IEA EBC Annex 67 – Energy Flexible Buildings

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Characterization of energy flexibility in buildings

Main results from SubTask A

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Characterization of energy flexibility in buildings

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Characterization of energy flexibility in buildings

- General definition and terminology
- Indicators at single building level
- Indicators at cluster level

- Methodology for assessing the flexibility
- Approach for labelling flexibility
- Sample application of the methodology

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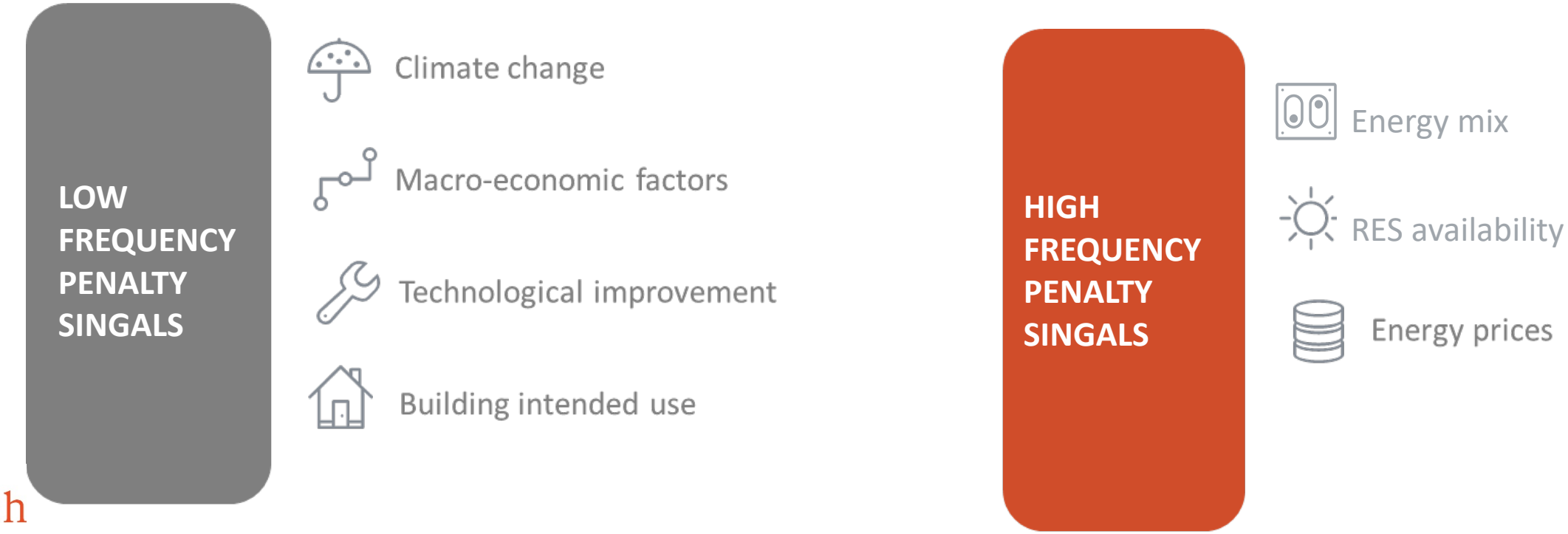
Energy flexibility – common definition

Energy Flexibility represents the capacity of a building to react to one or more penalty signals, without compromising the occupant comfort conditions and taking into account the technical constraints of the building and of its HVAC system.



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Energy flexibility - Terminologies and Definitions

Key categories describing the scope of the energy flexible building concept.

