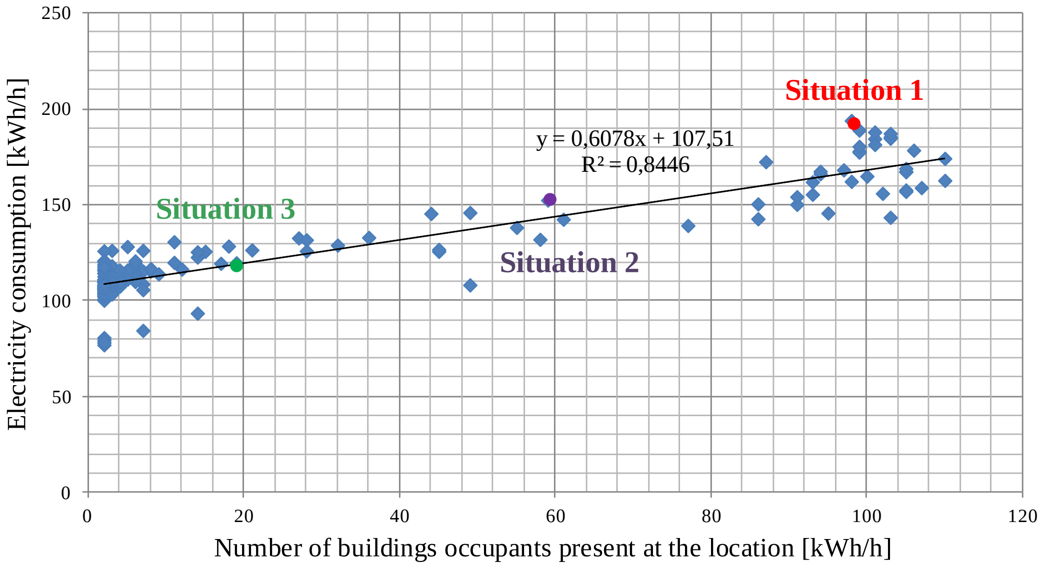
- Energy data
  - Energy and water consumption
- Contextual data
  - All other data



Context of energy use

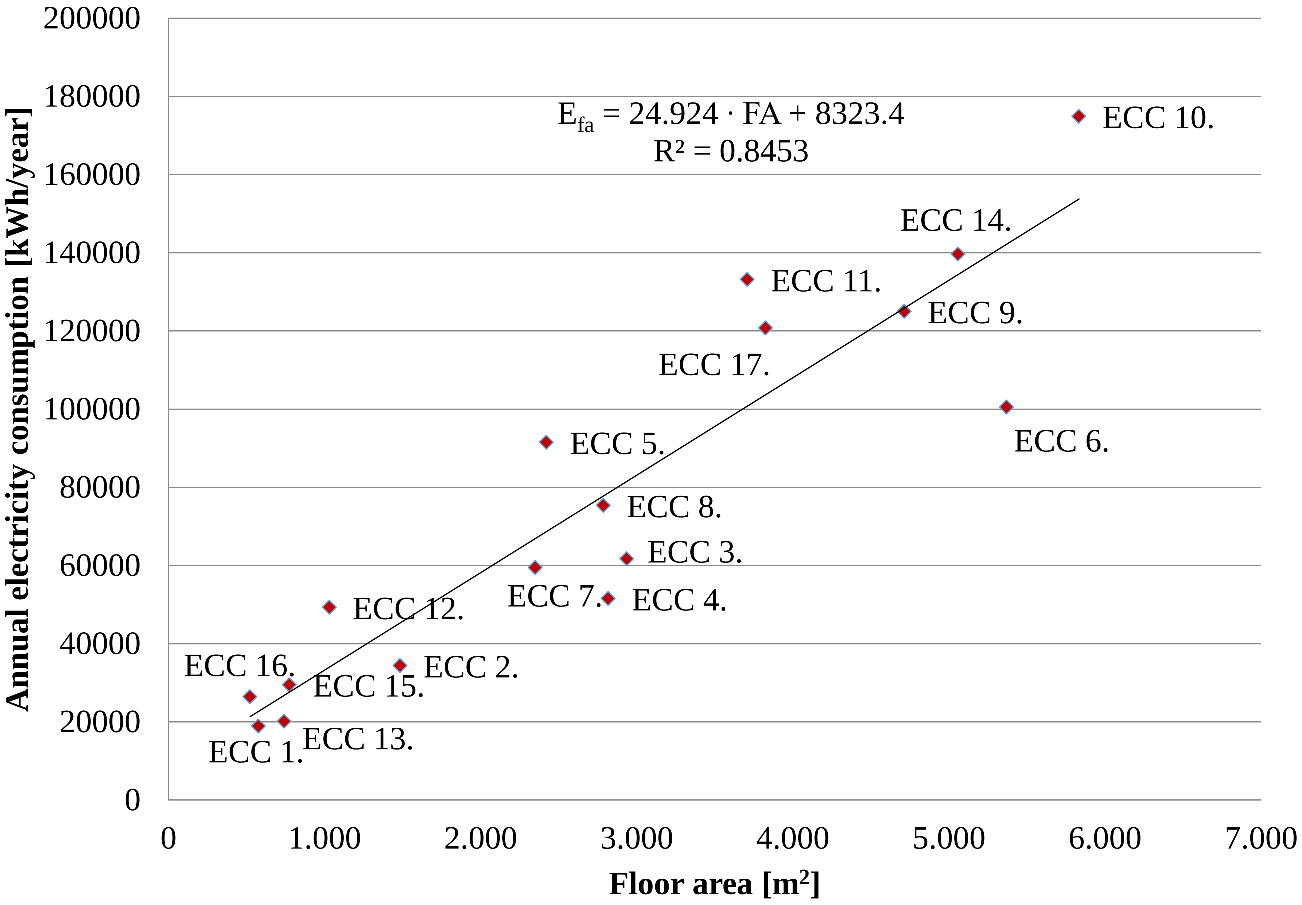
- Contextual parameters – non-energy data essential for a correct understanding of energy consumption (workplace presence, lecture schedule, outdoor/indoor temperature, or the social status of the end user)
- Indicators – must contain information about the context of energy consumption
- Specific hourly electricity consumption at the location:
  - Situation 1: 1.8 kWh/employee
  - Situation 2: 2.5 kWh/employee
  - Situation 3: 6.5 kWh/employee

