Electrical Energy Systems

a.j.m.pemen@tue.nl

May 3, 2017 - Explore Your Master

We are facing complex and urgent ch...

..which impact our energy supply for several decades...

..and whose outcome is by no means clear.

Current developments in NL:

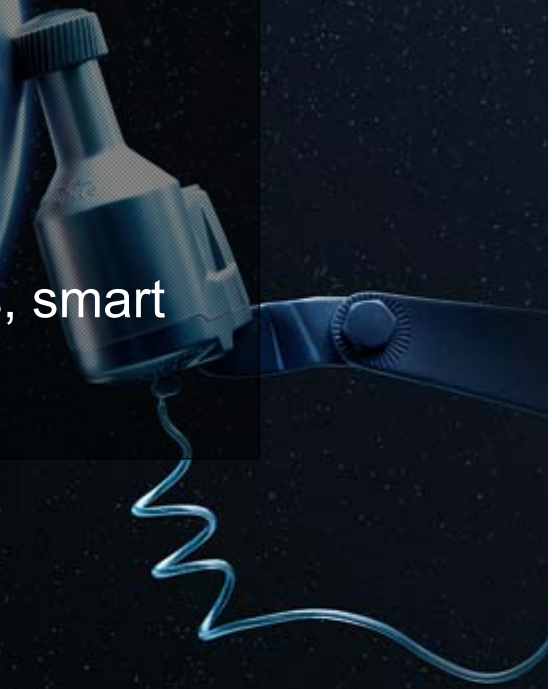
- Large investments in off-shore wind (and off-shore grid)
- Investments in (international) high-voltage connections
- Promotion of electrical vehicles
- Shut-down of coal-fired power stations
- Eventually eliminating natural gas

Next?

- Decentralized, residential areas
- Photovoltaics (ultimately the cleanest and cheapest?)
- Heatpumps, storage, CO_2 utilization
- Geothermal, fusion?

A sustainable society is an electrical society

- **Increase role of electrical energy in society**
  - Electricity is ***the*** sustainable energy carrier.
- **Electrify our economy**
  - Transport, homes (heat pumps), industry
- **Use energy more efficient**
  - Advanced (linear) drives and actuators, robotics, smart appliances, electrotechnologies.

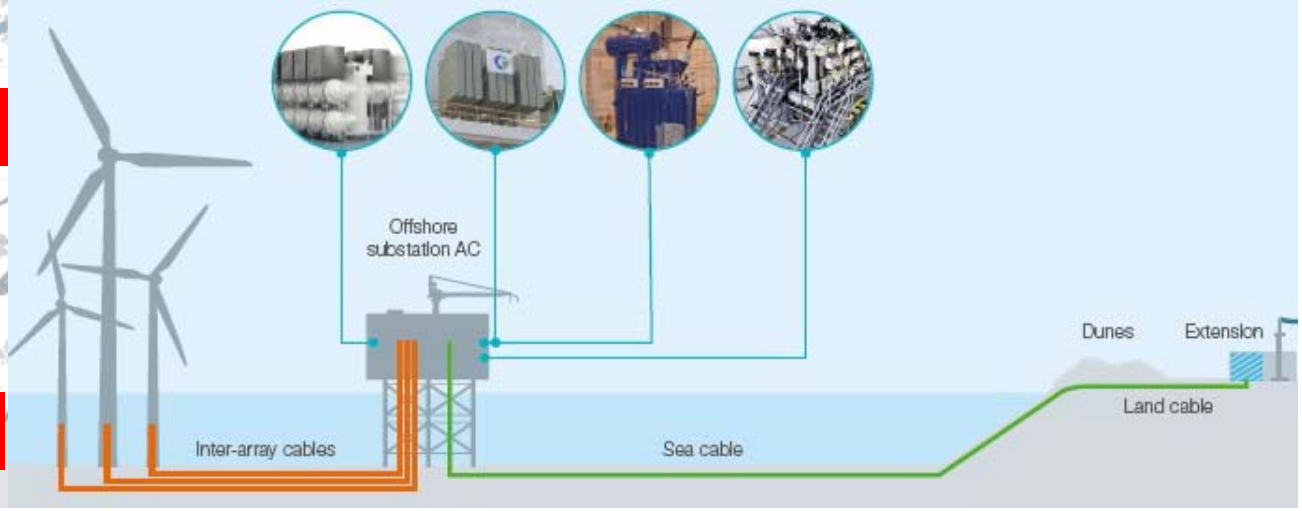


- Technically complex
- Higher yields.
- Potential 13.400 TWh/year (about total Middle East oil production)

