Sustainable Energy Systems

Assessment of Multi-building Microgrids' Potential in the Portuguese Urban Context

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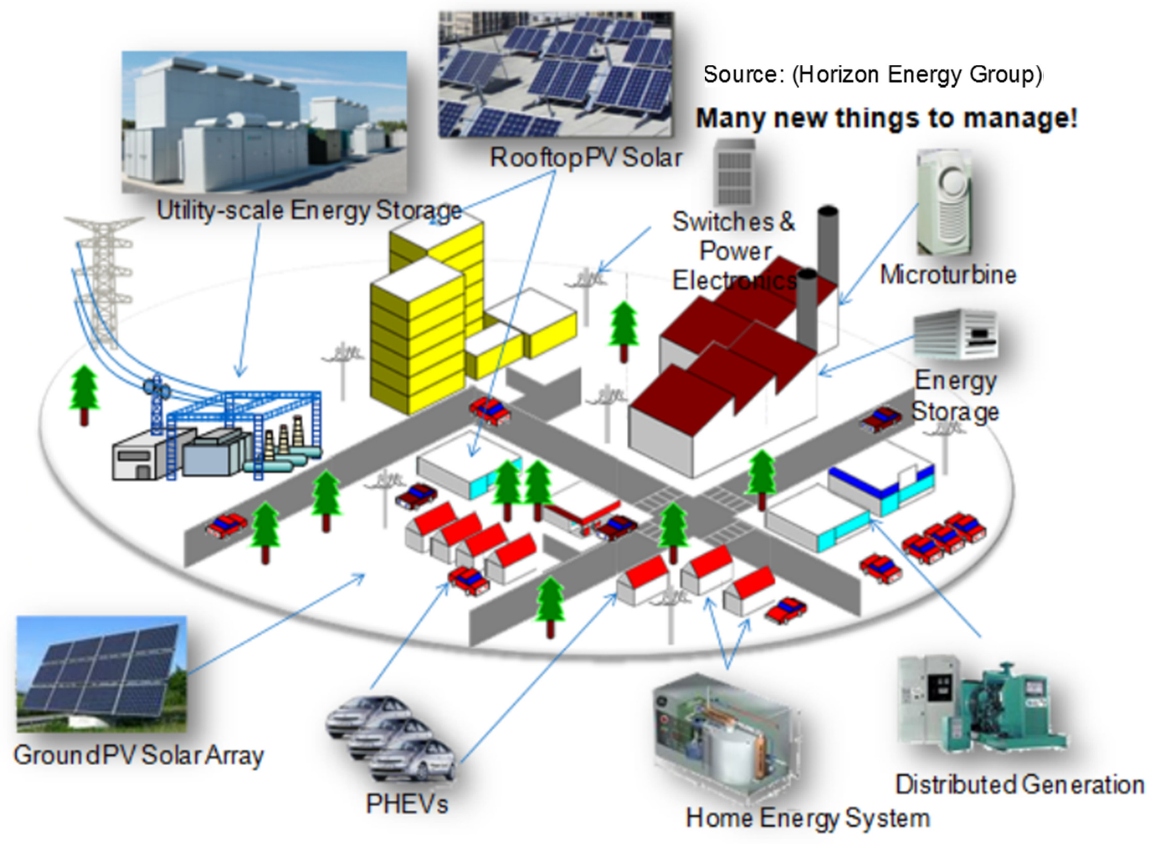
Introduction

We look at microgrids as alternative forms of energy distribution for Portugal, able to better realize the potential of **distributed, cleaner and localized supply of heat and power in urban building complexes**. The concept we adopt aggregates dispatchable as well as intermittent electricity and heat generation, along with storage, operating in a coordinated and grid-connected fashion, being capable of isolated operation, trough a PCC, if required.