- In which situation were we the most efficient?



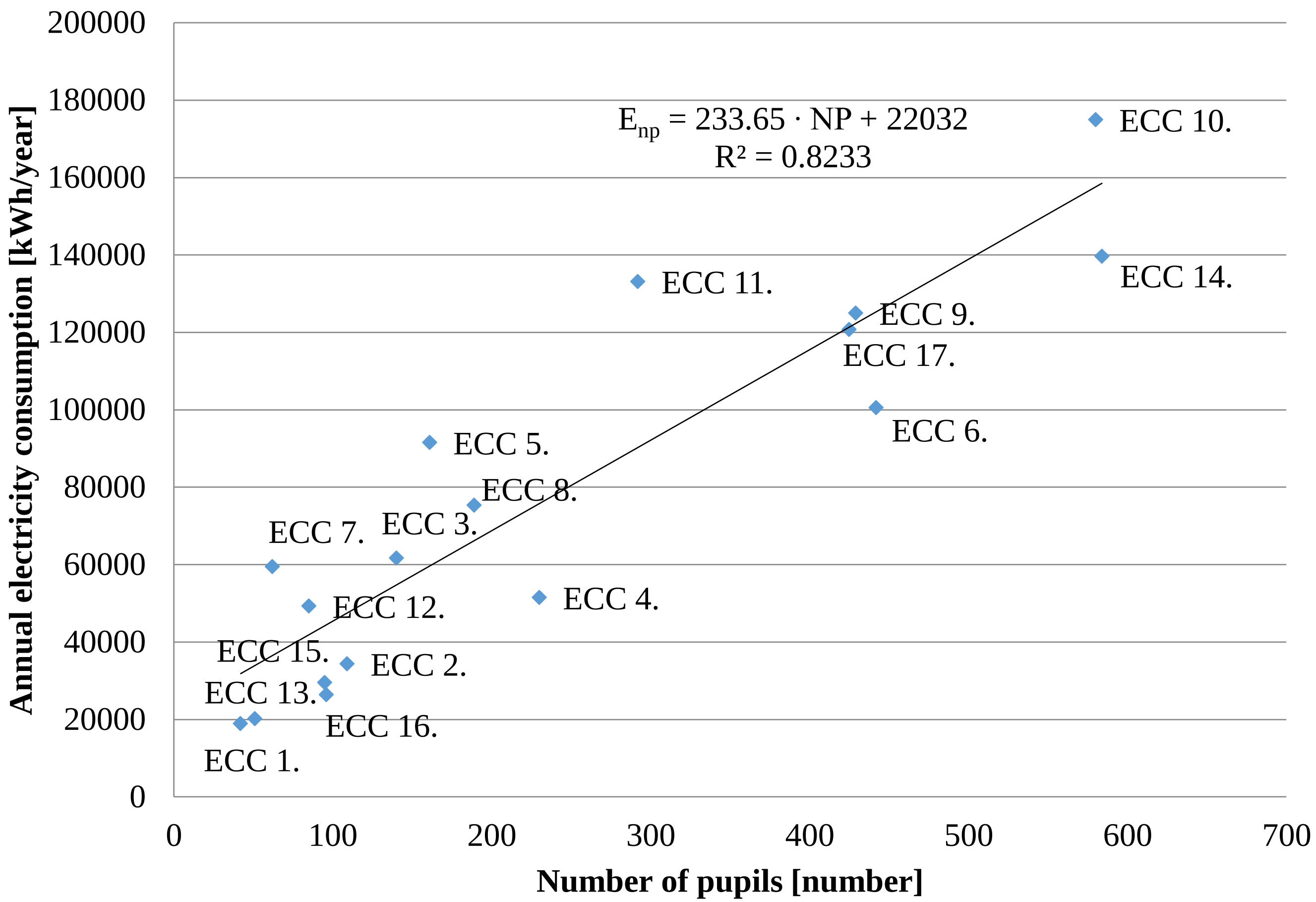
Analysis of available data - monitoring and targeting (1/4)