700 MW

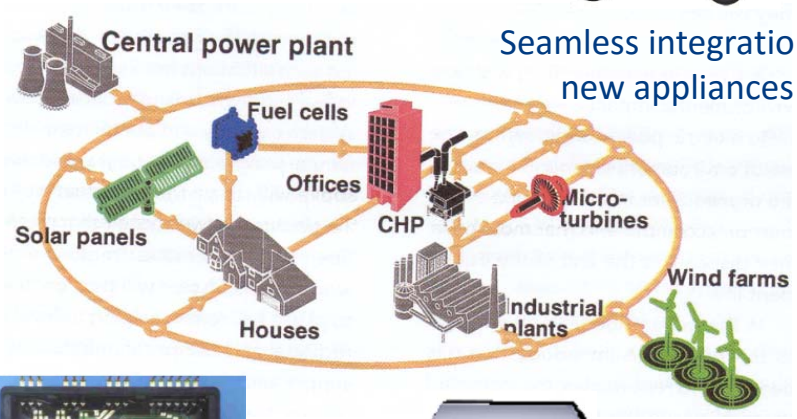
2 x 700 MW

2 x 700 MW

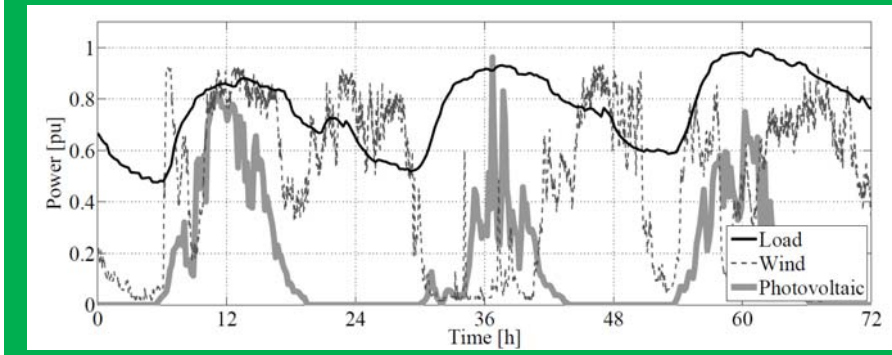


Our challenges

Seamless integration of new appliances



How Can We Deal with Variability?



