SPOTLIGHT ON AI:

Is AI the silver bullet to accelerate the clean energy transition?

Barry Hayes (University College Cork)

Energy Transition Summit 2024

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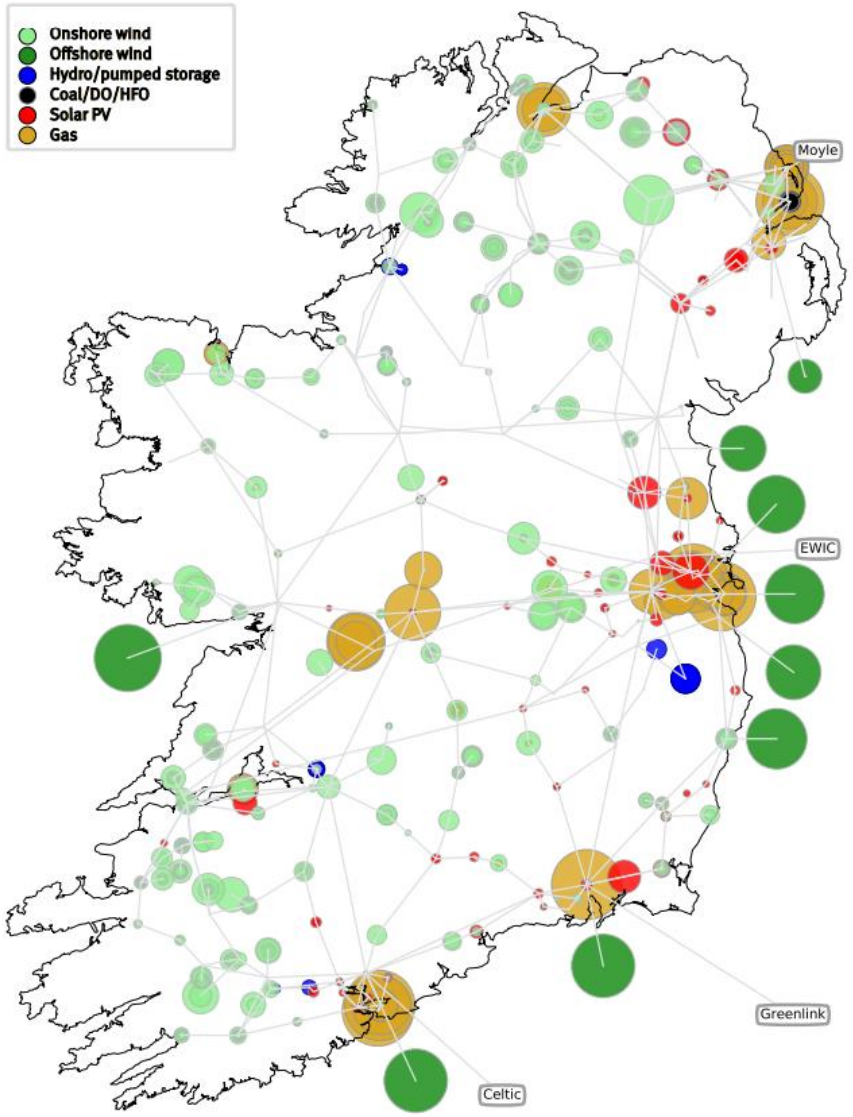
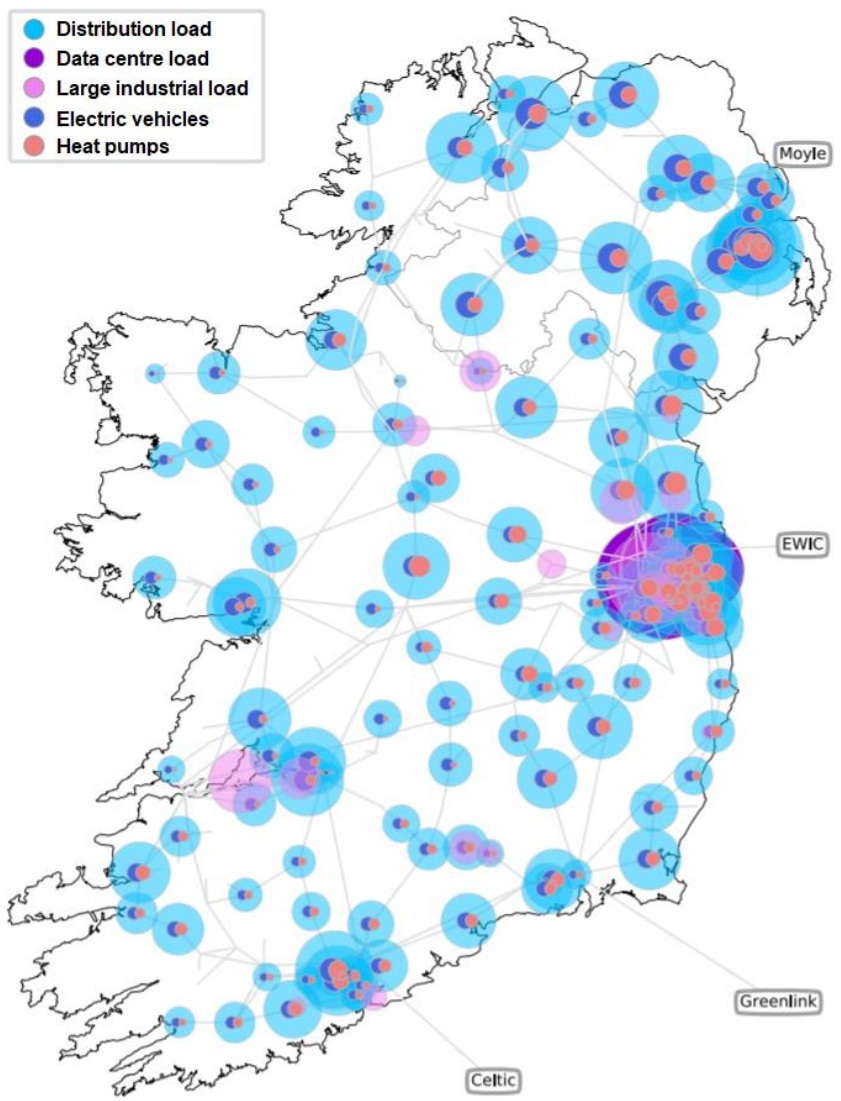
Energy Transition and the Grid





Projected spatial generation (right) and demand (right) in Ireland [Source: EirGrid]

Can AI Help?