- Regression Analysis



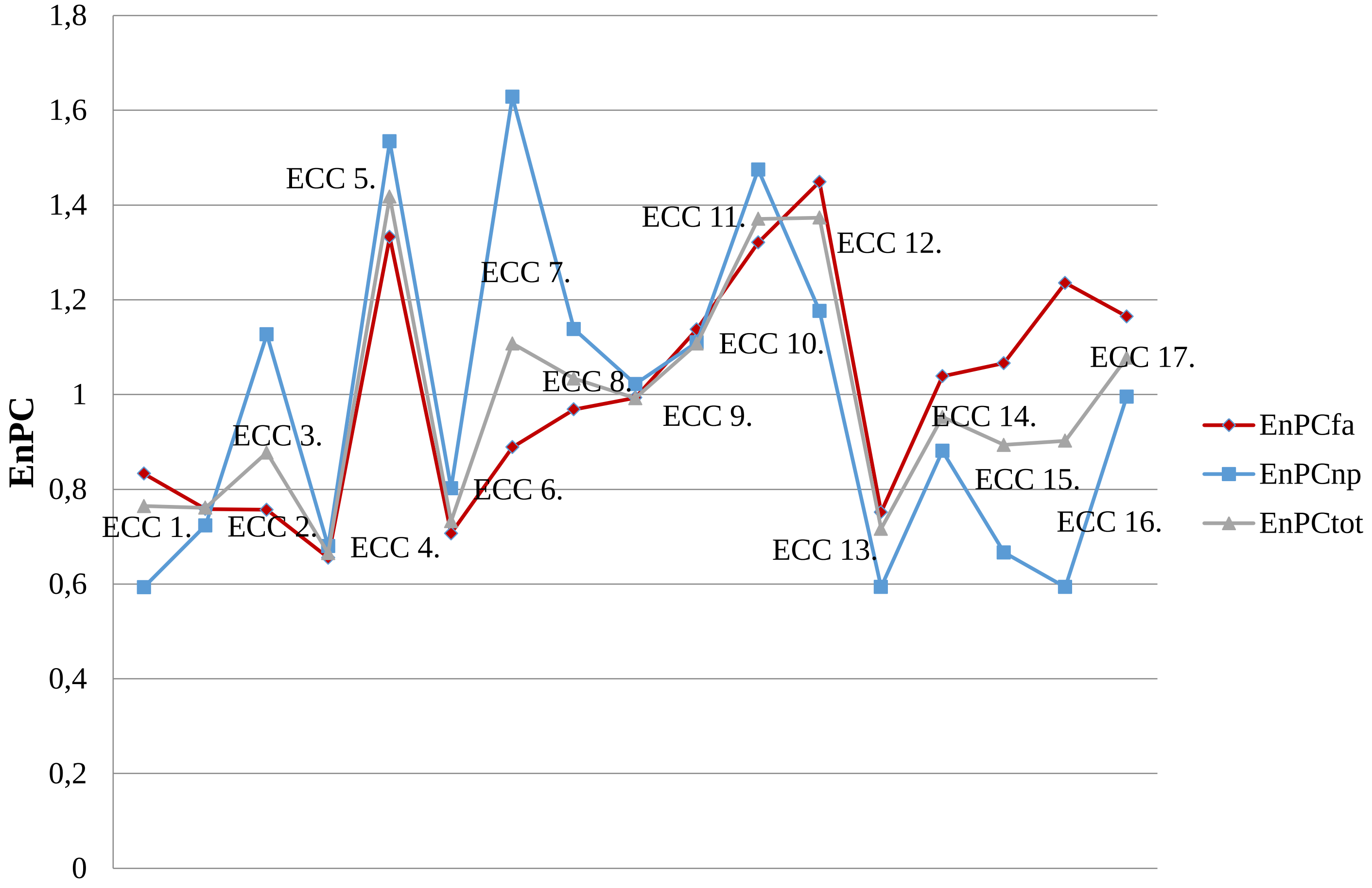
Analysis of available data - monitoring and targeting (2/4)

