Unintentional islanding in distribution networks

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Thesis supervision:

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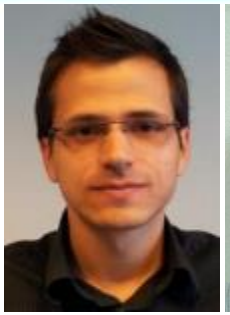
Part 1/2

Our research project

Part 2/2
Survey on protection for undesired islanding

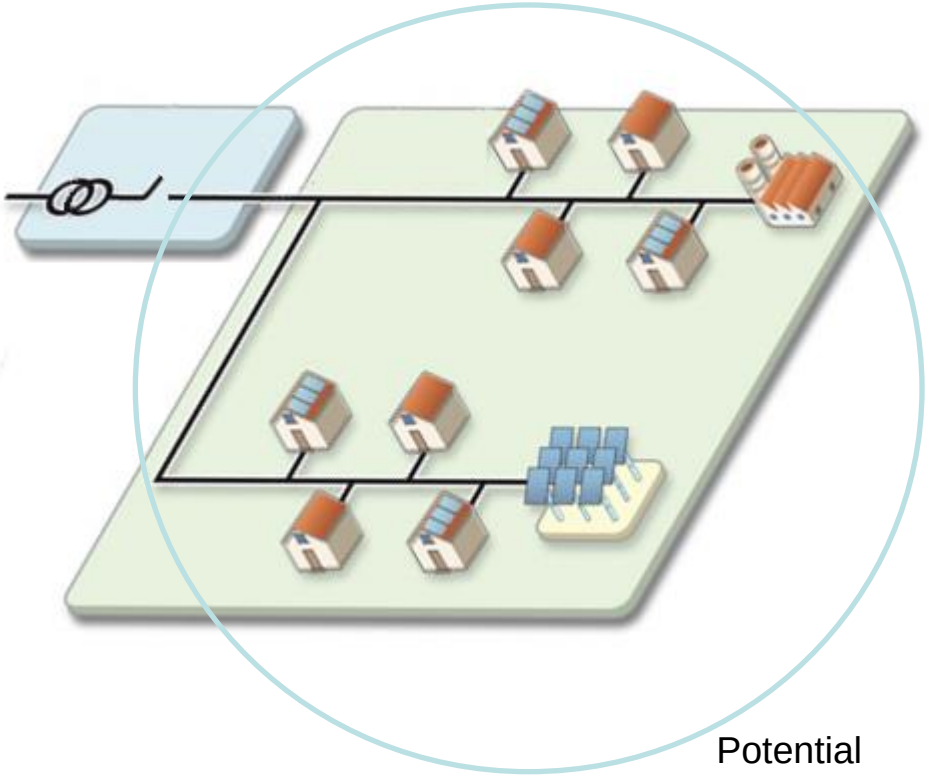
Project scope and objectives




- Topic: (protection against) unintentional islanding
- Research project funded by ERDF at G2ELab
- Timeline: Sep. 2013 – 2016
- Team:
  - *Julien Bruschi (PhD candidate)*
  - *Bertrand Raison, Yvon Bésanger, Florent Cadoux (advisors)*
  - *Jacques Merley, Sébastien Grenard (supervisors)*
- On-going work:
  - *Development of simulation models to understand the dynamic of islanded systems*
  - *Definition and simulation of test-cases*
  - *Benchmark of international practices related to islanding*
- Objectives:
  - *"Understand" the phenomenon of undesired islanding (likelyhood of occurrence, detection and protection…)*
  - *Assess impact of new European grid codes (RfG: Requirements for all Generators)*

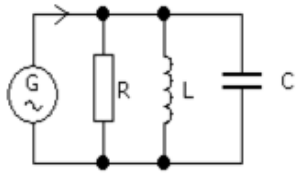
What is undesired islanding?