01 DRIVING FORCES

KEY FORCES:
Mitigation of carbon emissions; Intermittent renewable energy sources in energy system; Mitigation of operational bottlenecks in energy system

02 DEFINITION

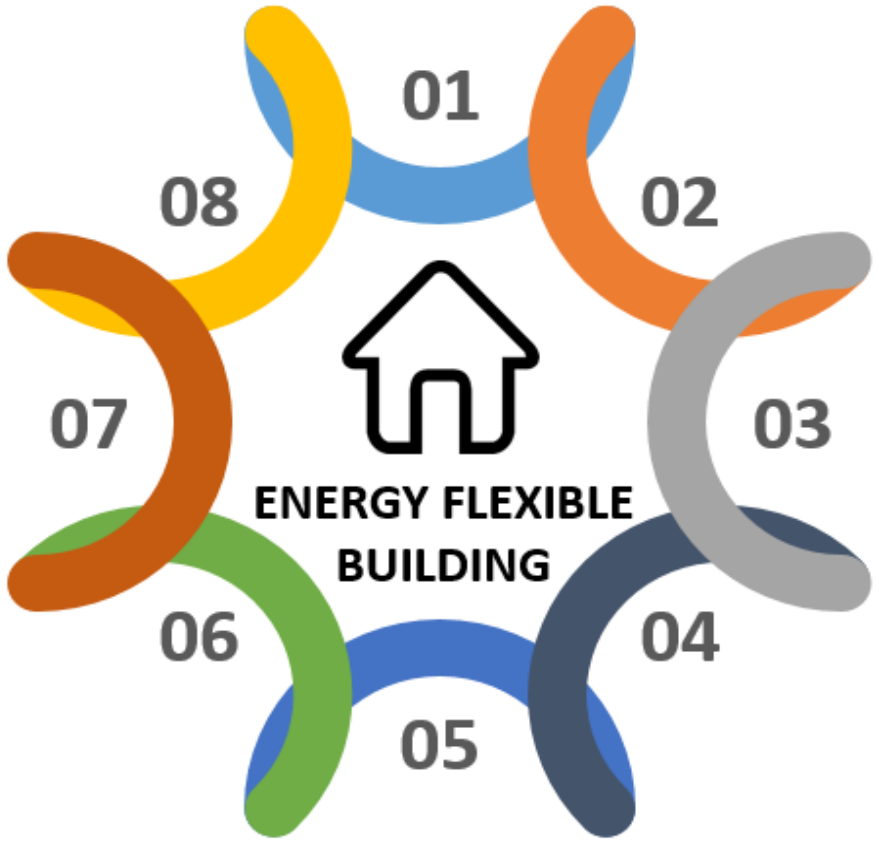
KEY CHARACTERISTICS:
Ability to manage its demand and generation according to local climate conditions, user needs and requirements of the surrounding grids.

03 METHODS

KEY CHARACTERISTICS:
Period of activation [minutes/hours], Energy saved and/or used [Wh], Peak Load increase/reduction [W].

04 ENERGY DEMAND

KEY ELEMENTS:
Space heating; Space cooling; Domestic hot water; Ventilation; Electricity use for plug loads (in some cases appliances include also electric vehicle)



08 INFRASTRUCTURE

KEY GRIDS:
Power network; District heating; District cooling

07 STAKEHOLDERS

KEY ACTORS:
Energy suppliers; Private, commercial and industrial customers; Building managers; Technology providers; The National Regulatory Authority; Aggregators