- Regression Analysis



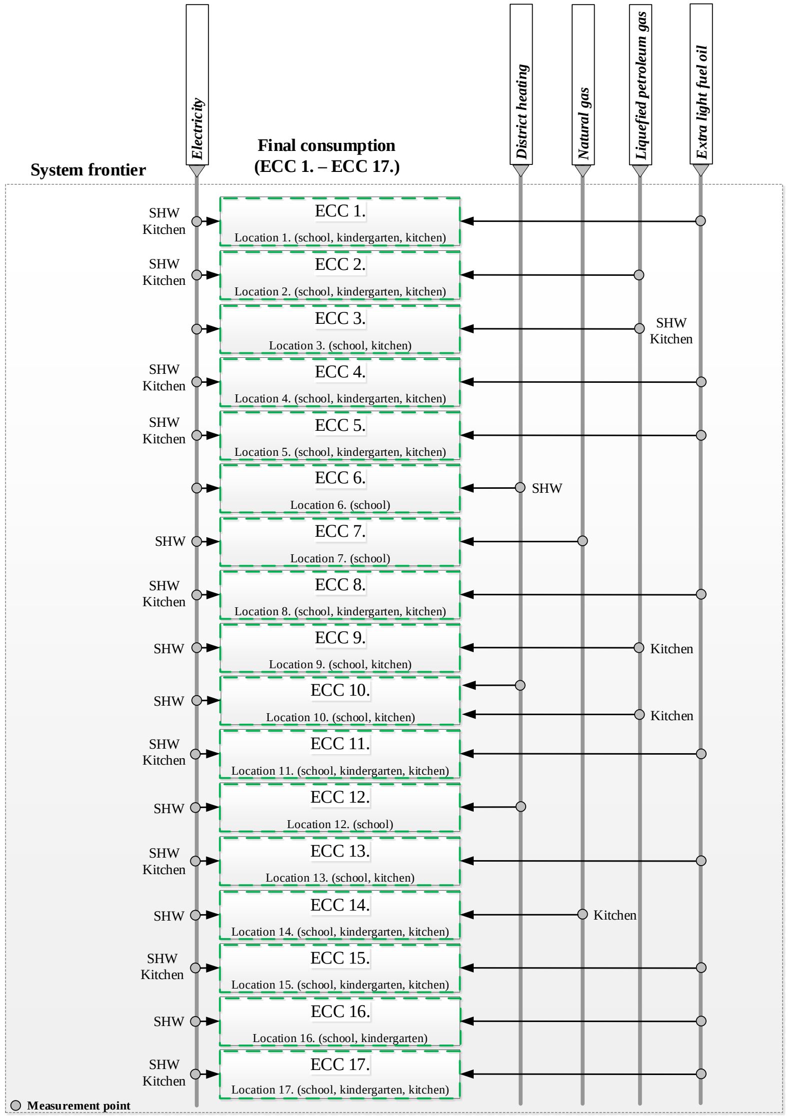
Analysis of available data - monitoring and targeting (3/4)