Smart (power) electronics integration

Smart appliances

Storage

End-user real time information and participation

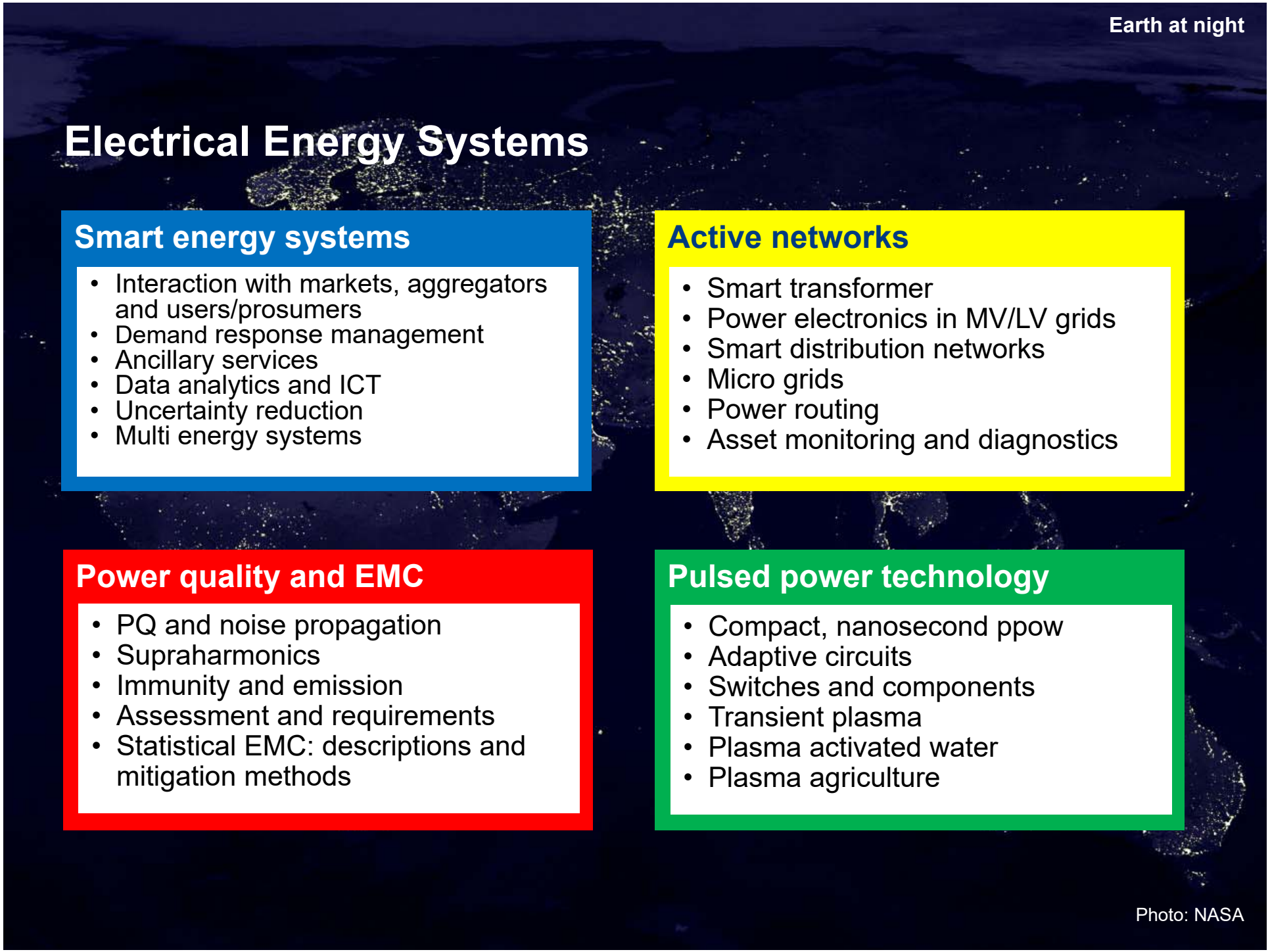
Integration intermittent sources.

Electrical Energy Systems

- Focus on methodologies for design and operation of future electricity supply systems.

- Special emphasis on smart MV/LV networks and interaction with
  - higher level grids
  - energy and ancillary services markets
  - connected users (prosumers).

- Future electricity grids must be:
  - self-supporting, self-healing, adaptive and active
  - inherently secure and stable
  - fulfilling power quality requirements



Electrical Energy Systems

Smart energy systems

- Interaction with markets, aggregators and users/prosumers
- Demand response management
- Ancillary services
- Data analytics and ICT
- Uncertainty reduction
- Multi energy systems

Active networks

- Smart transformer
- Power electronics in MV/LV grids
- Smart distribution networks
- Micro grids
- Power routing
- Asset monitoring and diagnostics

Power quality and EMC

- PQ and noise propagation
- Supraharmonics
- Immunity and emission
- Assessment and requirements
- Statistical EMC: descriptions and mitigation methods