06 TECHNOLOGY

KEY ELEMENTS:
Energy storage: thermal and electical; Smart applainces

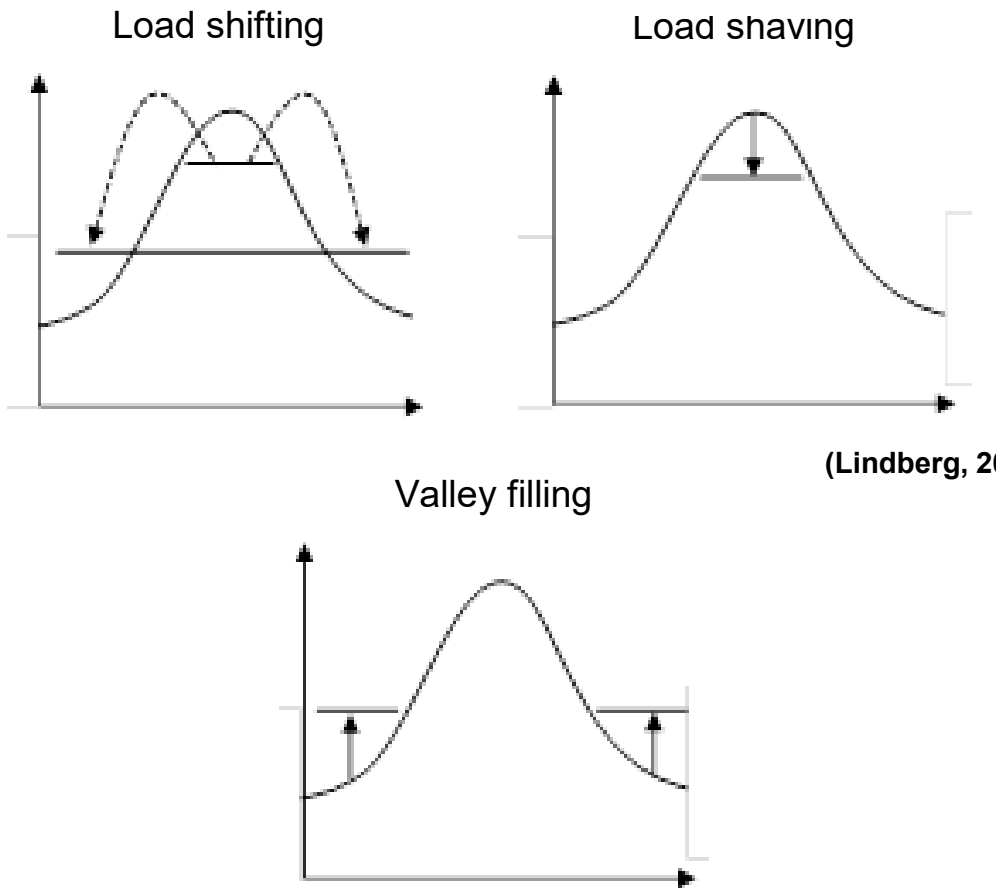
05 CONTROL

KEY ELEMENTS:
Controller type; Control approach: direct and indirect control; Control objective: Penalty signal; Requirements of the surroundings grids

Source: Anna Marszal-Pomianowska

Indicators for assessing Energy Flexibility

- Capacity - amount of energy that can be shifted per time unit, including the rebound effect as shown in Figure 1)
- Time - starting time & duration)
- Cost - potential cost saving or energy use associated to activating the available flexibility)



(Lindberg, 2017)

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Indicators for assessing Energy Flexibility

Indicator(s)	Unit	Author(s)	Links	Input parameter	Output
Flexible demand ($\Delta p_{k,w}$)	kW	Aduda et al. [35]	*https://www.scopus.com/record/display.uri?eid=2-s2.0-84959336445&origin=inward&txGid=5cee66e09ddc8bd0bd30b8cc649adb7d*	Consumed power of controllable loads such as ventilation system	Load reduction (by flexible load)
Power Shifting Potential (ΔP)	kW	Oldewurtel et al. [5]	*https://opticontrol.ee.ethz.ch/Lit/Olde_13_Proc-CDC2013_submitted.pdf*	Price signal and power consumption	Potential and efficiency for power increase/ decrease
Power Shifting Efficiency (PSE)	-				

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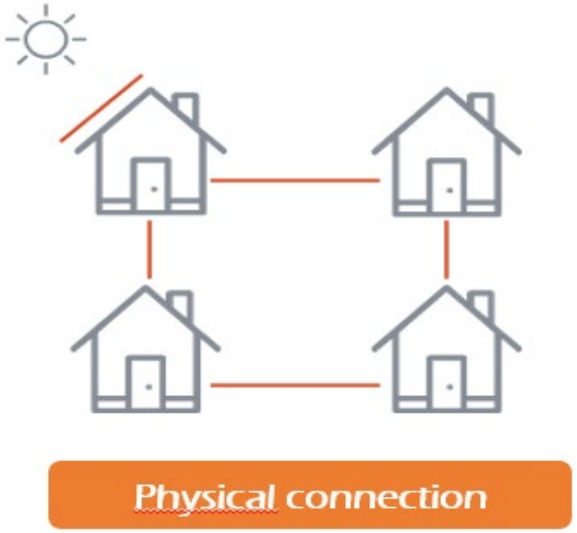
Indicators for building clusters



Physical connection: A building cluster is a group of buildings **interconnected to the same energy infrastructure**, such that the change of behaviour/energy performance of each building affects both the energy infrastructure and the other buildings of the whole cluster.

