

# EUROPEAN PATTERN RECOGNITION

## RENEWABLE ENERGY IMPACT

September 2016

European  
Pattern  
Recognition project

Smart Grids Plus  
ERA-Net

metrum

AVA  
Glava Energy Center

MälarEnergi

STRI

embriq.  
by Rejlers

ELTEK

ENERJISA  
e-on | BANCİ

Başkent  
Ayedaş  
Toroşlar  
e-on | QHANG

THE EUROPEAN PATTERN RECOGNITION PROJECT HAS RECEIVED FUNDING FROM THE SWEDISH ENERGY AGENCY, THE RESEARCH COUNCIL OF NORWAY AND THE SCIENTIFIC AND TECHNOLOGICAL RESEARCH COUNCIL OF TURKEY (TÜBİTAK) IN THE FRAMEWORK OF THE JOINT PROGRAMMING INITIATIVE ERA-NET SMART GRIDS PLUS, WITH SUPPORT FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME.



# METRUM

## MANAGING PARTNER OF THE EPR PROJECT



[www.metrum.se](http://www.metrum.se)

- Unique system solutions for measurement of energy and power quality
- Enabling optimized action to save energy & reduce cost and environmental impact
- Class A measurement instruments & easy to use system software
- Flexible through 100% in-house development
- Access to world-class PQ competence such as Borås University
- Proven products – over 10 years in the market
- Based in Gothenburg, Sweden

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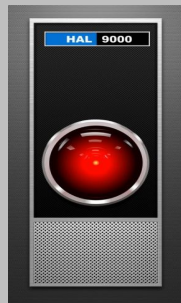
ELTEK

ENERJISA  
e-on BANCİ

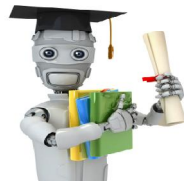
Başkent  
Ayedaş  
Toroşlar  
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# PATTERN RECOGNITION IS A BOOMING FIELD WITHIN ARTIFICIAL INTELLIGENCE

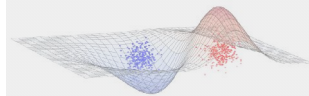
## ARTIFICIAL INTELLIGENCE



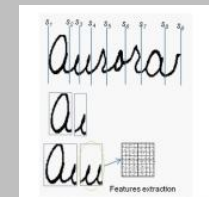
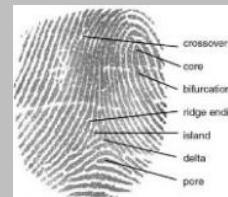
## MACHINE LEARNING



## PATTERN RECOGNITION



## EXAMPLES OF TODAY'S APPLICATIONS



"So why not apply it on the electrical grid?"

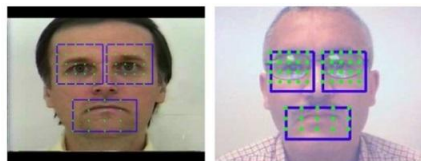
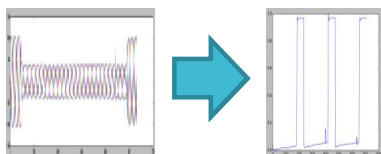
# PATTERN RECOGNITION WORKS IN 4-STEPS



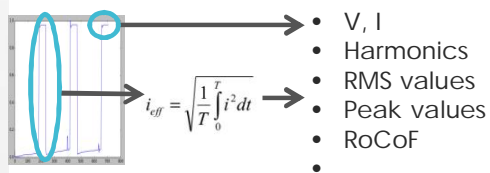
DATA ACQUISITION



PRE-CONDITIONING

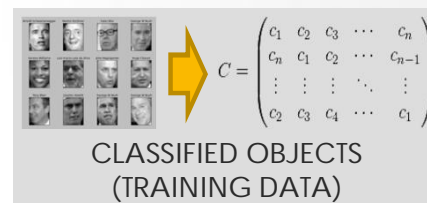


FEATURE EXTRACTION

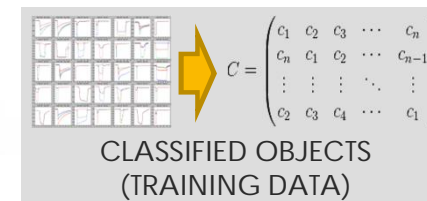
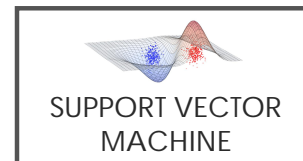


$\begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ \vdots \\ a_n \end{bmatrix}$

$\begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ \vdots \\ a_n \end{bmatrix}$