- Use of additional indicators



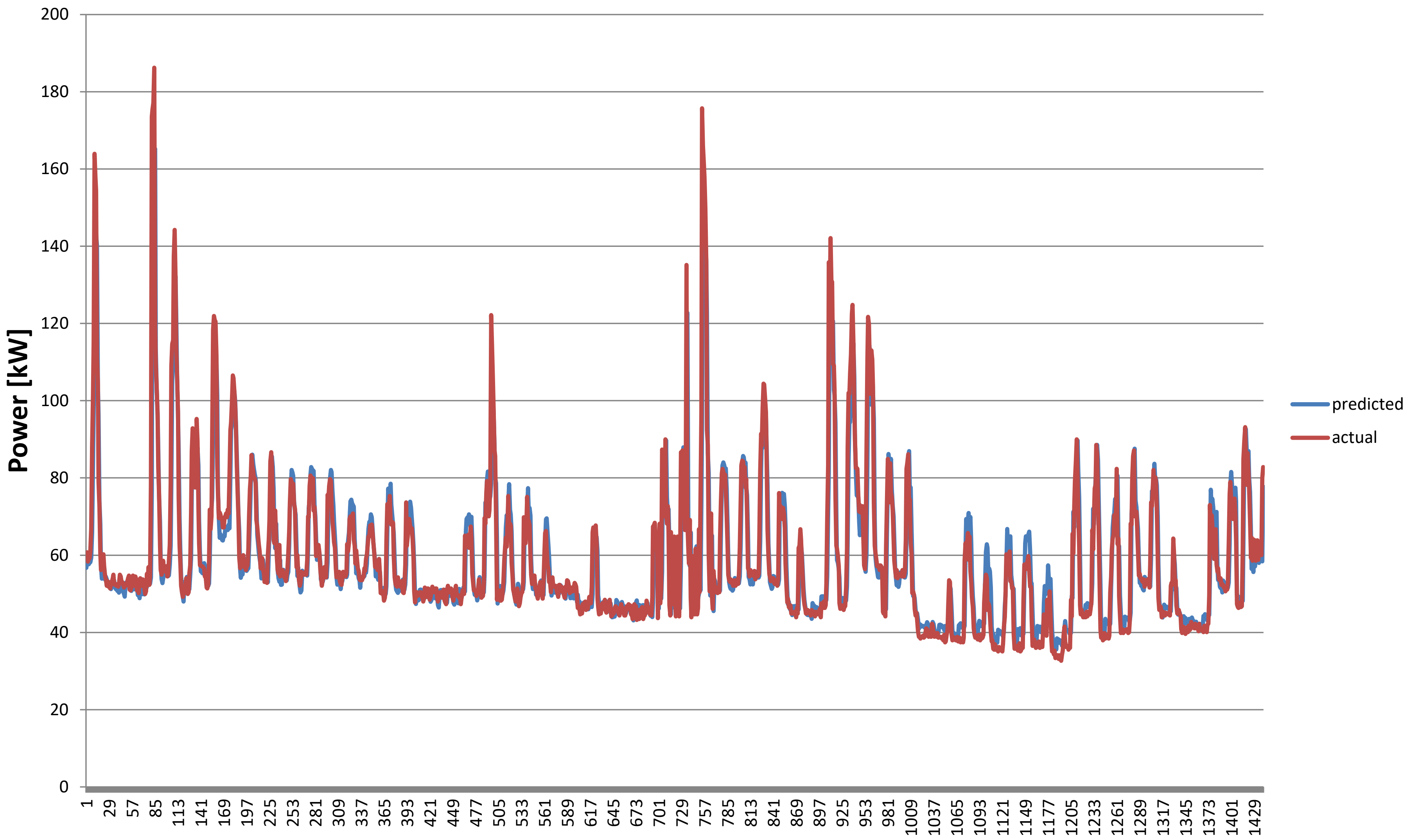
Analysis of available data - monitoring and targeting (4/4)

- ECC based modelling and DEA (data envelopment analysis) can be combined for the assessment of the energy performance of different buildings belonging to educational sector
- **Decision support for energy manager!**
- Point of interest – electricity consumption!