Main PhD work objectives

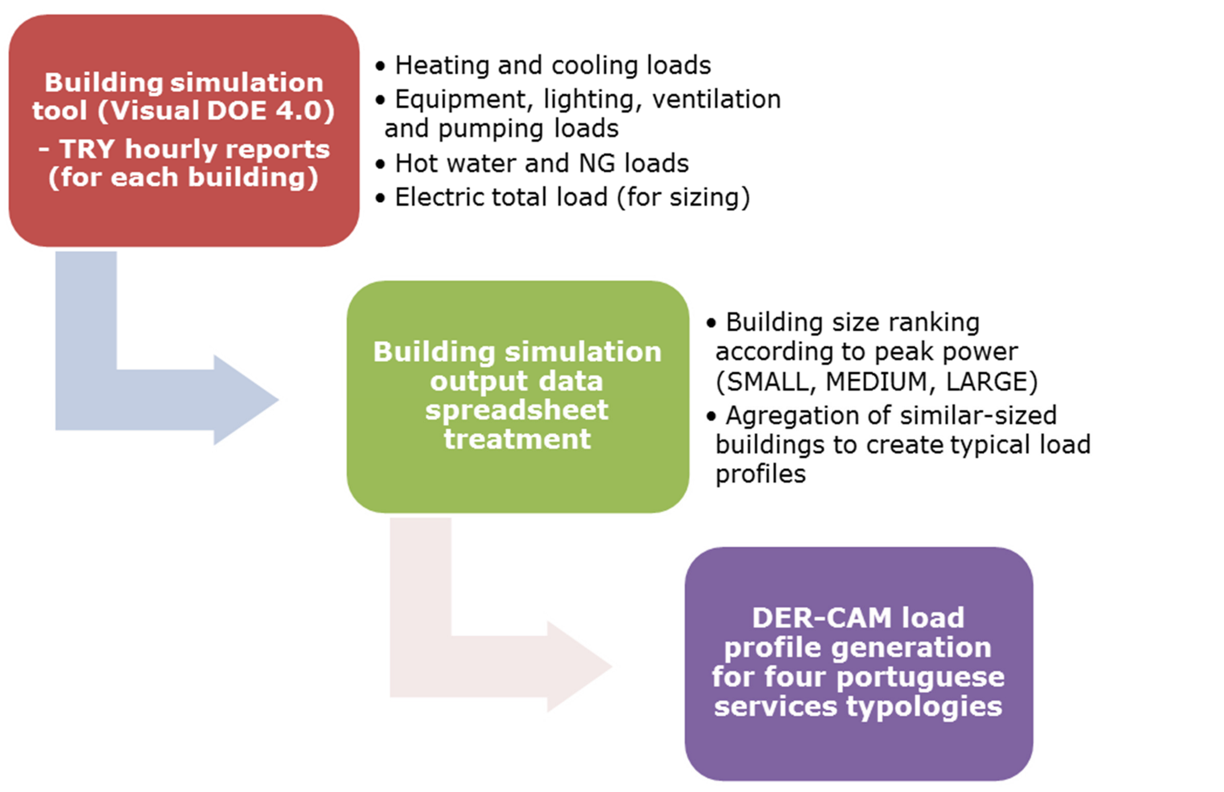
1. To develop a reliable **optimization methodology** able to address economically and environmentally the design of multi-building, multi-typology integrated microgrid systems
2. To identify **deployment pathways** for the development of the microgrid solution trough the identification of preferential adoption patterns for the Portuguese urban context



Schematics of a microgrid system, involving both intermittent and dispatchable generation and PEV's integration as mobile storage.

Methodology

We are developing a **database of Portuguese load data for services buildings and residential households**, gathered from Portuguese energy services companies. The goal is to define typical loads for each typology in order to explore its microgrid adoption patterns.



