Universitat Politècnica de Catalunya

Departament d'Enginyeria Elèctrica

Doctoral Thesis

Flexibility services for distribution network operation

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"Oh, how much is left to learn"

Ziggy Alberts

To Sílvia,
Joan and Jèssica.

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- Danish Tehcnical University (DTU), Denmark.

Abstract

Storytelling PhD

- What is the current situation?
  - Energy Transition - Clean Energy Package
  - Increase on electricity consumption
  - decomissioning of nuclear power plants
  - Importance on society awareness on sustainability, as well as prices in some countries for access to electricity - What is our current carbon footprint?
- What are the problems that we identify?
  - some of the solutions for the energy transition can lead to congestion in distribution networks, due to the placement of DERs in MV and LV networks.
  - Are we sure that DERs are completely sustainable? Are we really sure that smart grids are completely sustainable, in each and every country?
- Possible solutions
  - Enhance the development of carbon-free technologies by implementing sustainable solutions - Assessment of the environmental impact of electricity production by means of LCA to help in the development of energy policies and planning, as well as including LCA in end-user optimization for achieving lower carbon footprints.
  - Deployment of demand-side flexibility services by means of end-users flexible assets.
- Thesis contributions
  - Assessment tool for evaluating the environmental impact of electricity markets using hourly LCA, by means of Life Cycle Assessment
  - Definition of Flexibility: Characterization, modeling, implementation and evaluation

Resum

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incloure aquÃ capÃtol del llibre de local and micro power markets? Power market fundamentals

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entregable que vam fer amb el pau Plana TFG

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incloure aquÃ capÃitol del llibre de local and micro power markets? Power market fundamentals

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Explicacio sobre que entenem per sostenibilitat. Quina relacio hi ha entre sostenibilitat i smart grids local markets

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3.1 The importance of flexibility

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3.2.1 Flexibility definition

incloure aqui la definicio que vam treballar amb el pau Plana de segons qui vol la flex com es la definicio

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incloure aqui la idea de diferents definicions de flexibilitat

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incloure aqui idea review hussain sobre flexibility review

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4.1 Introduction

RESEARCH QUESTION: Feina que estic fent a DTU

4.1.1 Use cases/Business models for flexibility services and flexibility forecast

4.1.2 Literature review on flexibility forecast

4.1.3 Contribution

- non-intrusive approach
- less data required (15 kHz for NILM algorithms). Here we can work with 1 minute data
- no submetering (only main smart meter data)
- total aggregated load forecast
- from the total load forecast, we forecast the flexibility UP and flex DOWN, as well as the INFLEXIBLE load
- flexible capacity band (power band) forecast

4.2 Algorithms proposed

- Hidden Markov Model
- combinatorial optimization
- Factorial hidden markov model?

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OPF for Congestion management in MV distribution networks

5.1 Introduction

RESEARCH QUESTION: INCLOURE FEINA DEL PAPER DEL CIRED

- NUVVE Congestion management
- pilot estabanell INVADE - BD4OPEM
- altres pilots

5.1.1 Use cases/Business models for congestion management

incloure aqui diagrama interaccio de l INVADE-CIRED Possibilitat d incloure els use cases que estem fent pel BD4OPEM

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OPENADR - USEF?

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5.1.4 Contribution

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- OPF (Python)

5.3 Methodology

5.3.1 Datasets - Network Data

5.3.2 Mathematical formulation

5.3.3 Simulation

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5.5 Discussion

5.6 Conclusions

Chapter 6

Conclusions

6.1 General conclusions

6.2 Contributions

6.3 Future work

Appendix A

Publications

Included in the thesis

Published journal papers

J2 P. Olivella-Rosell, P. Lloret-Gallego, Í. Munné-Collado, R. Villafafila-Robles, A. Sumper, S. Ottesen, J. Rajasekharan, B. Bremdal, "Local flexibility market design for aggregators providing multiple flexibility services at distribution network Level," *Energies*, vol. 11, no. 4, p. 822, Apr. 2018. doi: 10.3390/en11040822

Submitted journal papers

J4 flexibility review hussain

Conference papers

C1 I. Munné-Collado, P. Lloret-Gallego, P. Olivella-Rosell, R. Villafafila-Robles, S. Ø. Ottesen, R. Gallart-Fernandez, V. Palma-Costa, A. Sumper, "System architecture for managing congestions in distributions grids using flexibility," 25th International Conference on Electricity Distribution, June 2019.

- conference sara LCA

Book chapters

BC1 Í. Munné-Collado, P. Olivella-Rosell, A. Sumper, "Power Market Fundamentals," in A. Sumper (ed) Micro and Local Power Markets, John Wiley & Sons, pp. 1-35, 2019. doi: 10.1002/9781119434573.ch1

BC2 Í. Munné-Collado, E. Bullich-Massagué, M. Aragüés-Peñalba, P. Olivella-Rosell "Local and Micro Power Markets," in A. Sumper (ed) Micro and

Local Power Markets, John Wiley & Sons, pp. 37-97, 2019. doi: 10.1002/9781119434573.ch2

Not included in the thesis

Published journal papers

J3 Í. Munné-Collado, F. M. Aprà, P. Olivella-Rosell, R. Villafafila-Robles, A. Sumper, "The potential role of flexibility during peak hours on greenhouse gas emissions: a life cycle assessment of five targeted national electricity grid mixes," *Energies*, vol. 12, no. 23, Nov. 2019. doi: 10.3390/en12234443

J4 review sara big data

J5 review hussain

Submitted journal papers

Conference papers

- kejrwejr

Local conferences

Published papers

Conference presentations

Supervised bachelor and master thesis

T1 F. Aprà, "Environomical analysis of peak hours electricity production in targeted European countries", June 2019.

T2 K.,Beehuspoteea, "Impact factors of heat generation units for zoned temperature controlled in office buildings", June 2019.

T3 A. Quattrone, "Development of flexibility device models for a microgrid laboratory test", June 2019.

T4 N. Condorelli, "Evaluation and forecast of CO2 emissions in the electricity sector for European targeted countries" March 2020.

T5 P. Plana, "Analysis of measures to increment the share of renewable energy in distribution grids" April 2020.

T6 A. Bové Salat, "Optimal scheduling of flexible assets under a HEMS for prosumers' economic savings" June 2020.

T7 M. Ferran, "Power flow tool for active distribution grids and flexibility analysis", June 2020.

Published technical reports

TR7 E. F. Bødal, P. Crespo-del-Granado, H. Farahmand, M. Korpås, P. Olivella-Rosell, I. Munné-Collado, P. Lloret-Gallego, "INVADE Deliverable 5.1 Challenges in distribution grid with high penetration of renewables," June 2017. doi: 10.5281/zenodo.853271

- entregables INVADE LCA?
- entregables EMPOWER LCA?