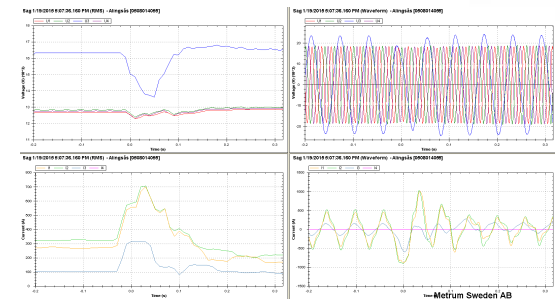


ANALYSIS



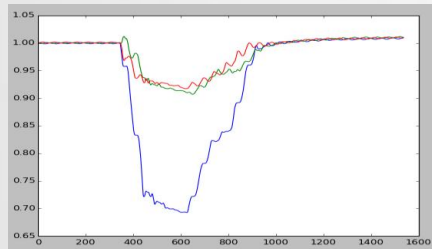
# PATTERN RECOGNITION IS WELL-SUITED FOR POWER GRID ANALYSIS

- Many useful patterns in PQ and energy data
- Algorithms handle large data quantities
- Large potential to provide:
  - New insights and ideas
  - Solutions to important problems
  - Optimized network planning & operation
  - Pro-active maintenance
  - Framework for future applications
  - ...

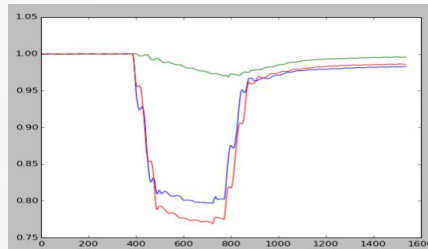


# EPR BUILDS ON PROMISING RESULTS FROM EARLIER STUDIES

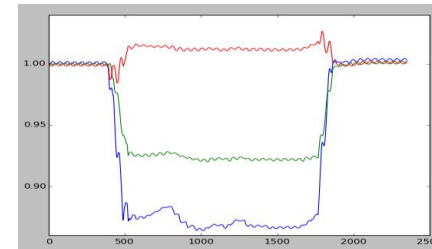
Pattern Recognition applied on 1642 disturbances from 2 network operators.



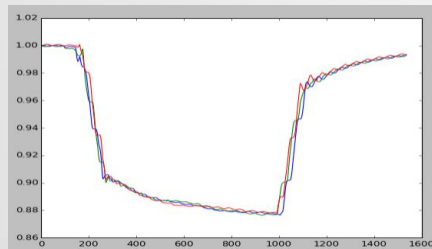
One-phase fault



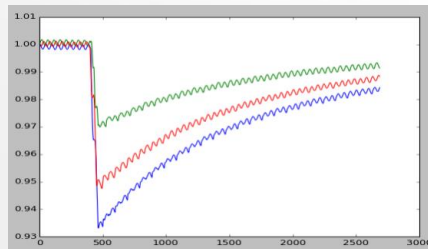
Phase-to-phase fault



Phase-to-phase-to-earth fault



Three-phase fault



Transformer start

à Accuracy: ~98 %

PROJECT OBJECTIVE:

DEVELOP, TEST AND VALIDATE METHODS FOR  
APPLYING PATTERN RECOGNITION TO  
6 APPLICATION AREAS



PROJECT GOAL:

USING PATTERN RECOGNITION AS A TOOL  
FOR GRID OPERATORS AND GENERATORS TO

- OPTIMISE THE POWER SYSTEM
- ENABLE HIGHER SHARE OF RENEWABLE  
ENERGY GENERATION IN THE SYSTEM

# 6 APPLICATIONS FOR PATTERN RECOGNITION = 6 WORK PACKAGES

## PRO-ACTIVE MAINTENANCE

LEAD: METRUM

DEMO:

ENERJISA  
& MÄLARENERGI



## POWER CONSUMPTION STUDIES

LEAD: EMBRIQ

DEMO:

FALBYGDENS ENERGI



## LOCAL ENERGY SYSTEMS - MICROGRIDS

LEAD: GLAVA E.C.

DEMO:

GLAVA E.C.