Pulsed power technology

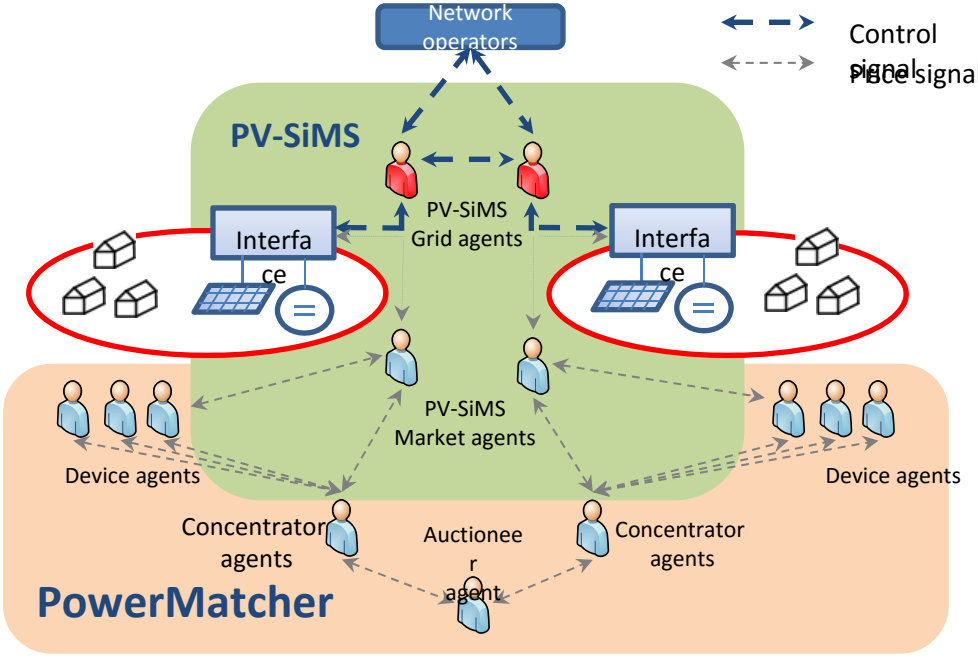
- Compact, nanosecond ppow
- Adaptive circuits
- Switches and components
- Transient plasma
- Plasma activated water
- Plasma agriculture

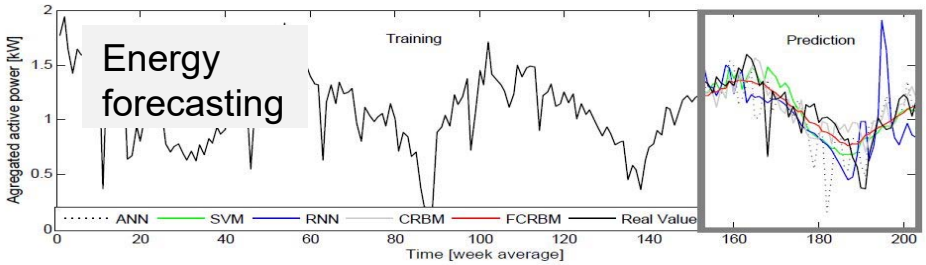
Photo: NASA

Smart energy systems

(and interaction with markets and users/prosumers)

- Demand response management
- Power matching
- Ict in smart grids
- Uncertainty reduction (e.g. in planning)