Market aggregation: common agent or company who can potentially exploit the Energy Flexibility of the whole cluster

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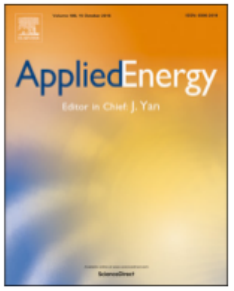

Characterizing the energy flexibility of buildings and districts

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- Penalty based setup
- Energy flexibility characterization
- Example

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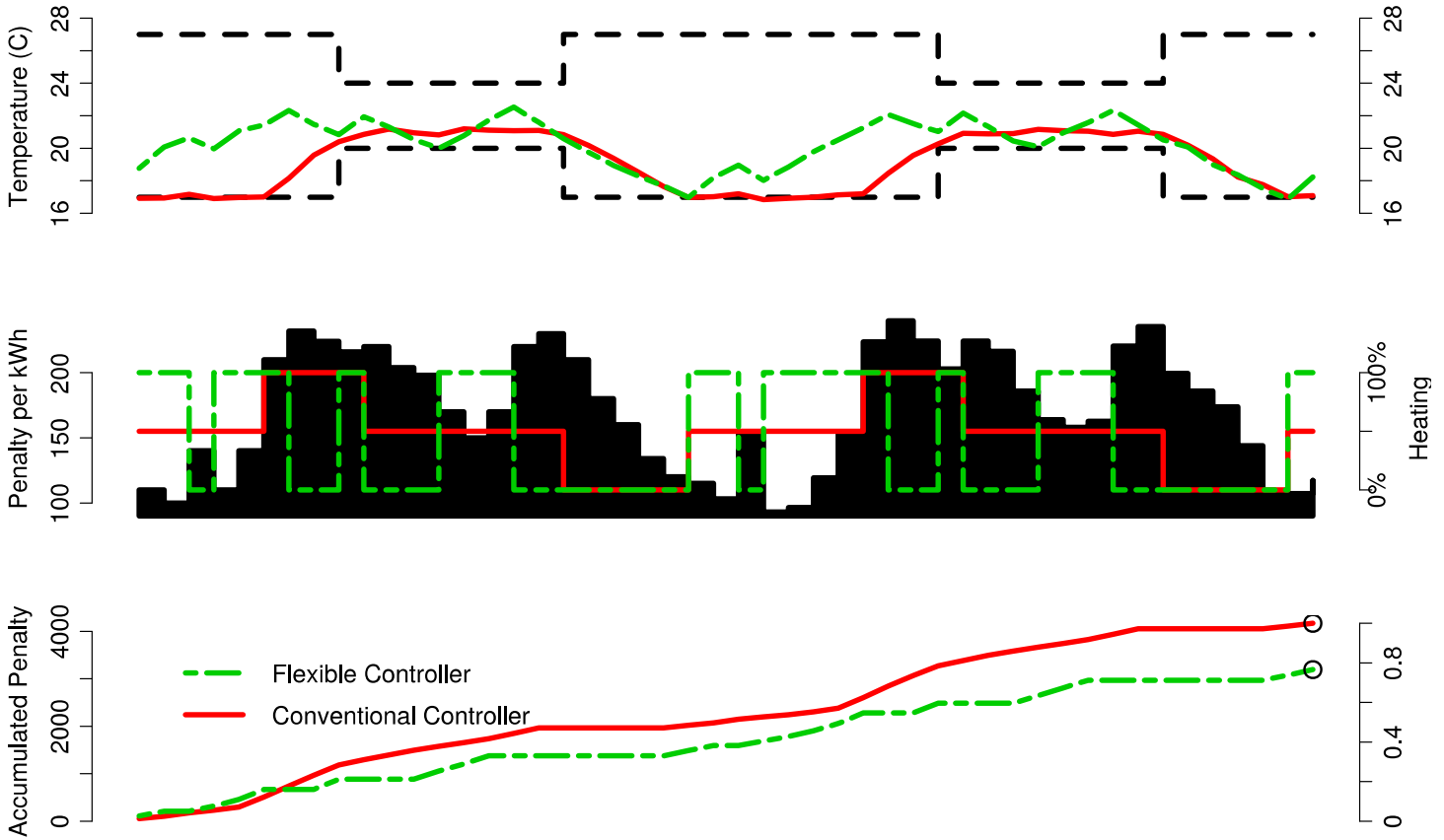
Penalty based setup



