SmartGY
S U M

ESR12
Saeed Akbari

HORIZON 2020
INNOVATIVE TRAINING NETWORKS
ETN 955614
Marie Skłodowska-Curie Actions (MSCA)
Innovative Training Networks (ITN)
H2020-MSCA-ITN-2020

Research and Training Network for
Smart and Green Energy Systems and Business Models

Introduction

ESR12 – Saeed Akbari

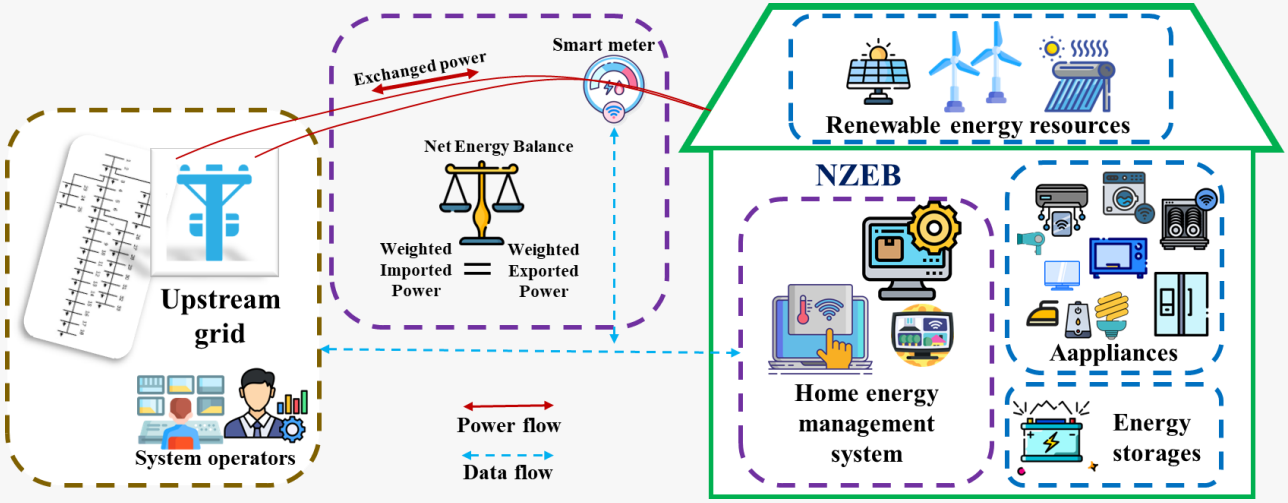
Individual Research Project:

Development of sustainable strategies for Net Zero Energy Buildings

Recruiting beneficiary:

NOVA University Lisbon

Individual research project



Main goal:

- **Developing sustainable strategies for NZEBs**

Objectives:

- **Characterizing energy flexibility in NZEBs/Ecs**
- **Using smart appliances aims to enhance energy flexibility**
- **Developing cooperation strategies for managing the use of the building/community flexibility**

Developed sustainable strategies

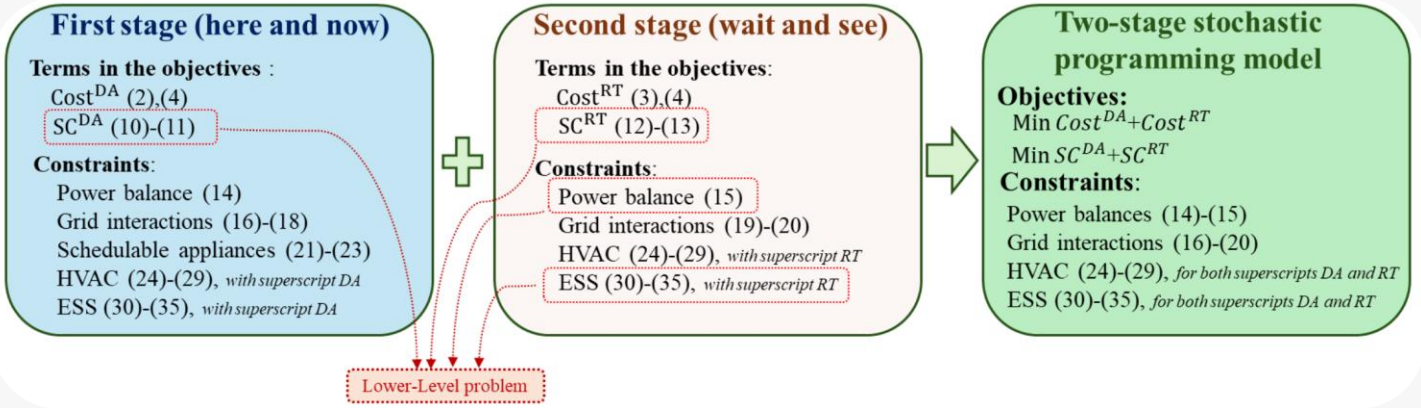
1. Optimal Clustering-Based Energy Management of Net Zero Energy Buildings through a Stochastic Hierarchical Approach