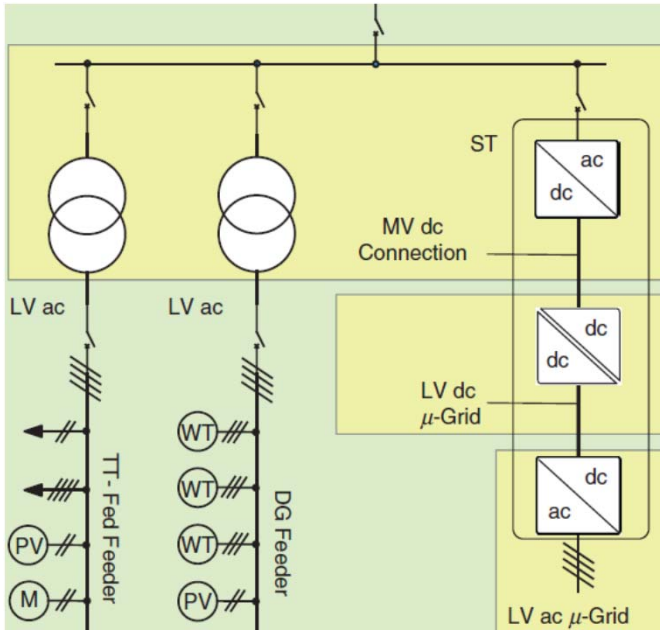


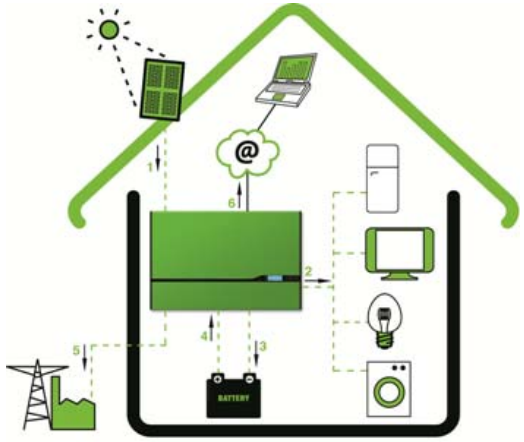


Active networks

(and interaction with higher level network)

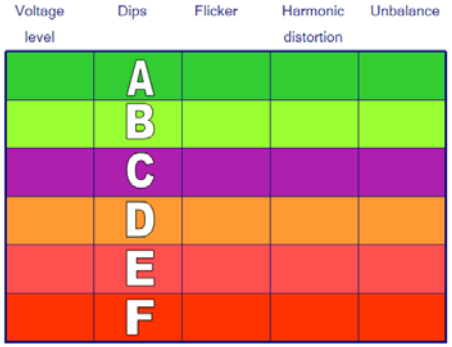
- Power electronics in MV/LV grids
- Smart distribution networks (AC, DC, hybrid)
- Residential energy systems (AC, DC, hybrid)
- Power routing
- Asset monitoring and diagnostics (cables, substations)





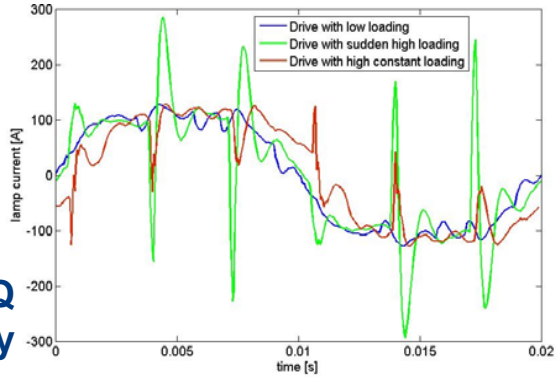
Power quality and EMC – 1/2

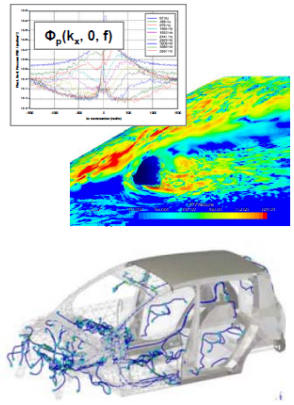
- Propagation of (hf) PQ through distribution networks
- Use of power electronics in distribution system operation
- Immunity and emission of (new) loads
- Assessment methods and requirements
- Systematic analyses of complex systems, advanced sensor development, noise propagation, analytical and statistical electromagnetic models.