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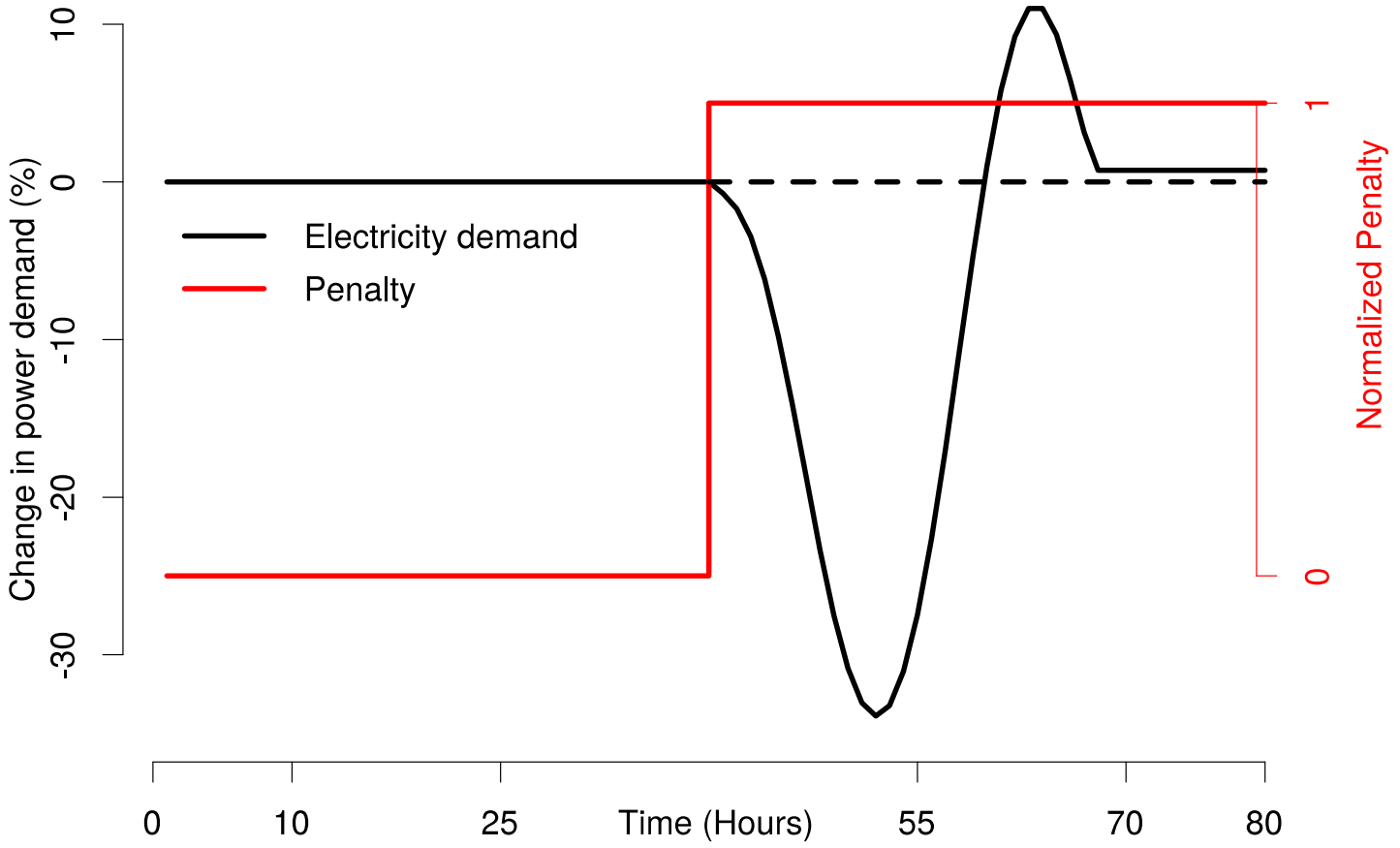
Flexibility Function of Indoor Swimming Pool