- Strategy framework: Bi-level programming

- Scope: NZEBs, ECs, or …

- Managing energy flow considering energy awareness criteria through assuring residents' comfort

- Proposing a novel self-consumption indicator for facilitating interactions among NZEBs and grid operators



Stackelberg game

$$\min_{x,y} F_0(x,y)$$
$$\text{s.t. } H_i(x,y)=0, \quad i=1,\dots,M$$
$$G_i(x,y)\le 0, \quad i=1,\dots,P$$

Leader's optimization problem

x* | y*(x*)

$$\min_{y} f_0(x,y)$$
$$\text{s.t. } h_i(x,y)=0, \quad i=1,\dots,m$$
$$g_i(x,y)\le 0, \quad i=1,\dots,p$$

Follower's optimization problem

Bilevel model

$$\min_{x,y} F_0(x,y)$$
$$\text{s.t. } H_i(x,y)=0, \quad i=1,\dots,M$$
$$G_i(x,y)\le 0, \quad i=1,\dots,P$$
$$\min_{y} f_0(x,y)$$
$$\text{s.t. } h_i(x,y)=0, \quad :\lambda_i, \ i=1,\dots,m$$
$$g_i(x,y)\le 0, \quad :\mu_i, \ i=1,\dots,p$$

Leader's optimization problem

Follower's optimization problem

Developed sustainable strategies

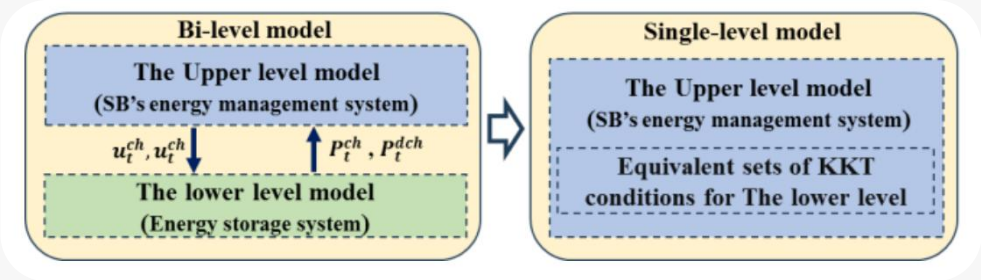
2. Multi-objective energy management of smart buildings through a bilevel optimization approach

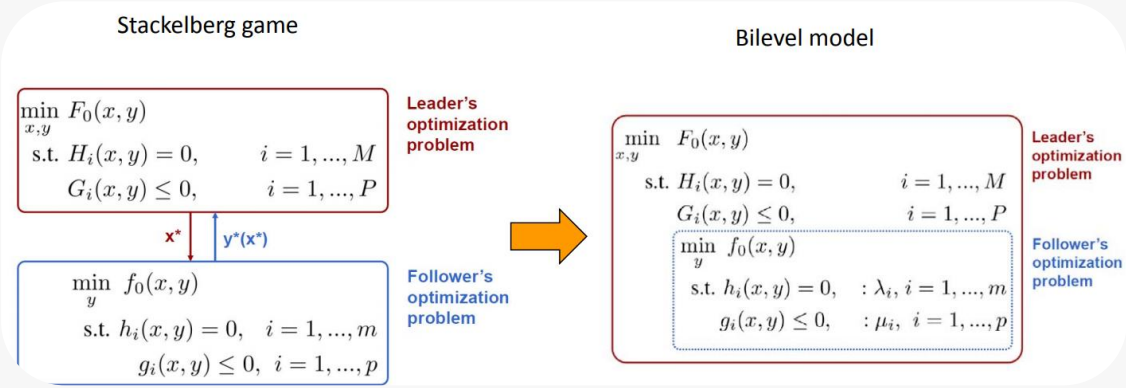
- Strategy framework: Bi-level programming

- Scope: NZEBs, ECs, or ...