- Definition: subnetwork separated from main (distribution) grid but remains energized
- Consequences: risks for people and equipment
- Likelyhood:
  - *Seems currently low, but…*
  - *Has been observed in practice*
  - *May become more frequent due to new grid codes*



Current standard practice (1/2)

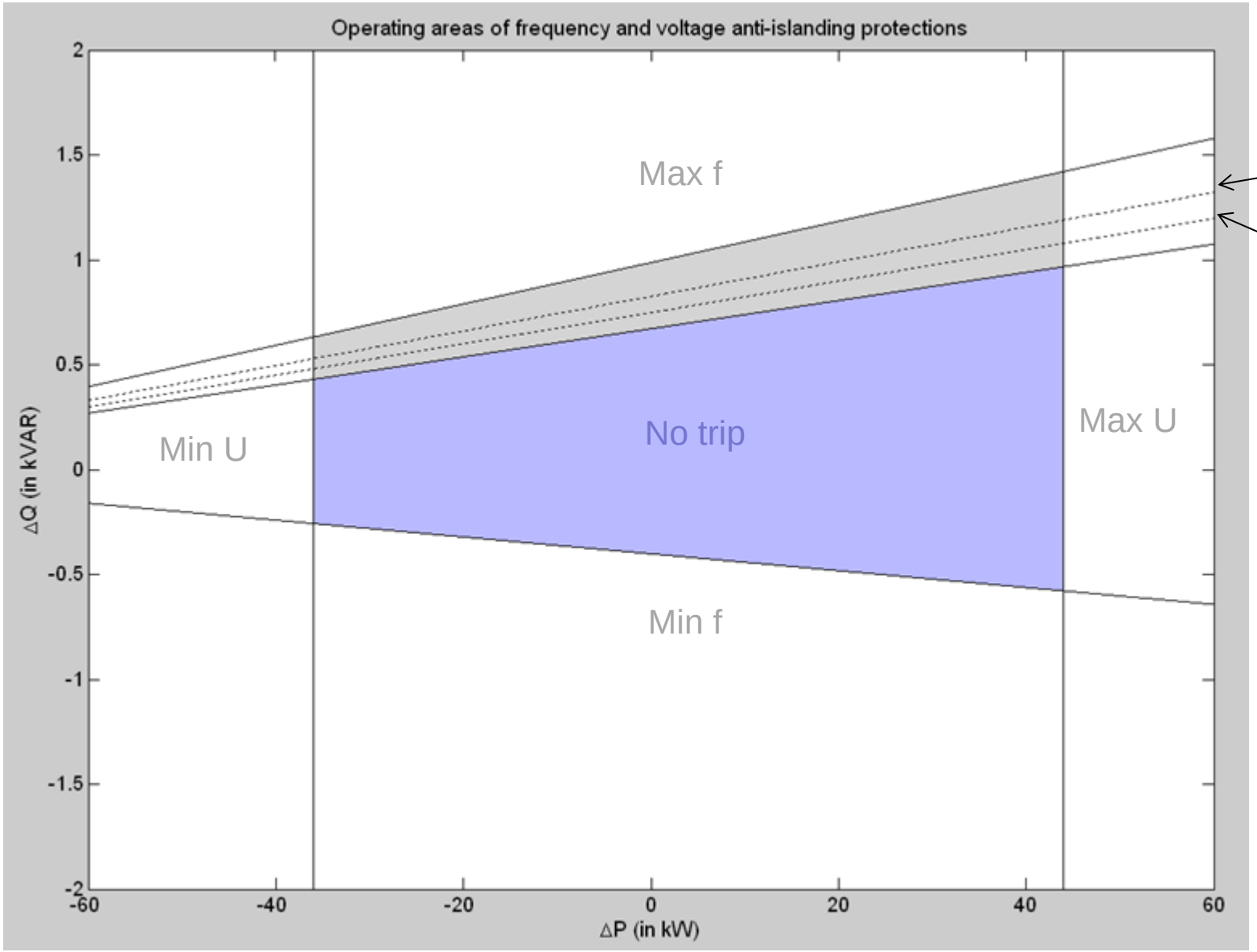
- Installation of anti-islanding protection at generators
- Protection relays monitor frequency and voltage
- Decoupling generators to avoid islanding situations
- Example of 2014 thresholds for LV connected DGs in France: [47,5 Hz, 50,6 Hz] ; ± 20% Vn
- Rationale: subnetwork will probably not be balanced in P and Q
- Ex: single generator (fixed PQ) + single RLC load
  - *Numerical example with:*
    - *P_{PV} = 100 kW and Q_{PV} = 0*
    - *R = 5000 Ω, L = 135,32 H and C = 79,6 nF (which corresponds to P_{RLC} = 80 kW and Q_{RLC} = 0,6 kVAR at 50 Hz and U = 20 kV)*
  - *Analysis shows that U = 17,9 kV and f = 48,5 Hz in islanded steady state, for these values of P_{PV} and Q_{PV}*