Classification of Power Quality phenomena

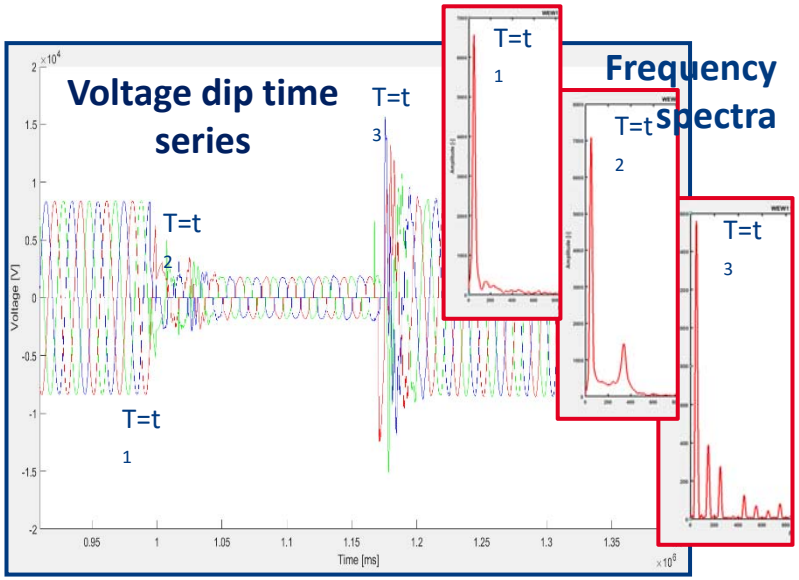
Research in PQ laboratory



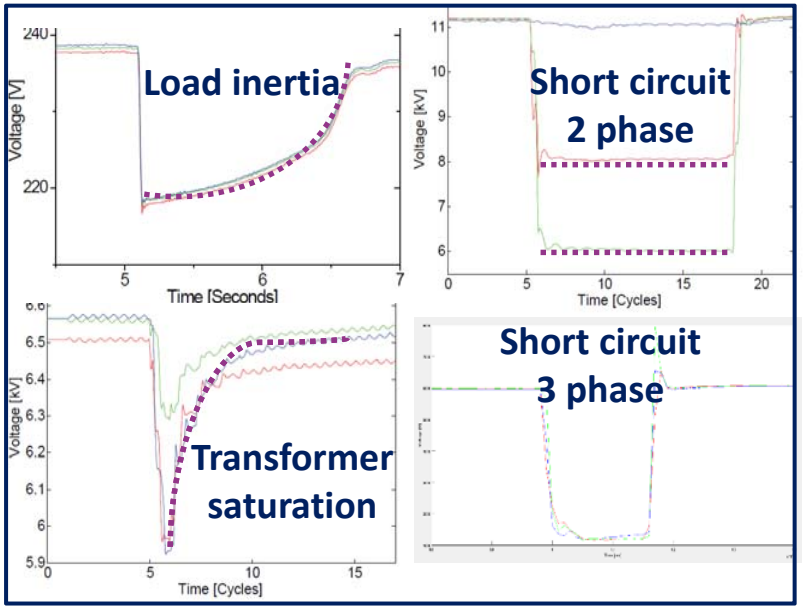


Power quality and EMC – 1/2

- PQ classification techniques

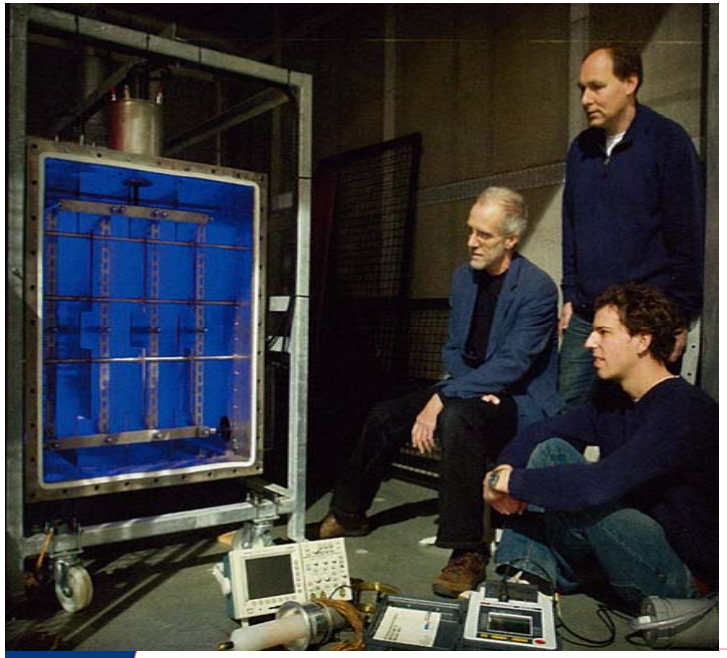


Voltage dip RMS curves



Pulsed power technology – 1/2

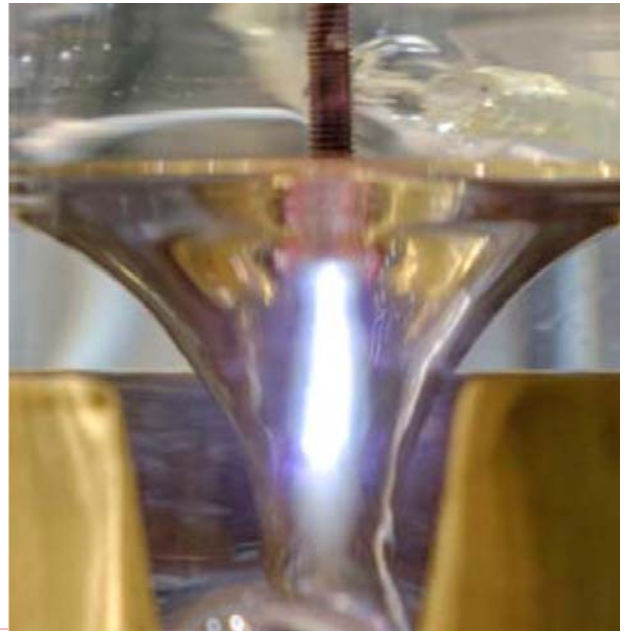
- Compact, repetitive, nanosecond pulse technologies
- Adaptive circuits (dynamic load matching)
- Applications: transient plasma, bioelectrics, hightech systems (HV)