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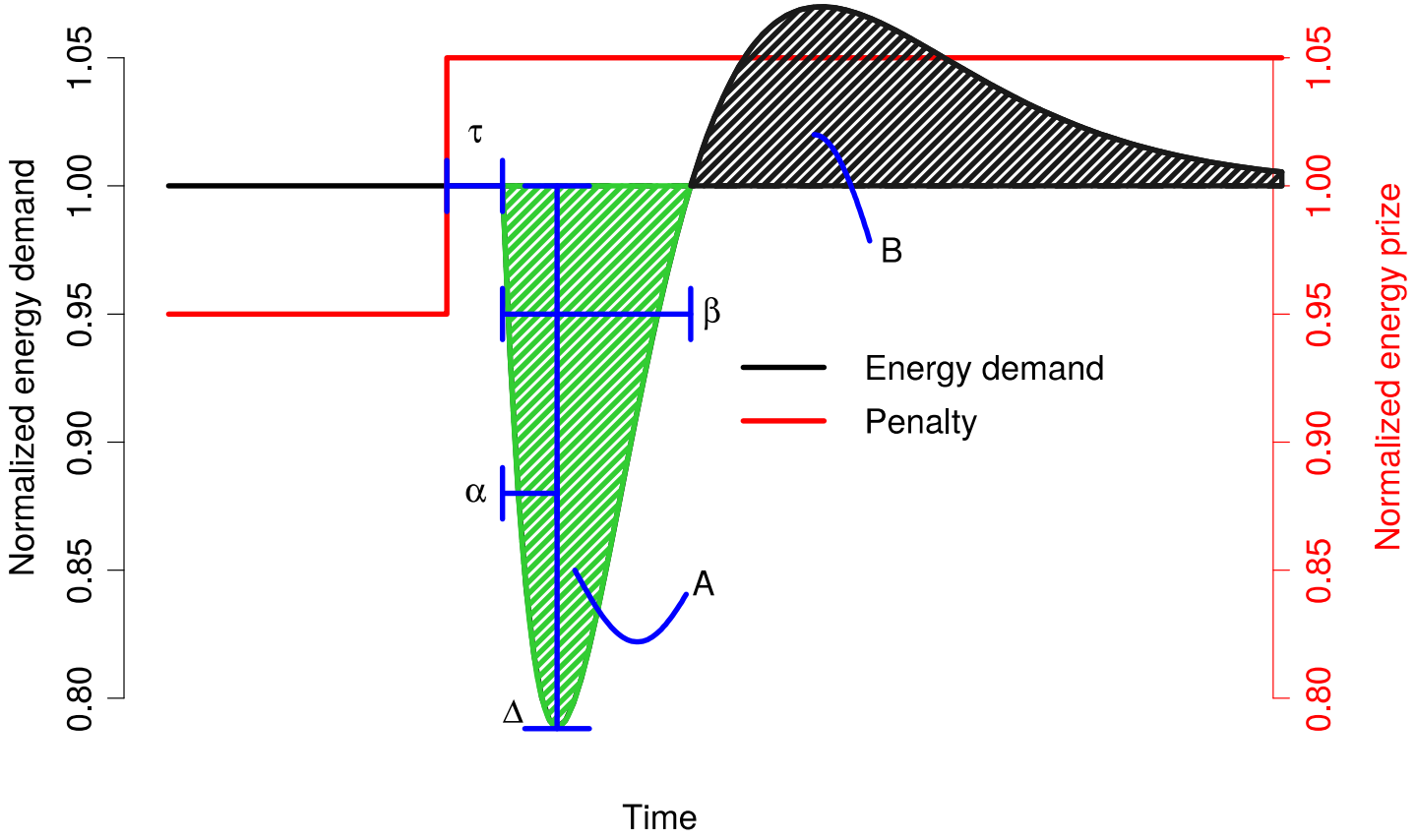
Flexibility Characteristics



