AI in the Energy Transition

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Current and Future energy systems

- Current Energy Systems (electricity)
  - Fossil ("gray") energy
  - Large power plants and many consumers
  - Plenty of gray energy, *always* available

Current and Future energy systems

- Future Energy Systems
  - Sustainable ("green") energy
  - Huge amounts of (small) generators and 'intensive' devices
    - Solar panels, wind turbines
    - Electric cars, heat pumps, data centers
    - Heat, cold, storage
  - Use plenty of energy *when* there is plenty of energy
    - Flexibility of users

Energy consumption and production

- Solar and wind (volatile production)
- Flexible consumption in time and space
  - E-vehicle charging
  - Supermarket cooling, home heating
  - Data centers
- Integrated energy systems
  - Electricity, hydrogen, heat

Energy consumption and production

- Solar and wind (volatile production)
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  - E-vehicle charging
  - Supermarket cooling, home heating
  - Data centers
- Integrated energy systems
  - Electricity, hydrogen H2, heat
- Infra-structure usage
  - Can be overloaded
  - Management & expansion
- Maintenance needed
  - Old(er) systems
- Users to be supported

NLAIC: AI as an Accelerator of the Energy Transition

Opportunities for a carbon-free energy system

Importance of AI for future energy systems (1)

- Support for strategic decision-makers
  - Electricity network expansion planning, scenario simulation, data analysis
- Management, operations and control of energy networks
  - Operations and control, congestion management, power flows, forecasting, sensing and data processing
- Managing supply, demand, and flexibility in energy systems
  - Decentralised markets, congestion management, forecasting, incentivizing

NLAIC: AI as an Accelerator of the Energy Transition
Opportunities for a carbon-free energy system

Importance of AI for future energy systems (2)

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- Supporting users in the energy system
  - Automated user support for local production and consumption, automated bidding in markets, participation in cooperatives, HCI
- Maintenance
  - Forecasting and scheduling in maintenance management of assets

and

- Energy-efficient AI
  - AI that is (co) optimised for using less energy

Future Energy and AI

- Artificial Intelligence
  - Data analysis
  - Learning systems
  - Forecasting
  - Optimization
  - Market mechanisms
  - Software agents
  - Smart user interfaces

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AI Opportunities and Needs for Energy Systems

- We ***do have*** several available tools and results in AI
  - Forecasting, optimization, (deep) learning techniques, agents
  - General techniques
  - Several dedicated approaches for AI in energy systems
- We ***don't*** have all the required (AI) technologies or best practices yet
  - For a stable and reliable energy system, efficiently used
  - Everywhere and always
  - Challenges: practical or fundamental
- ***All*** the topics need (further) research on AI in energy systems
  - For good/better/best practical application in energy systems
  - Every little last detail counts, especially for electricity systems
- We ***do*** have ***roadmaps*** and ideas how to get to a sustainable energy system
  - Many activities and results in research, development and deployment
- We ***will*** get in the future e.g.
  - Nearby expected results (e.g. improved t-prognoses, 1-4 year)
  - Longer-term expected results (e.g. decentralized market solutions, 4-8 years)

Some Topics Towards the Future

Decentralized Energy Markets and Flexibility

- Automated market mechanisms
  - For the many users in the energy system
  - Decentralized markets for supply/demand
  - Congestion markets and mechanisms
  - 1-to-1 contracting (P2P)

Stascade, ADREM,
HaPSISH, SES-BE, .. projects

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- AI-techniques and approaches
  - Market mechanism design (it does what you want, emergence, part of AI)
  - Software agents (software acting on behalf of users)
  - Learning techniques (learn the markets, the user(s) and, environment)
  - Simulation (experience market behaviour)

Stascade, ADREM,
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Decentralized Energy Markets and Flexibility

- Aspects
  - Incentivize flexibility
  - Handling uncertainty and risks
  - Service level agreements (SLAs, P2P)
  - Fairness by design
  - Multiple energy carriers (electricity, hydrogen H2, heat,..): system integration

Stascade, ADREM,
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Optimal Use of Electricity Networks

- Optimal usage of the capacity of the transmission (HV) network
- T-prognoses: expected supply/demand of electricity to be transported
  - Better t-prognoses increase the *available* network capacity
- AI techniques for forecasting
  - At connection points of transmission network
  - Research on improvement; diversity of fuels, reactive power, dynamic pricing, …
  - For DSOs and big actors,…

AIFES PoC project

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- Reduce bottlenecks in the network: currently urgent
  - Companies have to wait 8-10 years for connections…
- Proof-of-Concept project at NLAIC/AINED: AIFES

AIFES PoC project

AI and ICT Themselves..

- AI uses energy itself
  - More AI demands more energy
  - Learning techniques that are energy efficient
    - Spiking neural networks
  - AI can reduce energy usage elsewhere

- Data centres and energy
  - Energy-efficient computation and data handling by AI
  - Providing energy flexibility in time or place
  - Dynamic pricing for carrying out computing/data tasks

Some Final Thoughts/Teasers

- Data is important for much AI, but
  - See what and how much data is actually needed
    - Not: the more the better; but what is sufficient/needed, or use it smartly
  - Trade-off between aspects of data sharing:
    privacy and business intelligence vs. effectiveness

- In, say, 50 years, energy resources will be abundantly available
  - Sufficient solar and wind (PV, wind turbines)
  - The issue will be the usage of the electricity network (transportation, distribution), storage, and balancing/management
  - We still need AI

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Conclusion

- AI is important in current and future energy systems
- We are well underway, and, at the same time, still have a way to go
  - Fascinating area of research, development and deployment!

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Thank you!

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