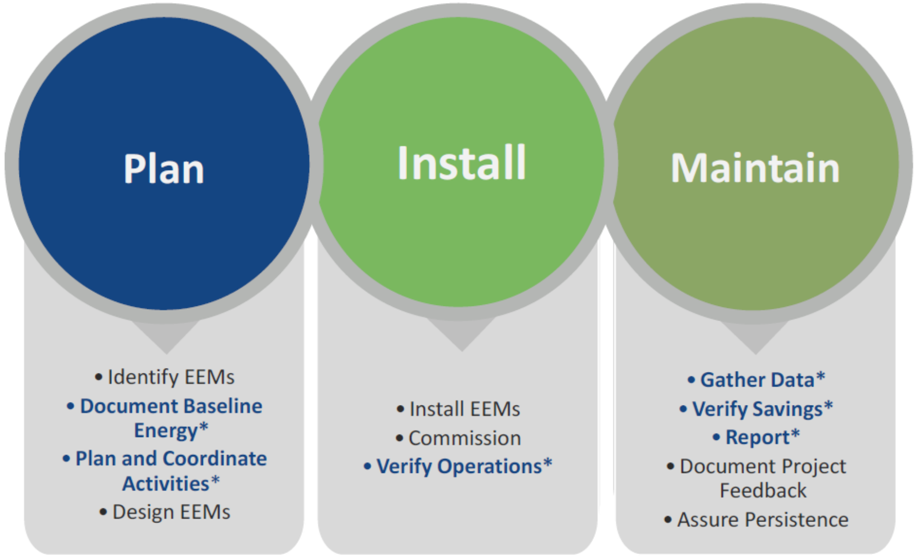


	CRS model	VRS model	Comparable ECCs according to VRS model and corresponding λ weight
ECC 1	0,557	1,000	ECC 1 is on the VRS efficiency frontier (peer)
ECC 2	0,789	0,913	ECC 13 (λ = 0,642) and ECC 4 (λ = 0,358)
ECC 3	0,870	0,872	ECC 4 (λ = 0,954) and ECC 6 (λ = 0,046)
ECC 4	1,000	1,000	**ECC 4 is the 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	–

Exercise – analysis and prediction of electricity consumption



Key elements of measurement and verification of saving (1/4)



*M&V Activities

Step 1: Determine Goals for M&V Efforts	*Baseline Period*
Step 2: Select IPMVP Option(s) and Approaches	
Step 3: Document Baseline Data	
Step 4: Develop M&V Plan	
Step 5: Set-up Metering and Ongoing Data Collection Processes	
Step 6: Monitor for Changes in Site Conditions	*Installation Period*
Step 7: Confirm Operational Verification	
Step 8: Ongoing Data Collection	*Reporting Period*
Step 9: Determine Savings for Period	
Step 10: M&V Report for Period	
Step 11: Track Energy Performance and Savings	

Type of Savings	Basis of Adjustment	Routine Adjustment Method	Description
Avoided Energy Consumption	Reporting Period Conditions	Forecasting	Baseline period energy is adjusted to reporting period conditions
	Baseline Period Conditions	Backcasting	Reporting period energy is adjusted to baseline period conditions
Normalized Energy Savings	"Normal" or Fixed Conditions	Normalizing	Both the baseline and reporting period energy are adjusted to standard conditions, e.g., Typical Meteorological Year (TMY) conditions