## POWER REGULATION BY VOLTAGE CONTROL

LEAD: MÄLARENERGI

DEMO:

MÄLARENERGI



## HOSTING CAPACITY

LEAD: STRI

CASE STUDY:

MÄLARENERGI



## INERTIA SUPPORT

LEAD: ENERJISA

DEMO:

ENERJISA



# FACTS & FIGURES

8 main partner companies from 3 countries



- Partners from industry, research & academic worlds
- >25 project team members
- 4 Demonstrators, 5 locations in Sweden & Turkey
  - >30 PQ instruments @ 3 distribution companies, 1 solar test site & 1 wind farm
  - Solar PV control system, micro-grid control system, energy data management system
  - Data from customer & other PQ meters
  - Data server
- Budget: 1.6 Million EUR
- March 2016 – February 2018



WITH FUNDING FROM:



# HAVING THE RIGHT COMPETENCE AND KEY END-USERS IN THE PROJECT

## TECHNOLOGY PROVIDERS



## COMPETENCE & TESTING FACILITIES PROVIDERS



UNIVERSITY OF BORÅS



## END USERS: UTILITIES / DSOs / TSOs



Validate goals, deliverables & create  
end-user acceptance:

Reference groups / advisory board:



... (more to be added)

# PRO-ACTIVE MAINTENANCE

Analyse trends  
in  
Power Quality  
with  
Pattern  
Recognition

- à Give early warning signals
- à Enable pro-active maintenance of electrical grids' components
- à Decrease interruption costs

LEAD: METRUM



DEMO:  
Enerjisa  
Mälarenergi



# POWER CONSUMPTION STUDIES

- § Use P.R. to categorize events, consumers and describe loads' voltage dependency
- § Combine PQ and energy metering
- § Develop a search engine for DSOs and others to identify unwanted events

- à Increase power grids' effectiveness
- à Reduce costs for DSOs to upstream networks
- à Increase capacity
- à Increase flexibility

LEAD: EMBRIQ



DEMO:  
Falbygdens Energi



# LOCAL ENERGY SYSTEMS - MICROGRIDS

§ Use P.R. to analyse PQ, generation & weather data to:

§ Monitor, detect & predict errors in solar PV generation

§ Identify faults in micro-grids' components

§ Use advanced IT to manage "smart power components" in micro-grids

à Enable preventive maintenance, optimise design of micro-grids

à Increase solar generation

à Provide system services to DSOs/TSOs

à Increase power grids' capacity and flexibility

LEAD: GLAVA E.C.



DEMO:

Glava Energy Center /  
Arvika kommun



# POWER REGULATION BY VOLTAGE CONTROL

§ Using Pattern Recognition to estimate the voltage dependency of loads

§ Use simulations to estimate the level of impact of voltage regulation on loads

- à Optimise & lower DSOs subscribed capacity to upstream network and avoid penalties
- à Enable congestion mgmt & peak shaving, increase capacity
- à Enable peak shaving on national level

LEAD: MÄLARENERGI



DEMO:  
Mälarenergi



# HOSTING CAPACITY

- § Develop “hosting capacity” method
- § Investigate KPIs that limit renewables’ integration
- § Identify & quantify bottlenecks
- § Case study

- à Provide a tool for network planning
- à Increase capacity for renewable integration

LEAD: STRI



CASE STUDY:  
Mälarenergi

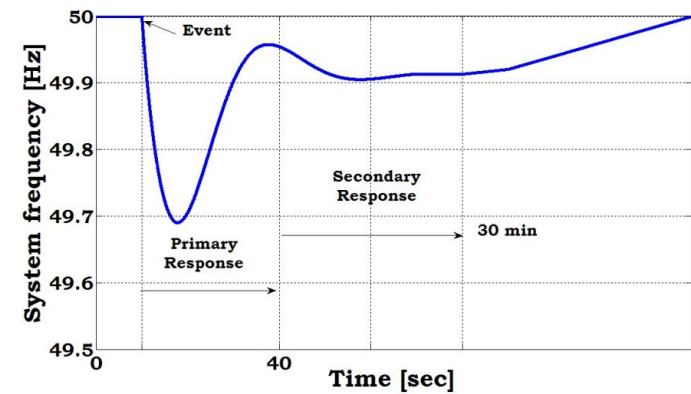


# INERTIA SUPPORT

- § Use Pattern Recognition to analyse changes in frequency to
- § Assess the level of inertia in a power system
- § Trigger signals to a wind farm for inertia support

- à Verify TSOs estimation of inertia
- à Enable inertia support from wind farms based on P.R. technology
- à Analyse the impact on inertia from changing of the loads