- Managing energy flow considering energy awareness criteria through assuring residents' comfort

- Proposing a novel self-consumption indicator for facilitating interactions among NZEBs and grid operators

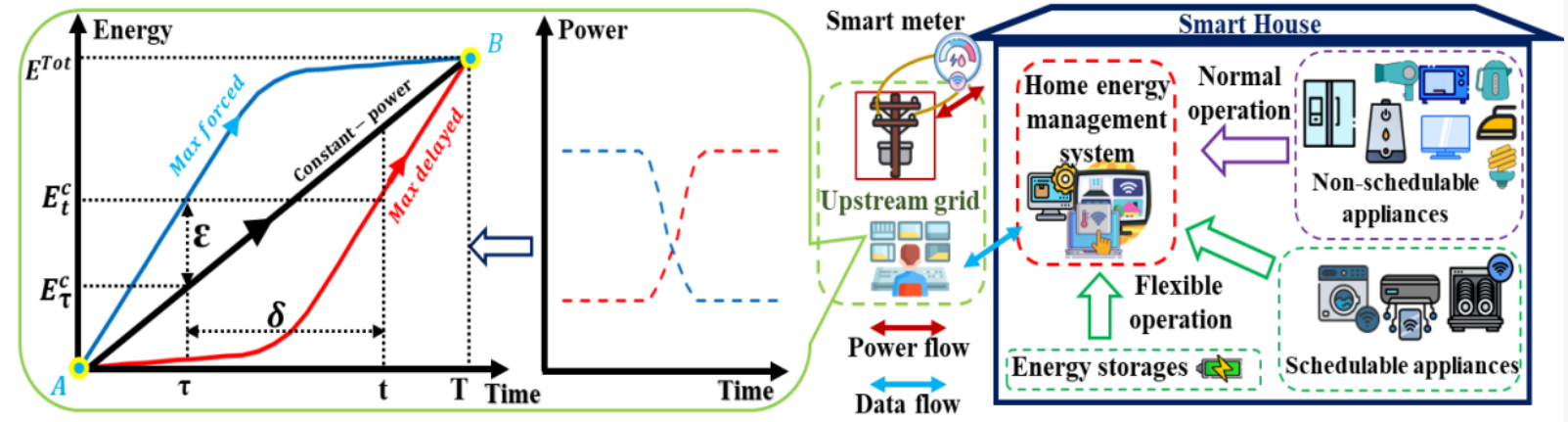




Developed sustainable strategies

3. The potential of residential load flexibility: an approach for assessing operational flexibility

- Strategy framework: A Mixed-Integer Linear Programming model for assessing prosumers flexibility
- Scope: NZEBs, ECs, or ...
- Managing energy flow considering energy awareness criteria through assuring residents' comfort
- Proposing two novel indicators facilitating interactions among NZEBs and grid operators
- Considering users' comfort