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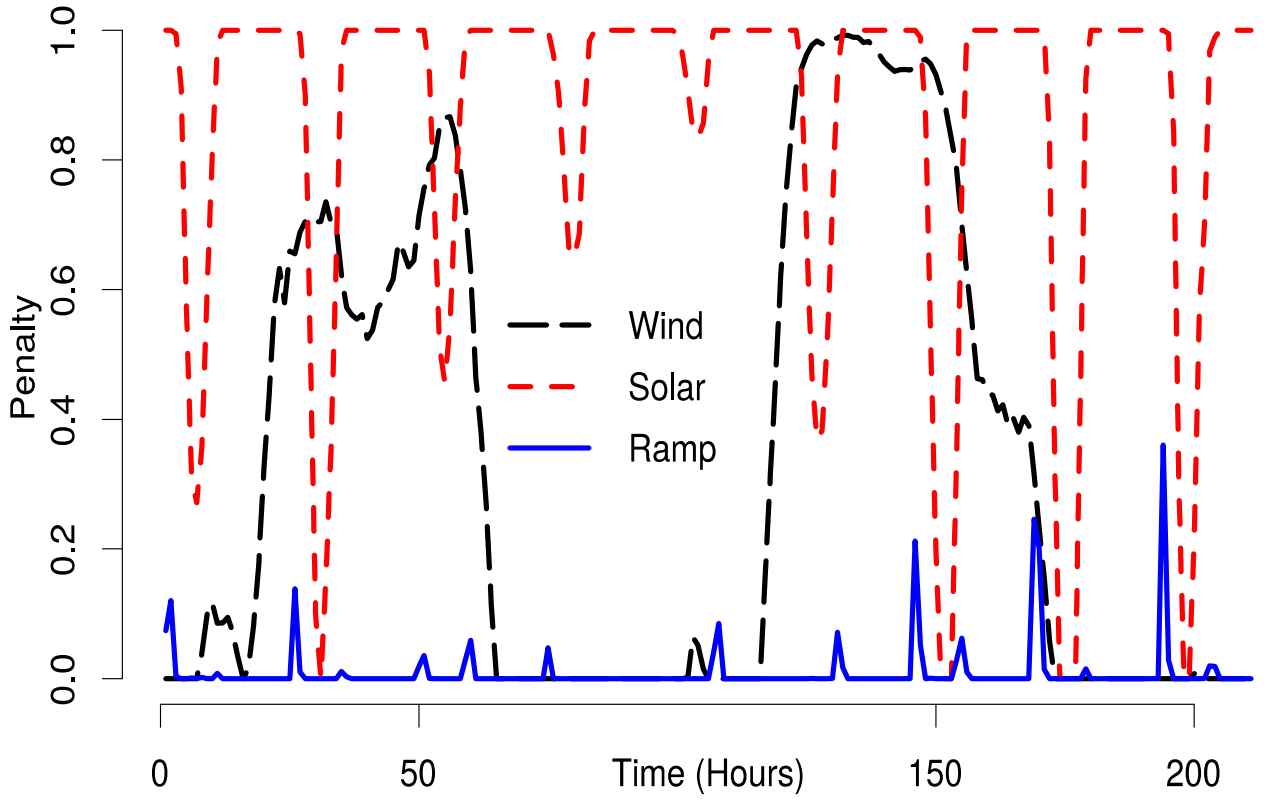
Examples of Penalty signals



