AN OPTIMAL NON-WIRE SOLUTION VIA UTILISING THE INVERTER-BASED DERS IN DISTRIBUTION NETWORKS

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MONASH ENERGY INSTITUTE

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Via Zoom Only
Energy Systems Integration Partnership Programme (ESIPP)

25 academics from 13 Schools across 5 institutions
16 interconnected Work Packages organised into three strands
Three strands:
- Modelling & Data (MD)
- End Use Integration (EUI)
- Markets & Strategic Planning (MSP)

To develop flexible integrated energy systems, nationally and internationally

Uncertainty & flexibility
- Supervisory data
- Weather
- Dynamic modelling
- Climate
- Consumer Behaviour
- Financial Risk
- Models

Proxy metering
- Commercial buildings
- Electrified heating
- Wastewater treatment
- Water/energy nexus
- Data centres
- Gas supply

Partnerships: UCD Dublin, Trinity College Dublin, DCU, ESRI, NUI Galway
Core strengths of ESIPP

Multidisciplinary research team
- Power System
- Gas Networks
- Climate and Weather
- Residential and Commercial Buildings
- Manufacturing
- Wastewater Treatment
- Data Centres
- Market structures – incentives and risks
- Consumer Behaviour

Integration and Optimisation!

www.esipp.ie
Non-wire Solution

Quick
Flexible
Effective
Efficient

Public acceptance
Republic of Ireland

Location of Ireland within Europe
Non-wire Solution

Use of Power Flow Controllers to Enhance Transmission Network Utilisation on the Irish Transmission Network
Work Package 1 - System Level Work for RES integration
Work Package 2 - Frequency stability by design
Work Package 3 - Voltage stability by design
Work Package 4 - Pan European real time simulation infrastructure and live 5G testing platform
Work Package 5 - Test-beds for validation of research results
Work Package 6 - Regulatory, legal issues & business models for RES
Work Package 7 - Creating impact with RESERVE
Active distribution networks

Phase a/b/c

Upstream network
Technical Challenges

- Voltage profile
- Thermal ratings of cables
- Active losses
- Asset utilisation
- Transformer loading
Solution

VVC of the DER unit

Phase a/b/c

Upstream
Solution

Reactive power curve of the DER unit

1. Relax PV
2. Lag/lead PV with thermal limits
3. Lag/lead PV with thermal limits and $P_{\text{max}}$
4. Lag PV with thermal limits and $P_{\text{max}}$
5. Lag PV with thermal limits and $P_{\text{max}}$, PF control
6. Proposed limits
Network Data
- Topology
- Section Impedances
- RESs and Loads’ Connection points

Technologies
- RES Technologies
- Inverter capability limits

Demand Historical Data
- Peak demand
- Load factor
- Power factor
- Load unbalance

RES Historical Data
- Power production
- Climate data

Scenario Generation Tool

3-Phase Optimal Power Flow Tool

Linear Regression

3-Phase Optimal Power Flow Tool

Operator Objective

Volt-VAR Curves for decentralised online optimisation in LV grids

\[ y = -0.0236x + 0.9613 \]
Control method

Decentralised Distribution network

Set-point

Offline simulations

V

Q

P

V

Q

P

V

Q

V

Q

P

V

Q

P

V

Q

Offline simulations
Trial sites
How to tune the VVC in a Robust way?
Decision making under uncertainty

Available information regarding uncertain parameter

- PDF
- Membership function
- Exact uncertainty set
- Uncertain uncertainty set

Stochastic
Fuzzy
Robust Optimization
IGDT

Alireza Soroudi, Turaj Amraee, Decision making under uncertainty in energy systems: State of the art, In Renewable and Sustainable Energy Reviews, Volume 28, 2013, Pages 376-384, ISSN 1364-0321
How to implement the optimization?
How to implement the optimization?

Problem

OF1
Constraints

OF1
OF2
Constraints

OF1
Constraints
OF2

OF1

OF2
Optimization tools

Data
- Table
- Set
- Parameter
- Scalar

Variables
- real
- int
- 0/1
- sos
- semi

Constraints
- GAMS
- Variable values

Model
- LP
- MCP
- MIP
- NLP
- QCP
- MINLP

GAMS
AC Optimal Power Flow

\[
\begin{align*}
\min_{DV} \text{OF} &= \sum_{\text{gen}} a_{\text{gen}} P_{\text{gen}}^2 + b_{\text{gen}} P_{\text{gen}} + c_{\text{gen}} \\
\sum_{\text{gen}} P_{\text{gen}} &\geq \text{Load} \\
P_{\text{min}} &\leq P_{\text{gen}} \leq P_{\text{max}} \\
P_{ij} &= \frac{0.5 V_i^2}{Z_{ij}} \cos(\theta_{ij}) - \frac{V_i V_j}{Z_{ij}} \cos(\delta_i - \delta_j) \\
Q_{ij} &= \frac{0.5 V_i^2}{Z_{ij}} \sin(\theta_{ij}) - \frac{V_i V_j}{Z_{ij}} \sin(\delta_i - \delta_j) - \frac{b V_i^2}{2} \\
P_{gi} - P_{di} &= \sum_j P_{ij} \\
Q_{gi} - Q_{di} &= \sum_j Q_{ij} \\
-P^2_{ij} &\leq P_{ij}^2 + Q_{ij}^2 \leq P^2_{ij}
\end{align*}
\]
GAMS book

Chapter 1: Start Coding
Chapter 2: Simple Examples
Chapter 3: Economic Dispatch
Chapter 4: Dynamic Economic Dispatch
Chapter 5: Unit Commitment
Chapter 6: Multi-period DC/AC OPF
Chapter 7: Energy Storage Systems
Chapter 8: Observability via PMU
Chapter 9: Transmission Operation & Planning
Chapter 10: Energy System Integration
Application of general algebraic modeling system to power system optimization

Abstract:
This paper gives a systematic exposure to modeling language as applied to power system optimization problems. Specific reference to the GAMS (general algebraic modeling system) language has been made keeping in mind the popularity, flexibility and available algorithmic tools in it. An overview of the GAMS language followed by simplistic examples are provided to illustrate the ease and efficiency with which power system models can be developed and experimented with. References are cited to the related mathematical programming literature as well as some selected application of GAMS in power system area. Finally the pros and cons of reliance on modeling languages have been discussed.

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Metrics
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Thanks for your attention
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