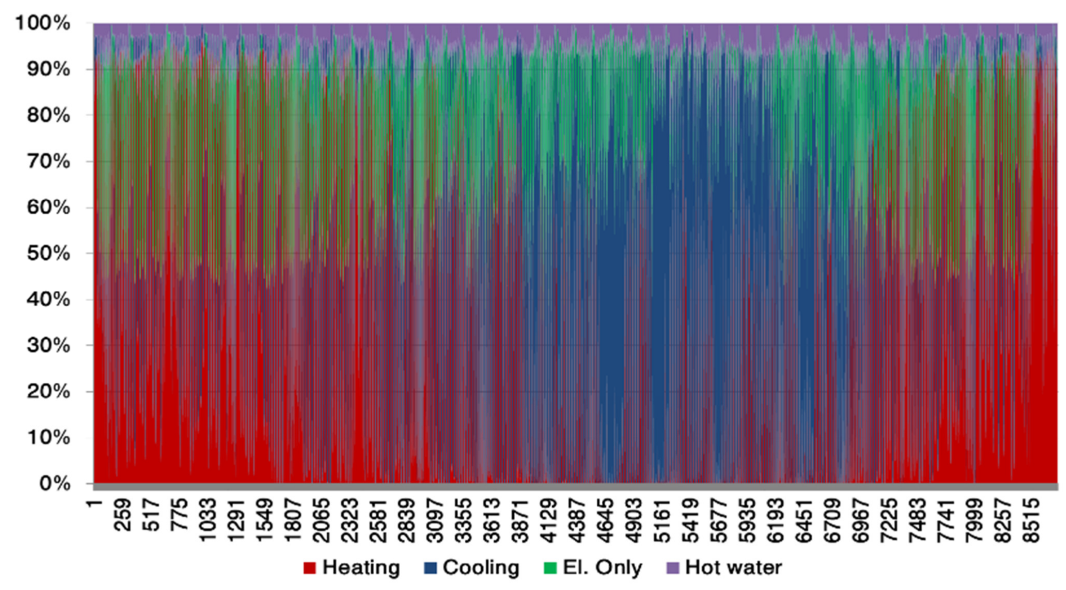
[1]For this case, medium-sized services buildings (with electrical peak load under <300kW) and a residential neighborhood with 200 households.

Optimization modeling with DER-CAM

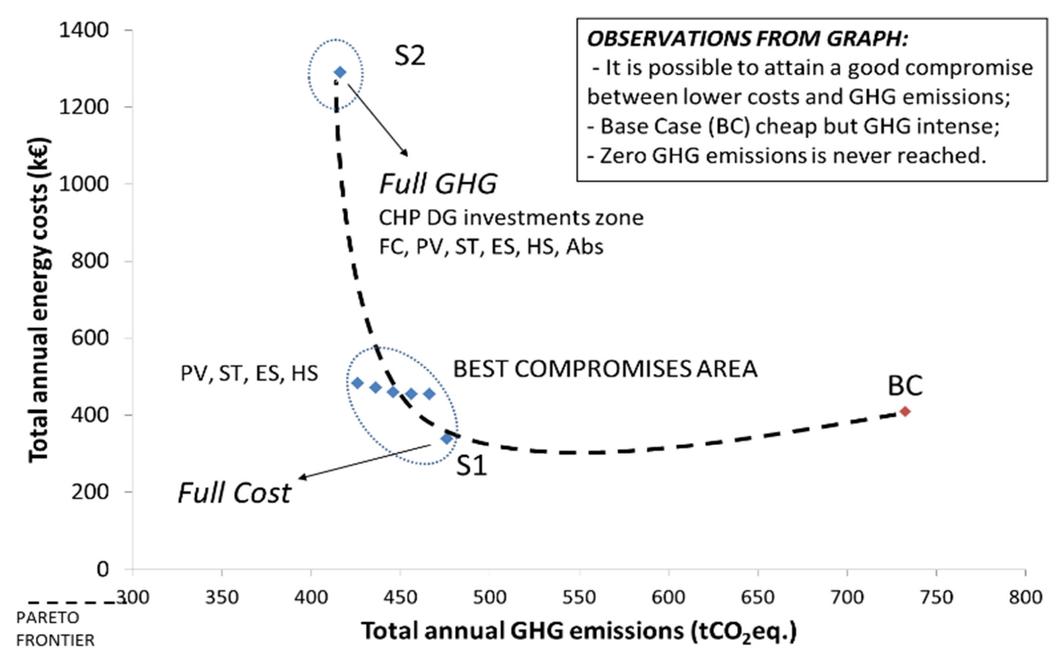
Cost f_1 and GHG emissions f_2 minimizing microgrid adoption is performed with the multiobjective optimization tool DER-CAM, extended to the Portuguese market context and expanded to support **multi-building typologies modeling capabilities**.