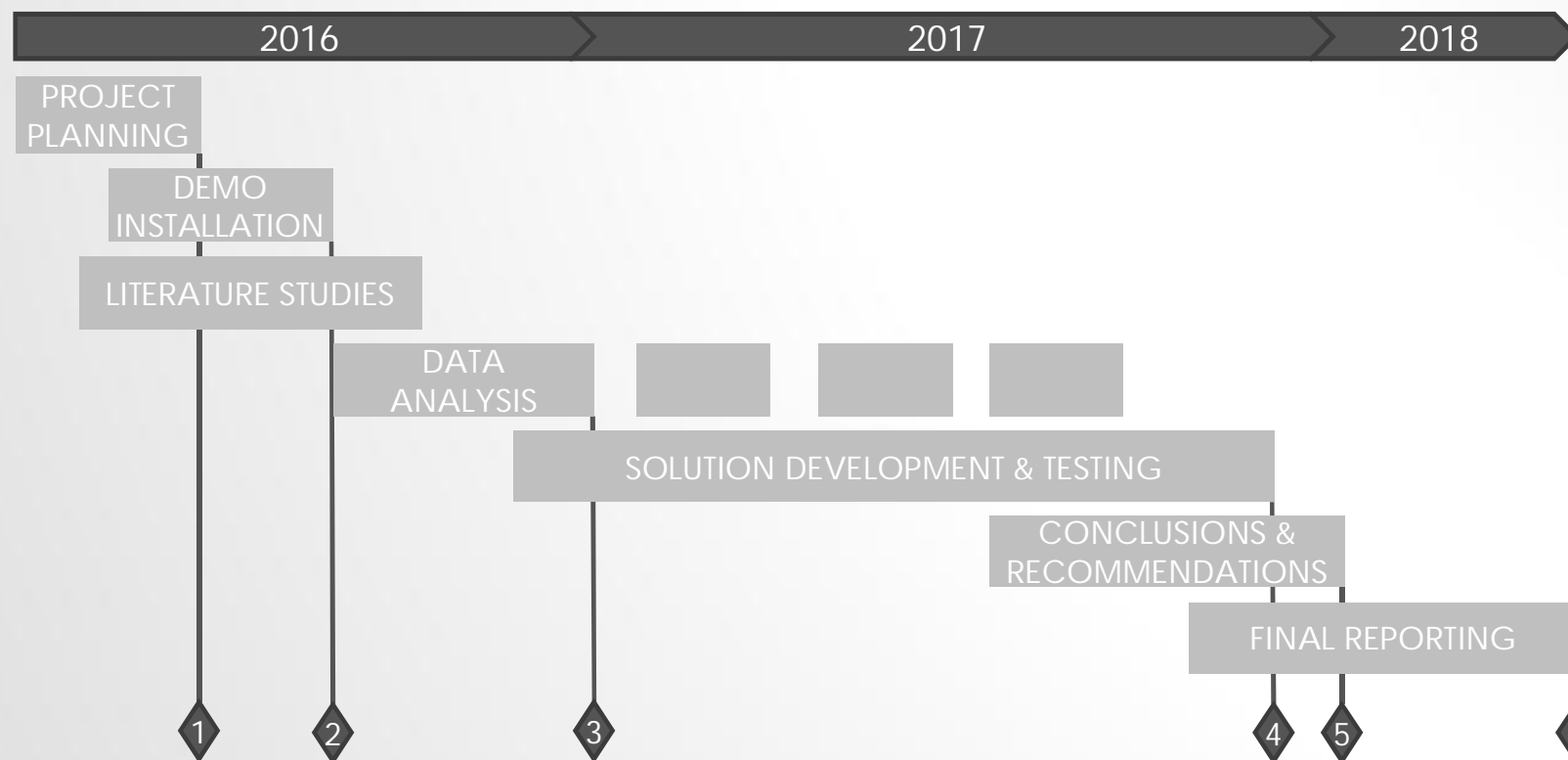
## LEAD: ENERJISA



## DEMO: Enerjisa



# CLEAR MILESTONES, CLEAR DELIVERABLES



# DISSEMINATION & KNOWLEDGE SHARING: KEY PART OF THE PROJECT

- Active communication
  - Seminars, Articles
  - (Social) media
- Creating a knowledge database
  - Power quality and other energy data samples
  - Including object/feature classification
  - Basis for further research in pattern recognition
- Find us on ERA-Net's SG+ EXPERA community & working groups:  
<http://www.smartgridsplus.eu/>
- Linkedin: <https://www.linkedin.com/groups/8541881>



# THE EPR PROJECT WILL BRING:

- ü A platform for development of pattern recognition applications
- ü Applications for DSOs, TSOs, industry and energy companies
- ü Help tackle present & future challenges (e.g. distributed generation, power electronics, electrical vehicles):
  1. Keeping STABILITY
  2. Increasing CAPACITY
  3. Increasing FLEXIBILITY
  4. Decreasing COSTS FOR INTERRUPTIONS  
(improved power quality and security of supply)
- ü Active contribution to the European knowledge community
- ü A basis for research on pattern recognition technology in power systems

# CONTACT US

[www.europeanpatternrecognition.eu](http://www.europeanpatternrecognition.eu)

[www.metrum.se](http://www.metrum.se)



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# THANKS FOR YOUR ATTENTION !!

## QUESTIONS ??