

Open consultation on Metrology for Smart Electricity Grids

Measurement challenges related to smart electricity grids including a discussion on Digital transformation and cybersecurity

# Modelling and data analytics in smart grids

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Modelling and data analytics in smart grids–25.11.2021



- Smart grids. Measurements and control
- Information vs. data
- HRR, SM, PMUs and WAMCS
- A hidden treasure: P(t) examples of data analytics
- Wrap-up



### **SMART GRIDS AND THE LOWER INERTIA ISSUE**



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### **MEASUREMENTS AND CONTROL TODAY**





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### **MEASUREMENTS AND INFORMATION. NEED OF HIGH REPORTING RATES**

- by averaging the measurement result, the message becomes less sensitive to measurement errors;
- However, there is a **lack of significance** of the quantity at the end of aggregation process:
  - the decimation introduces an additional uncertainty which is associated NOT with the measurement but with the meaning of the resulting quantity; this error can be related to the "adequacy" of the information [output message] to the model (of the physical system)  $\rightarrow$ definitional uncertainty, an estimate of the semantic noise  $u_M^*$ : model/definitional uncertainty



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### [ENERGY VS. POWER] METERING. ENERGY COMMUNITIES AND NEW BUSINESSES



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## [ENERGY VS. POWER] METERING. SMART METERS AND INHERENT DATA COMPRESSION



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### **SYNCHRONIZED MEASUREMENTS. WAMCS**



frequency in case of generation loss caused by lightning



Tantaren

Cernavoda

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system under large perturbations, Proc. of 55th Universities Power

Engineering Conference (UPEC 2020) – Torino, Italy, 1-4 September 2020

### SYNCHRONIZED MEASUREMENTS. Role of inertia



#### Cernavoda Nuclear Power Plant 2 x 700 MW

- CNPP\_ev1: 1<sup>st</sup> June 2017
- One unit was under planned maintenance (half inertia available)
- Sudden full disconnection of the unit (no inertia remained)
- The instant of perturbation:
  - 18% wind generation
  - 17% power export

#### CNPP\_ev2: 16 August 2018

- Both units in operation
- Sudden full disconnection of the unit
- The instant of perturbation:
  - 4.4% wind generation
  - 6% power export

L. Toma, M. Sanduleac, M. Albu, C. Diaconu, C. Stanescu, *Frequency analysis in the Romanian power system under major grid disturbances*, CIGRE e-Session, 2020



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### SYNCHRONIZED MEASUREMENTS. Role of inertia



- The local mechanical inertia determines the frequency dip, which is double when both units of CNPP are disconnected
- The frequency is stabilized within 1 second, earlier than the time delay specific to the primary frequency control

L. Toma, M. Sanduleac, M. Albu, C. Diaconu, C. Stanescu, *Frequency analysis in the Romanian power system under major grid disturbances*, CIGRE e-Session, 2020

### **EMBEDDED FORECASTING AND ANOMALY DETECTION FOR POWER PROFILES**

## Short Term Load Forecasting (STLF)

Classical system identification / statistical models Good performance with expert knowledge for model structure selection

Machine learning models

Data-driven modelling that can incorporate domain knowledge in the feature engineering stage

Good performance and adequate explainability

Deep learning models

State-of-the-art performance

Opaque models with large computational requirements

Task: **to predict power profile P(t<sub>k</sub>)** on a variable prediction horizon (hour, day, week) with associated confidence intervals Subtask: **anomaly detection** 

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- local control to enable DR schemes and mitigate the risk of anomaly occurrences → flexibility!
Local control loops executed on the edge in real time



### **MULTI-SCALE DATA ANALYTICS FOR POWER PROFILES**

- Development of **data driven models** that operate in a robust manner at various timescales
- Incorporate domain knowledge at pre-processing and feature engineering stages
- Potential for model compression to run on embedded hardware with resource constraints
- Micro-load forecasting and classification e.g. steady state and transients labelling
- How do data-driven models perform under varying input reporting rates? Can we keep the same models w/o retraining?
- One month of residental energy measurements sampled at 1s; Offline processing of daily text record files





Grigore Stamatescu, Irina Ciornei, Radu Plamanescu, Ana-Maria Dumitrescu, Mihaela Albu, *Reporting Interval Impact on Deep Residential Energy Measurement Prediction,* Proc. of AMPS2021, 1 Oct. 2021



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 $\rightarrow$  fusion of data recorded at significantly different reporting rates  $\rightarrow$  increase the situational awareness

→framework for knowledge extraction from HRR data. The process takes place at smart meter level →to increase the accuracy of the monitoring tools for distribution power grids by using statistics (the percentiles - e.g., p95 and p99 and the cdf). able to capture system dynamics relevant for network diagnosis.





M. Sanduleac, V. I. Ciornei, L. Toma, R. Plamanescu, A. -M. Dumitrescu and M. Albu, "High reporting rate smart metering data for enhanced grid monitoring and services for energy communities," in *IEEE Transactions on Industrial Informatics*, 2021

- [NEW] CONTROL ALGORITHMS IN SMART GRIDS REQUIRE FASTER MEASUREMENTS
- ACCURATE MODELLING/VALIDATION OF MODELS
- NEW SOLUTIONS FOR [LOSSLESS!] DATA COMPRESSION
- HIGH REPORTING RATE MEASUREMENTS [SMART METERS]
- DATA ANALYTICS FOR ENERGY COMMUNITIES

....  $\rightarrow$  data security?