$$f_1(x),\ f_2(x): A \rightarrow \Re$$
$$\min\ f_1(x) \mid x \in D\ \ s.t.$$
$$g_i(x) = 0 \mid i = 1..k\ ,\ \ h_j(x) \leq 0 \mid j = 1..m$$
$$f_2(x) \leq \varepsilon_n \mid n = 1..h$$

The energy analysis includes five different typologies of building complexes[1]: **Residential**, **Lodging**, **Educational**, **Health** and **Office**.



Total energy consumption percent distribution for a typical Portuguese education building complex, over a typical year.



Example multiobjective Pareto frontier for the investment case in microgrid adoption for the RES+EDUC case.

Results

[2]For each case, the upper area shows the Base Case run total annual energy cost (TEC) and GHG emissions. The lower area refers to the minimize cost run (minCost), with indication of the percent change in relation to the initial setting.

Result Matrix[2], 28 DER-CAM runs

Overall improvements. All typologies benefit from switching to the microgrid configuration, whether in economic (avg. 20% reduction) or in environmental terms (avg. 30% reduction). Best relative cost reductions achieved with typologies that most value reliability, HLTH and OFF. Best GHG emissions reduction with HLTH typology, due to high electricity-only needs. Overall relatively low heating loads have prevented great investments in CHP. High trend for adoption of solar enabled technologies, both thermal and electric.
Scale economies. Joint adoptions (examples: RES+EDUC) result in greater reduction in total energy costs.
Load complementarity. The aggregation of complementary loads (example: RES+OFF) is economically beneficial.

	RES	LODG	EDUC	HLTH	OFF
RES	BC 148689 195344 minCost -7% 138727 -24% 149012	BC 396252 704888 minCost -15% 335023 -33% 470946	BC 409376 732474 minCost -18% 337556 -35% 476086	BC 440002 775016 minCost -19% 355935 -36% 493558	BC 491636 821451 minCost -20% 391028 -30% 572476
LODG		BC 277999 509544 minCost -19% 225528 -34% 335690	BC 622173 1116802 minCost -20% 500474 -32% 764013	BC 601158 1089217 minCost -22% 469959 -41% 637243	BC 652169 1135652 minCost -21% 512823 -30% 791364
EDUC			BC 292698 537130 minCost -20% 234365 -34% 355818	BC 617149 748022 minCost -23% 474116 -20% 601530	BC 666498 1163237 minCost -22% 521203 -30% 810476
HLTH				BC 323505 579672 minCost -24% 246347 -43% 328829	BC 698166 1205780 minCost -24% 534074 -44% 677508
OFF					BC 370267 626108 minCost -23% 283796 -27% 454731

Some conclusions:

1. Microgrids can play an important role in a forthcoming distributed energy future in Portugal.
2. There are prospective economic and environmental improvements in adopting the microgrid concept, especially for urban multi-typology complexes.
3. Load complementarity is revealed a significant aspect in microgrids design.
4. Microgrids might become exceptionally attractive to HLTH and OFF complexes.
5. The Portuguese technical-economical context added to the climatic conditions currently favors investments in solar energy technologies, namely PV and ST.
6. CHP and absorption cooling can play an important role if PV area is constrained.
7. Average TEC with reforming a standard building complex[3] comes around 400k€.

[3]Applicable to the case-study conditions and medium-sized service buildings.

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