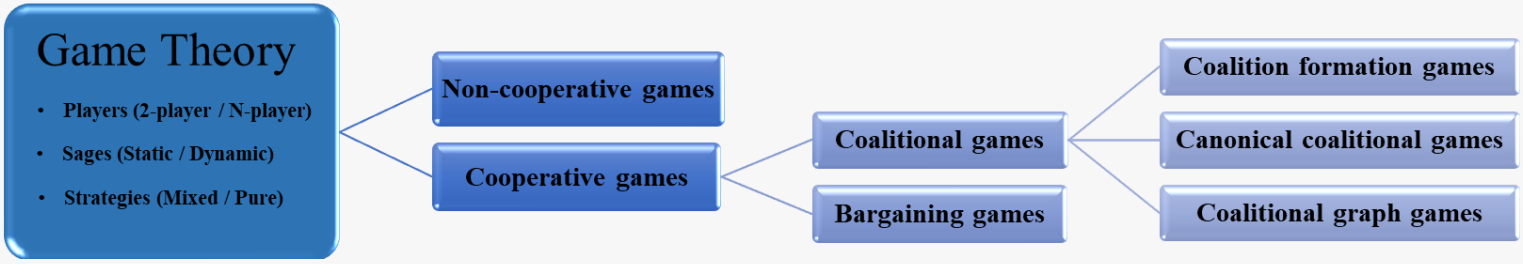


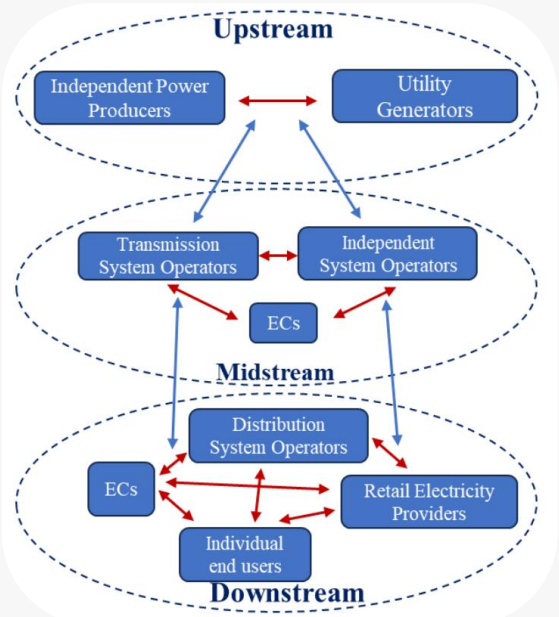
Developed sustainable strategies

4. Analyzing Value-Sharing Methods in Energy Communities with Coalitional Game Theory

- Review paper

- Scope: ECs

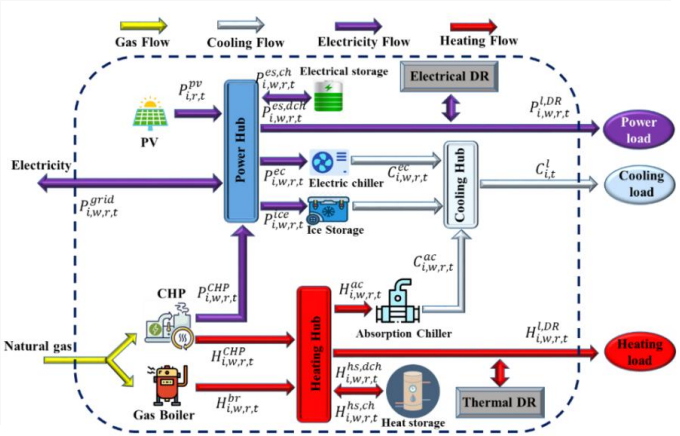


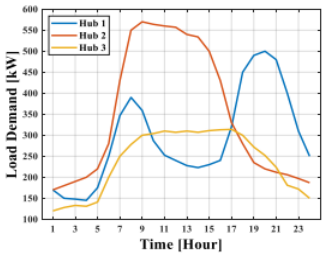


Developed sustainable strategies

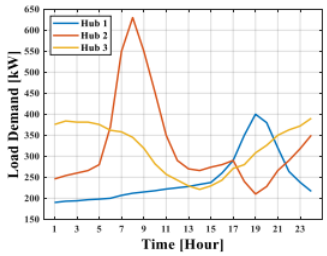
5. Cooperative stochastic energy management of multi-energy hubs considering environmental perspective

- - Strategy framework: A Mixed-Integer Linear Programming model for cooperation of energy communities
- - Scope: Ecs
- - Addressing CO2 emission
- - Dealing with uncertainties based on clustering approaches

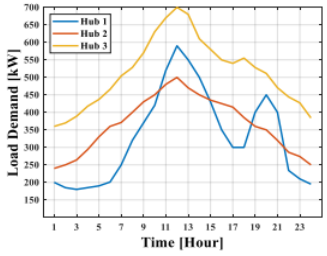




(a) Electrical load demand



(b) Heat load demand



(c) Cooling load demand

$$Min\ Cost = Cost^{Energy} + Cost^{EM} + Cost^{OM}$$

$$Cost^{Energy} = \sum_{i}\sum_{w}\sum_{r}\sum_{t}(\lambda_t^{elec}.P_{i,w,r,t}^{grid} + \lambda_t^{gas}.G_{i,w,r,t}^{gas,purc}).\rho_w.\rho_r.\Delta t$$