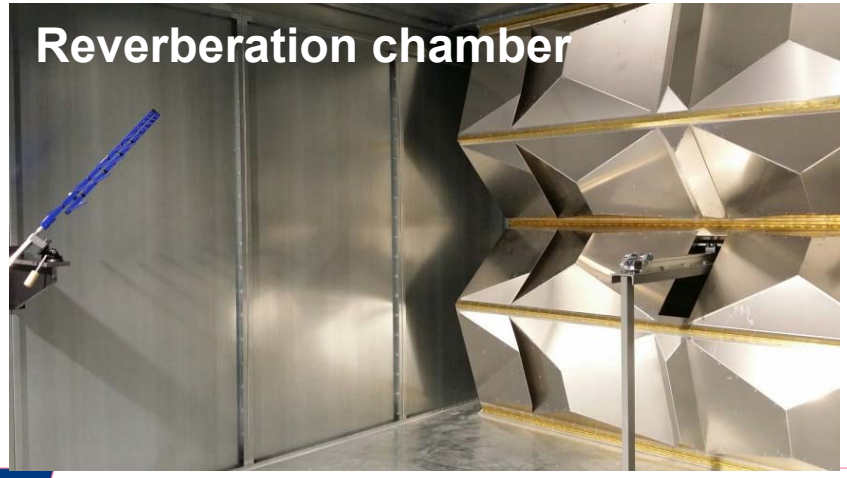
Pulsed power technology – 2/2

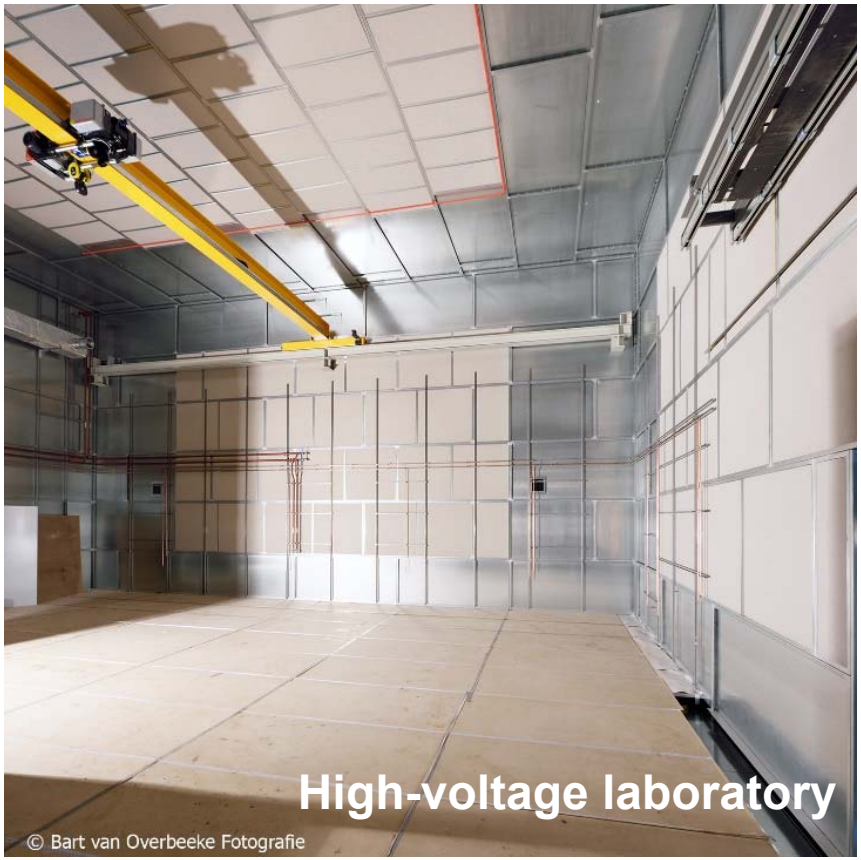
- 40% of world population would not have anything to eat without it
- State-of-the-art Haber-Bosch process:
  - 2 % of the total global energy consumption (7.8 EJ)
  - 300 million ton CO_2/year (3.2 %)
  - Best performance 29 GJ/tN

- Transient plasma assisted N_2 fixation:
  - Zero-emission of CO_2
  - Only air, water and (renewable) electricity
  - Eliminates use of fossil fuels
  - Estimated energy yield 20-30 GJ/tN
  - Decentral, on-site production



Electrical Energy Systems labs





Electrical Energy Systems – MSc courses

Specialization paths EES	ECTS	Quartile	Responsible lecturer
Planning and Operation of Power Systems (track 1)	5	Q2+Q3	Han Slootweg
Decentral Power Generation and Active Networks (track 1)	5	Q3	Phuong Nguyen
High Voltage Technology (track 2)	5	Q2	Peter Wouters
Electromagnetic Compatibility (EMC) (track 2)	5	Q3	Ramiro Serra
Electives	**ECTS**	**Quartile**	**Responsible Lecturer**
Protection and Automation of Distribution Networks	2,5	Q3	Johan Morren
Environment and Power Engineering	5	Q1-4	Bert van Heesch
Power Quality Phenomena	2,5	Q4	Sjef Cobben
Underground Power Cables	5	Q3	Fred Steenis