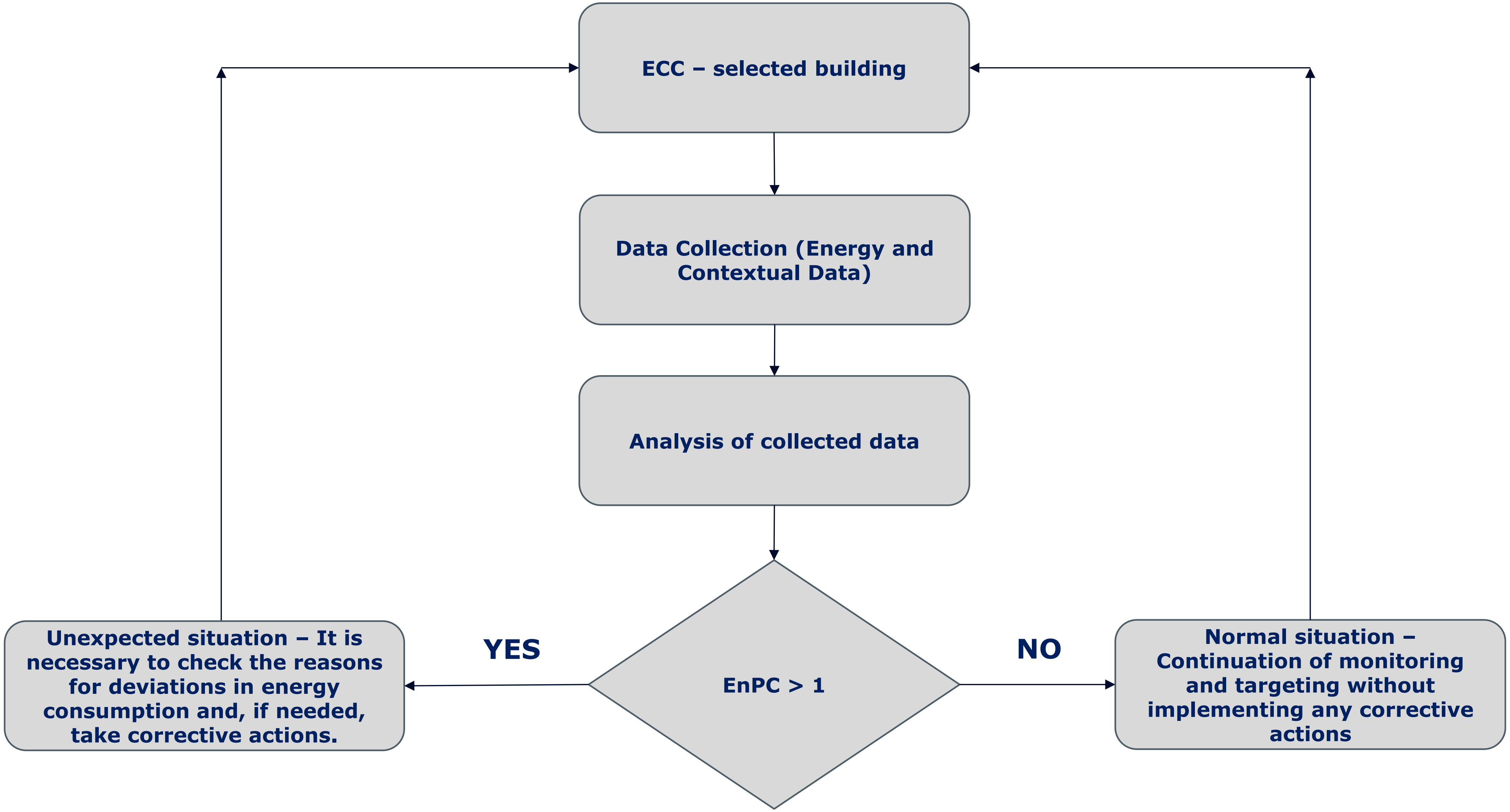
Key elements of measurement and verification of saving (2/4)

IPMVP Option	Definition	How Savings are Calculated	Typical Applications
A. **Retrofit Isolation: Key Parameter(s) Measurement**	Savings are determined by field measurement of the key parameter(s), which define the energy consumption and/or demand of the EEM's affected system(s). Performance indicators may also be defined and measured to ensure the success of the project. Measurements range from periodic short-term to continuous long-term, depending on the expected variations in the key parameter(s). Parameters not selected for field measurements are estimated values. Estimates can be based on historical data, manufacturer specifications, or engineering judgment. Documentation of the source and justification of the estimated value is required. The plausible savings error arising from estimation rather than measurement is evaluated and is acceptable to stakeholders.	Calculation of baseline period energy and reporting period energy from periodic short-term energy measurements, or from periodic short-term or continuous measurements of key parameter(s) and from estimated values. Routine and non-routine adjustments as required. Key parameter(s) must be measured during both baseline and reporting period.	A lighting retrofit where the change in power drawn by the lighting system is the most uncertain parameter and is measured, and secondly, lighting operating hours are estimated based on facility schedules and occupant behavior. Notes: Multiple key parameters often exist, and selection of key parameters to measure is an important consideration.
B. **Retrofit Isolation: All Parameter Measurement**	Savings are determined by continuous field measurement of the energy consumption and/or demand or validated proxy variables and the related independent variables of the EEM affected system. Measurements range from periodic short-term to continuous long-term, depending on the expected variations in the key parameters.	Determination of baseline period energy based on short-term or continuous measurements of baseline and reporting period energy, or on engineering computations using measurements of proven proxies of energy consumption or demand. Routine and non-routine adjustments as required.	Installation of a variable-frequency drive and controls to a motor to adjust pump flow. Measure electric power with a kW meter installed on the electrical supply to the motor, which reads the power demand every minute. In the baseline period, this meter is in place for a month and system testing was conducted to verify constant loading across a full range of operating conditions. The meter remains in place throughout the reporting period to measure energy consumption and demand.