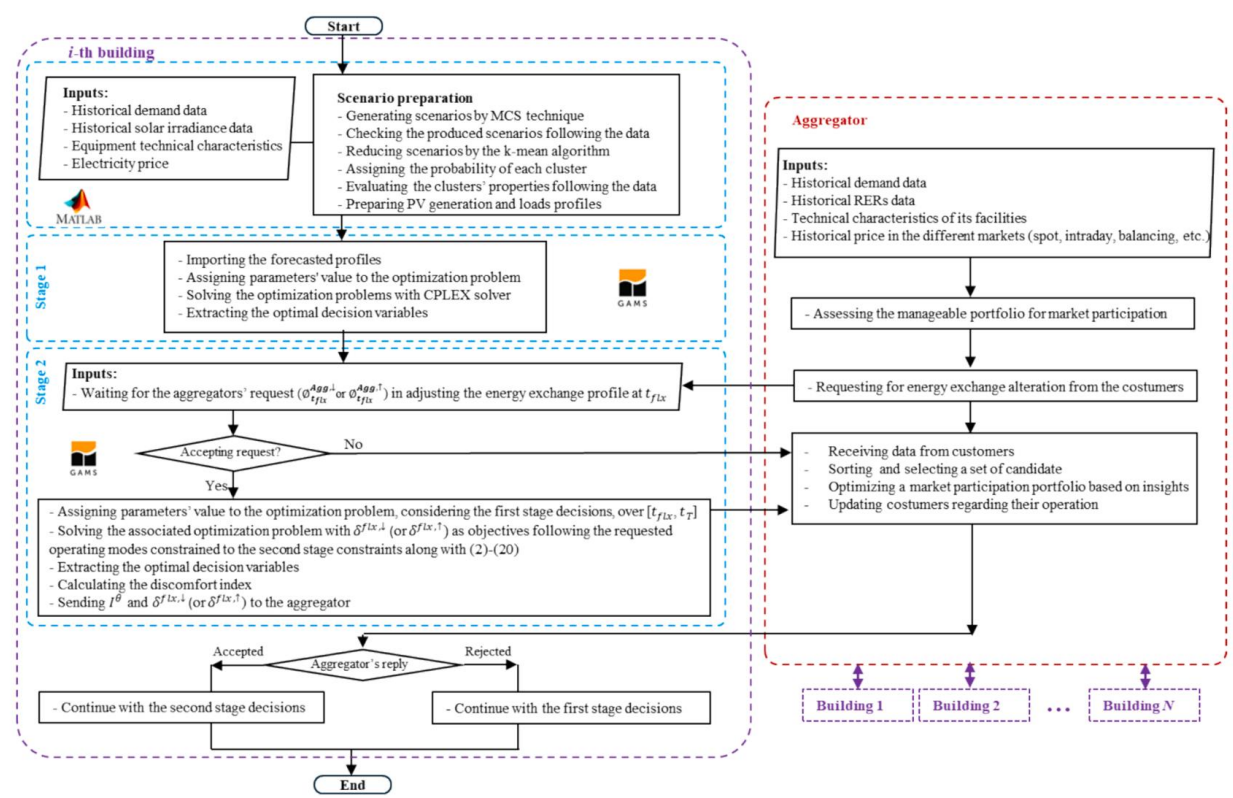
$$Cost^{EM} = \sum_{i}\sum_{w}\sum_{r}\sum_{t}\varepsilon.(\beta^{grid}.P_{i,w,r,t}^{grid,purc} + \beta^{gas}.LHV.G_{i,w,r,t}^{gas,purc}).\rho_w.\rho_r.\Delta t$$

$$Cost^{OM} = \sum_{i}\sum_{w}\sum_{r}\sum_{t}\{[OM^{pv}.P_{i,r,t}^{pv}] + [OM^{CHP}(P_{i,w,r,t}^{CHP}+H_{i,w,r,t}^{CHP})] + [OM^{br}.H_{i,w,r,t}^{br}] + [OM^{es}(P_{i,w,r,t}^{es,dch} + P_{i,w,r,t}^{es,ch})] + [OM^{hs}(H_{i,w,r,t}^{hs,dch} + H_{i,w,r,t}^{hs,ch})]\}.\rho_w.\rho_r.\Delta t$$

Developed sustainable strategies

6. A two-stage probabilistic flexibility management model for aggregated residential buildings

- - Strategy framework: Probabilistic programming
- - Scope: Energy Aggregators
- - Quantifying flexibility for ancillary services



Questions

Thanks for your attention!