Smart Grid Operation through ICT	5	Q3+Q4	Rene Kamphuis
Pulsed Power Technology	5	Q3	Tom Huiskamp

Last 10 MSc thesis

Gang, M	Overvoltage and transformer overloading mitigation in LV distribution networks with High PV penetration
Gharda Derrian Tradewa, G.	Voltage profile analysis during network faults in hybrid multi-infeed HVDC system
Hunnekens, L.J.P	An algorithm for electrical energy cost minimization for agricultural farm loads in the Netherlands
Jin, J.	Realization of active harmonic mitigation function on power electronics converters for medium voltage network
Kazaras, S.V.	Optimal OLTC and inverter control in unbalanced distribution networks
Kuijsters, B.C.J.	Energy cost optimization in local smart grid with two level thermal energy storage
Li, Chengxi	Quantification of the electric field of dielectric barrier plasma
Li, T.	Recurrence plot method for characterization of condition related signals in low voltage underground power cables
Plackattu, T.	Simulations and detection of transients on a 150 kV high voltage AC cable
Scharrenberg, R	DC fault protection scheme in multi-terminal VSC-HVDC system

EE students *like* energy

- 2014: 21 (47)
- 2015: 25 (60)
- 2016: 33 (70) (incl. SET, Sense and Sel

- Ambition for coming 5 years
  - 150 MSc and PhD students in Elec