$$f = \frac{-\frac{Q_0}{|U|^2} + \sqrt{\left(\frac{Q_0}{|U|^2}\right)^2 + \frac{4C}{L}}}{4\pi C}$$

$$|U| = \sqrt{P_0 \cdot R}$$

Current standard practice (2/2)



f_{max} = 50,6 Hz

f_{max} = 50,4 Hz

Other detection methods

- State of the art of islanding detection methods, based on academic bibliography *(non exhaustive)*
  - *Passive methods*
    - Based on *local* voltage and current measurements, at generator level
    - 12 different methods
  - *Active methods*
    - Same, plus special modifications of inverter controls (or addition of other active components to the grid)
    - 20 different methods
  - *Communication-based methods*
    - Share data in real time over the grid (very fast and reliable data exchange are required for protection means)
    - 4 different methods
  - *Hybrid methods*
    - Use both active and passive methods
    - 2 different methods

Some results

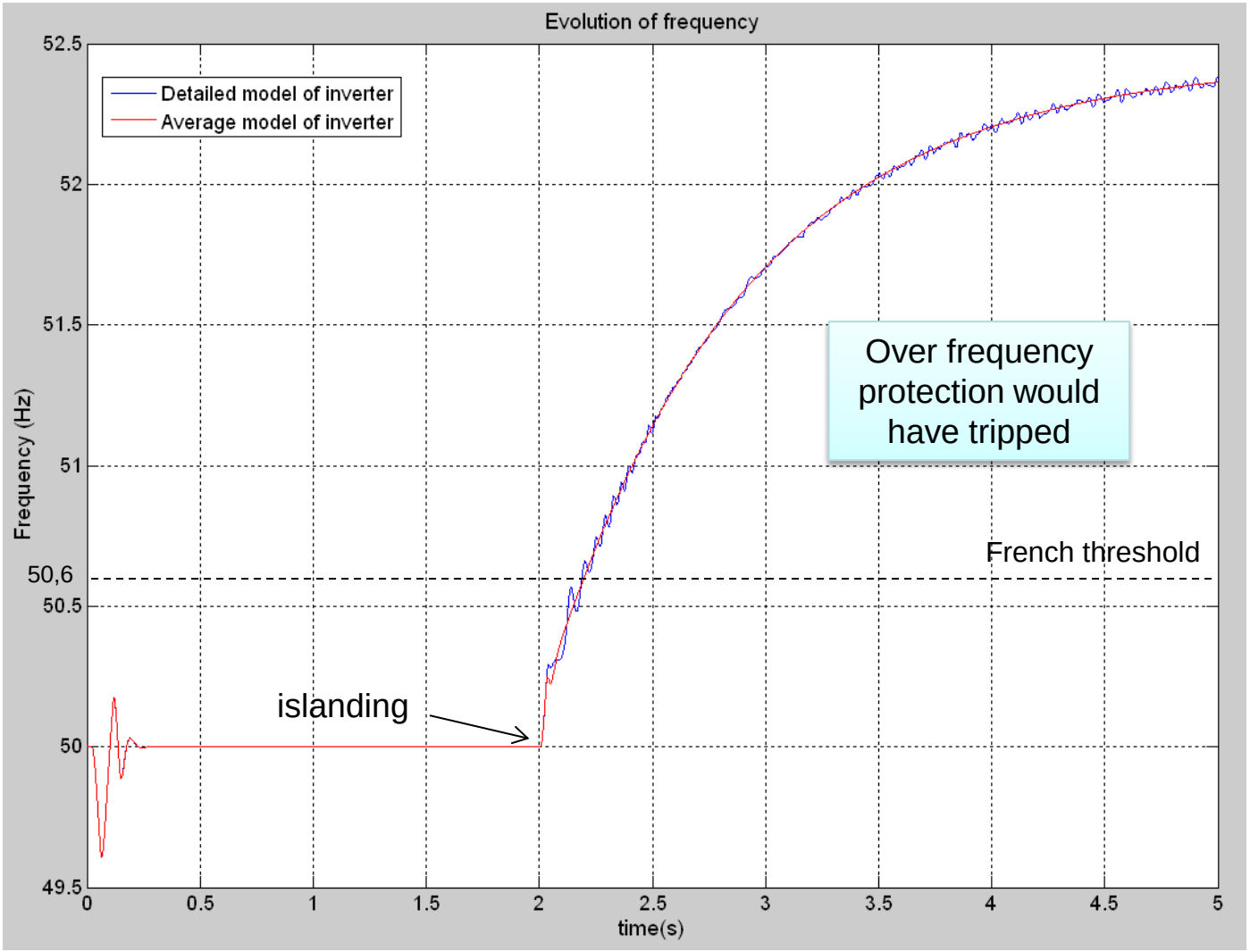
- Assumptions:
  - *Constant irradiance at 1000 W/m²*
  - *Load : parallel RLC*
- Pre-islanding conditions:

$$P_{prod} \approx 100\ kW$$
$$P_{load} = 80\ kW$$

$$Q_{prod} \approx 0\ kVAR$$
$$Q_{load} = -Qc + Ql$$
$$= -10 + 11$$
$$= 1\ kVAR$$

- Steady state frequency of hypothetic island:

$$f = 50\ Hz \cdot \sqrt{\frac{Ql}{Qc}} = 52{,}44\ Hz$$



Some results

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  - *Constant irradiance at 1000 W/m²*
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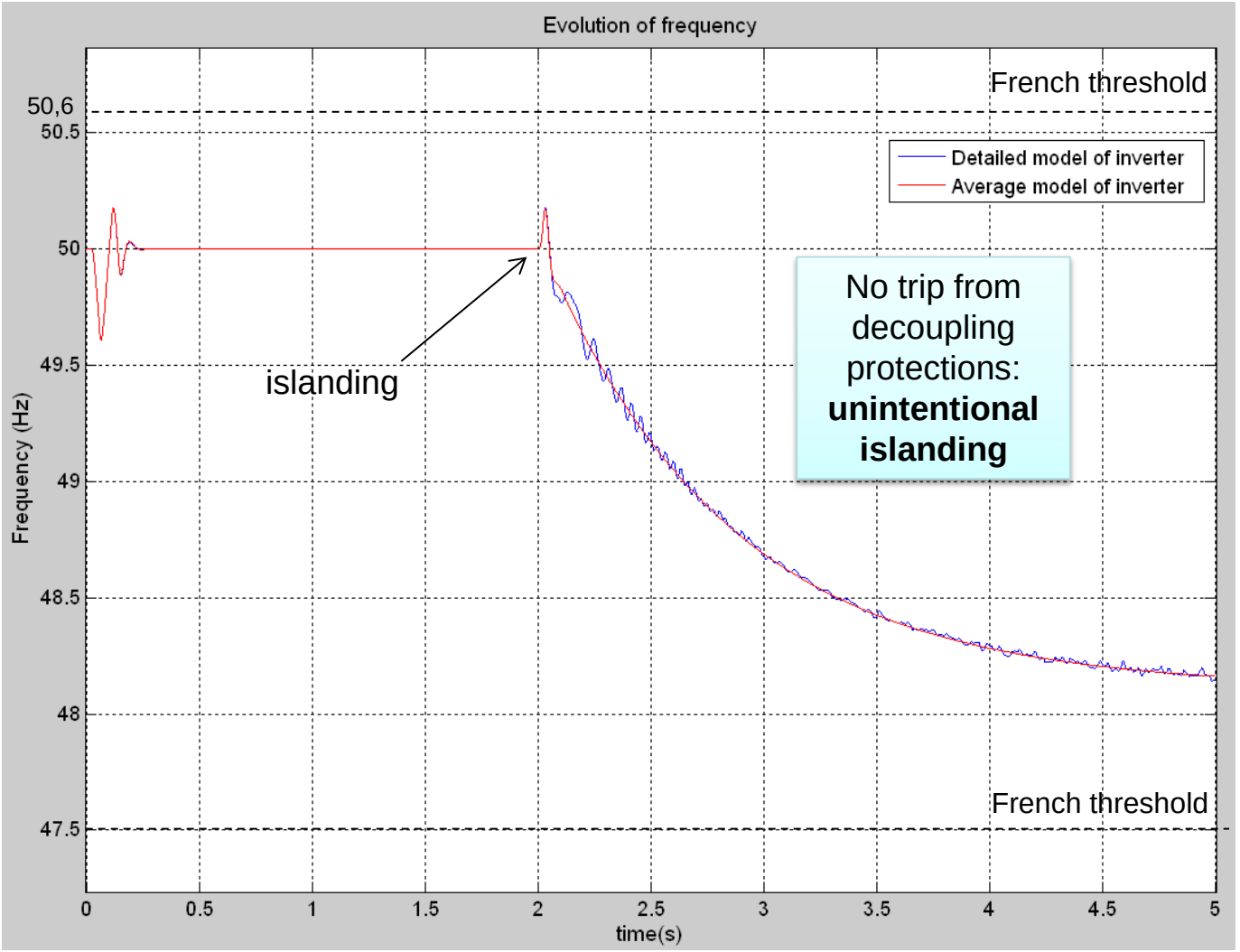
- Pre-islanding conditions:

$$P_{prod} \approx 100\ kW$$
$$P_{load} = 80\ kW$$

$$Q_{prod} \approx 0\ kVAR$$
$$Q_{load} = -Qc + Ql$$
$$= -10{,}8 + 10$$
$$= -0{,}8\ kVAR$$

- Steady state frequency of hypothetic island:

$$f = 50\ Hz \cdot \sqrt{\frac{Ql}{Qc}} = 48{,}11\ Hz$$



Future work

- Simulate various test-cases
  - MV and LV connected Distributed Generators
  - Different scenarios of islanding occurrence (circuit breakers trip after occurrence of a fault, manual operation of switches for maintenance operation)
  - Impact of different types of network (rural, urban), types of loads (impedance, motors)
  - Real time simulations for anti-islanding algorithms
  - …
- Experiment on French distribution grid
  - ERDF will add sensors to a feeder - having a lot of renewable energy - to record the dynamic of hypothetic islanding
- Analyze relevance of islanding « indicators »
  - Frequency, voltage magnitude, and their time derivatives
  - « Network impedance »
  - …

End of part 1 of 2.

Questions, comments?

Part 1/2
Our research project

Part 2/2
Survey on protection for undesired islanding

Survey

Why a questionnaire about islanding?