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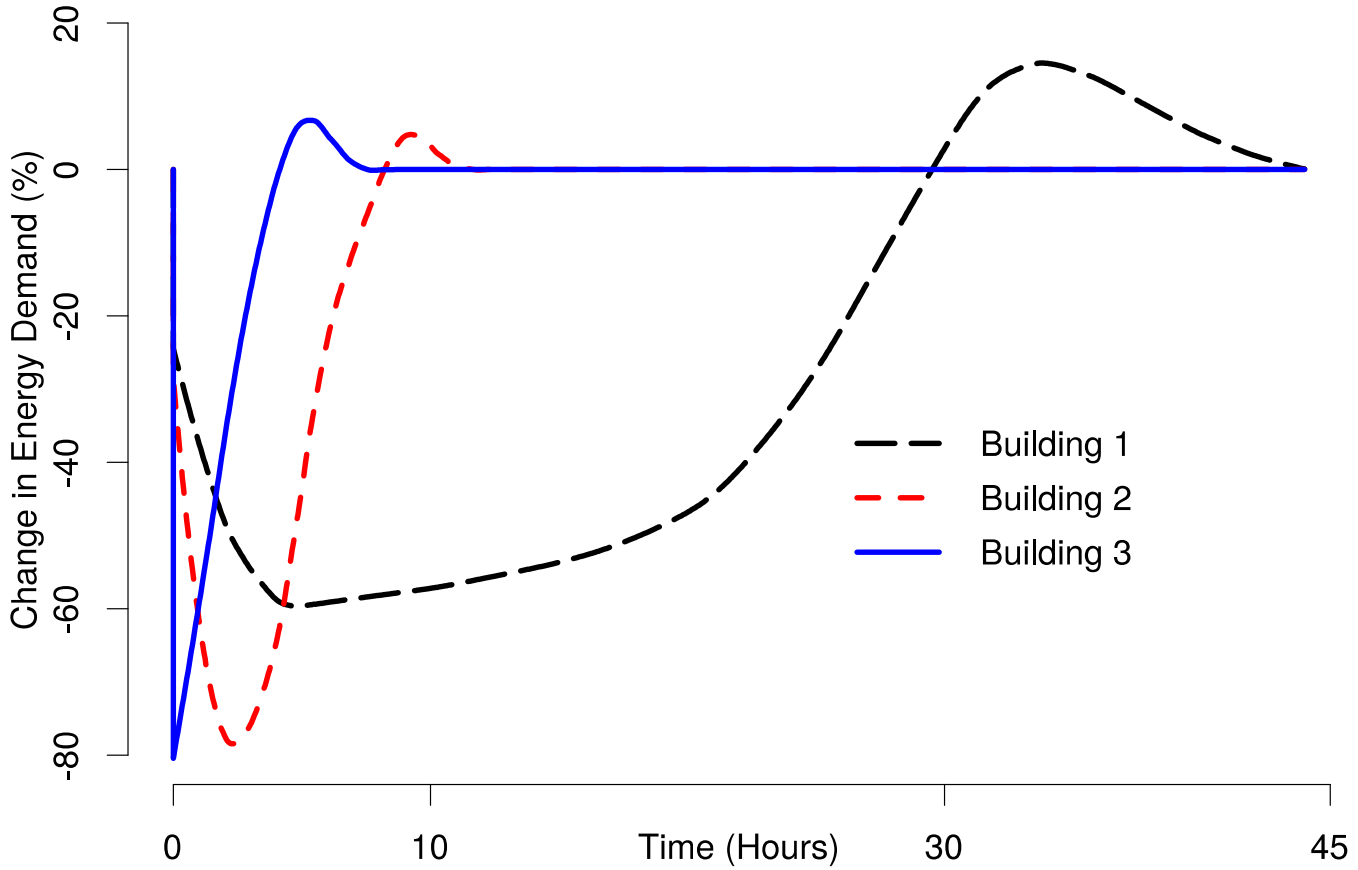
Examples of Flexibility Functions



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Performance-based Flexibility Index

$$FI_j^i = \int_0^T Y_j^i(t)U_i(t)dt \Big/ \int_0^T Y_j(t)U_i(t)dt$$

	Wind (%)	Solar (%)	Ramp (%)
Building 1	11.8	4.4	6.0
Building 2	3.6	14.5	10.0
Building 3	1.0	5.0	18.4

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Conclusions

- Energy flexibility depends on the problems
- The problems depend on time and location
- Different solutions for different problems

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