Key elements of measurement and verification of saving (3/4)

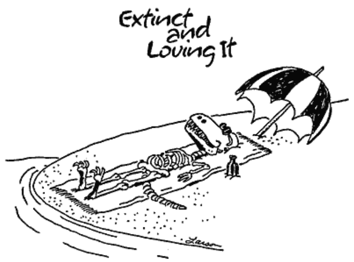
IPMVP Option	Definition	How Savings are Calculated	Typical Applications
C. **Whole Facility**	Savings are determined by measuring energy consumption and/or demand at the whole facility or sub-facility level, often using utility meter data. Continuous measurements of the entire facility's or sub-facility's energy consumption and/or demand are taken throughout the baseline period and the reporting period.	Analysis of the whole facility or sub-facility baseline and reporting period energy data (e.g., utility meter) and independent variables. Routine adjustments as required, typically using models based on regression analysis techniques. Non-routine adjustments as required.	Multifaceted energy management programs affecting many systems in a facility. Measure energy consumption and/or demand with the gas and electric utility meters for a twelve-month baseline period and throughout the reporting period.
D. **Calibrated Simulation**	Savings are determined through simulation of the energy consumption and demand of the whole facility, or of a sub-system in the facility and comparing results with actual energy consumption and demand. Simulation models are demonstrated to adequately model actual energy performance in the facility. This option requires considerable skill in calibrated simulation and experience with the equipment and processes being modeled.	Actual energy consumption and demand and results from simulation model(s). Energy consumption and demand from the simulation, calibrated with hourly, daily or monthly energy data. Energy sub-metering and metered performance data including processes may be used in further model calibration. Non-routine adjustments as required.	Multifaceted energy management programs affecting many systems in a facility but where no meter existed in the baseline period. Energy consumption and demand measurement, after installation of natural gas, electric or other energy meters, is used to calibrate a simulation model.

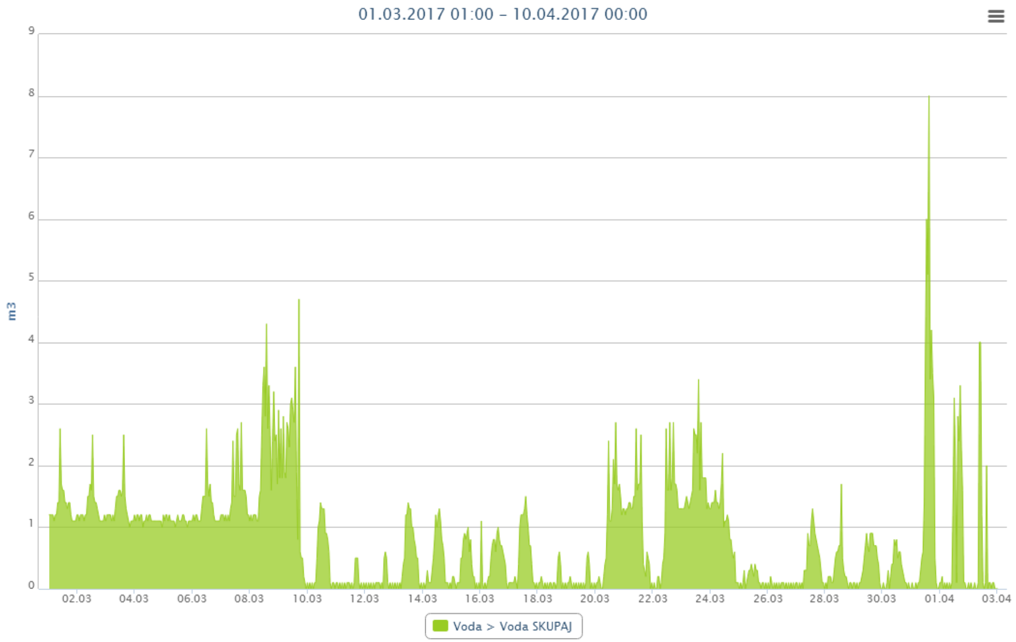
Key elements of measurement and verification of saving (4/4)



Conclusion

- **Be demanding in the implementation of energy efficiency measures and demand sustainable solutions!**
- **Knowledge and a good understanding** of on-site processes are crucial for the successful implementation of new solutions – a cyclical process of improvements!
- **Good practice – why pay more?**





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