- To have a better **understanding** of islanding phenomenon
- To know about the **state of the art** of the industrial islanding detection methods (methods, thresholds used,…) and to understand the different **choices made at European level**
- To have an idea about how many islanding have been **identified** (location, period, duration,…)
- To know what kinds of academic islanding detection methods are interesting for industrials (**future** of anti-islanding protections, current **research trends** on the topic)

Questions for the survey (1/7)

1. Root cause of subnetwork separation from main grid, that could lead to islanded operation?

- Protection (e.g. breaker) tripping
- Maintenance operation
- Line/cable "breakup" (e.g. building site machines)
- (other: specify)

2. What consequences for operations?

- Danger to operators (specify if possible)
- Danger to third-parties (specify if possible)
- Equipment damage (specify if possible)
- Power quality problems (e.g. auto-reconnect failing after transient fault)
- (other: specify)

Questions for the survey (2/7)

3. If an islanding situation occurred (or has occurred) in your network, how would you identify it?
   - Voltage Presence Indicator or issue at reconnection
   - Voltage testers by operators
   - Advanced Metering Infrastructure (AMI)?
   - Other: specify
   - We would probably not identify it

4. Have you indeed gathered evidence of islanding occurring in your networks?
   If yes:
   - How long did it last?
   - Do you have enough information about operating conditions, at the time islanding occured, to attempt to reproduce the situation by simulation?
   - Was any data recorded during the event?

Questions for the survey (3/7)

5. Do you have any suspicion or evidence of frequent unnecessary anti-islanding protection trips? (E.g. complaints from producers).
   - If yes, what kind?
   - If yes, what is the suspected cause (fault at transmission level, voltage dip at distribution level...)

6. What kind of distribution network characteristics (beside the presence of distributed generators at distribution level) do you think may increase the risk of unwanted islanding?
   - Type of generators (wind, PV, small hydro, CHP...)
   - Type of power converter (power electronics / electrical machine, manufacturer of the converter, user settings...)
   - Type of load (e.g. industrial loads ; all small vs a few large ones ; etc.)
   - Type of conductors (overhead vs underground)
   - Type of grounding system and protection plan
   - Presence of reclosers

Questions for the survey (4/7)

7. New European grid codes (RfG) will probably introduce enlarged frequency thresholds, primary frequency control and perhaps other mechanisms aiming at improving European system stability. According to you, will these mechanisms increase the risk of unwanted islanding?
   - Enlarged frequency threshold: y/n?
   - Over-frequency active power droop: y/n?
   - Other techs (please specify)

8. According to you, what should be the future of anti-islanding protection?
   - Simply integrating new grid codes should be sufficient (both from the DSO and TSO perspective)
   - New passive islanding detection mechanisms
   - Active detection mechanisms
   - Communication mechanisms
   - None, we should learn to control and use islanding situations instead of trying to eliminate them.

Questions for the survey (5/7)

9. Anti-islanding protection in your system has an operating impact on:
   - Managing electricity supply / Service restoration?
   - Setting other protections?
   - No impact?
   - Other (please specify)

10. Overall, do you consider that unwanted islanding is a subject of concern in your organization, and are you currently working on this topic?
   - Concern: - => +
   - Working on it: y/n (if yes: please explain how)
   - Not working on it, but would be interested in knowing about current research: please specify what kind of research you'd like to see carried out and what scenarios you would suggest researchers to study

Questions for the survey (6/7)

11. Remarks, comments, suggestions -- if you have a great idea to detect islanding, please let us know (open)

12. Participant information (optional)
    - Name of contact person (for organizers only, in case we would need to contact you e.g. in case we need some clarification)
    - Country
    - Type of organization
    - Role in organization (manager, expert, operator... several answers allowed)

13. What is the 'level of anonymity' to use when returning your answers to all participants?

Questions for the survey (7/7)

14. Are you interested in being informed once a year of the latest results about our islanding study?

Contact info:

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End of part 2 of 2.

Thank you for your attention!

Questions, comments?