- Dealing with huge volumes of data, complexity, uncertainty…
- Faster and more accurate computations…
- Data-driven control of 1,000,000s of energy devices in real-time?

But…

Can we trust AI with a critical infrastructure such as the electricity grid?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"Evil" Bill Gray
RESCUE
AFRL
In-Flight Simulator

A Brief History…

AI in power/energy applications is not a new idea:

- Demand forecasting (*e.g., ANN-STLF used by ERCOT in 1992*).
- Weather forecasting
- Electricity price forecasting
- Predictive maintenance

[Source: European Centre for Medium-Range Weather Forecasts]

EU AI Act

The EU AI Act (2024) defines an “AI system” as:

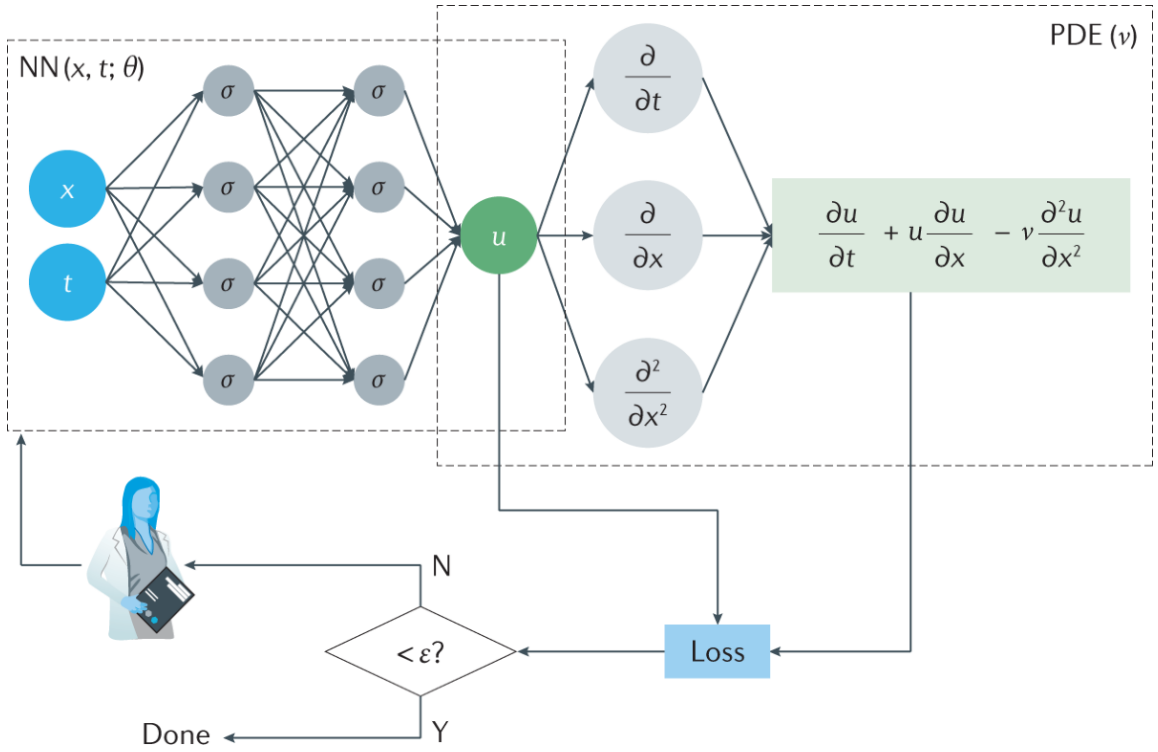
*“…**a machine-based system designed to operate with varying levels of autonomy** … may exhibit adaptiveness after deployment … infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or **decisions that can influence physical or virtual environments**.”*

EU AI Act

"… *AI systems falling into specific areas that will have to be registered in an EU database:*
1) Management and operation of critical infrastructure …"

- "Conformity Assessment" is required.
- Mandatory regulations for **Trustworthy AI** (e.g., data quality, documentation and traceability, transparency, human oversight, accuracy).

Current Research



G. Karniadakis et. al., “Physics-informed machine learning”, *Nature Reviews Physics* (2021)

Physics-Informed Neural Networks for Power Systems

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***Abstract*—This paper introduces for the first time, to our knowledge, a framework for physics-informed neural networks in power system applications. Exploiting the underlying physical laws governing power systems, and inspired by recent developments in the field of machine learning, this paper proposes a neural network training procedure that can make use of the wide range of mathematical models describing power system behavior, both in steady-state and in dynamics. Physics-informed neural networks require substantially less training data and can result in simpler neural network structures, while achieving high accuracy. This work unlocks a range of opportunities in power systems, being able to determine dynamic states, such as rotor angles and frequency, and uncertain parameters such as inertia and damping at a fraction of the computational time required by conventional methods. This paper focuses on introducing the framework and showcases its potential using a single-machine infinite bus system as a guiding example. Physics-informed neural networks are shown to accurately determine rotor angle and frequency up to *87 times faster* than conventional methods.**

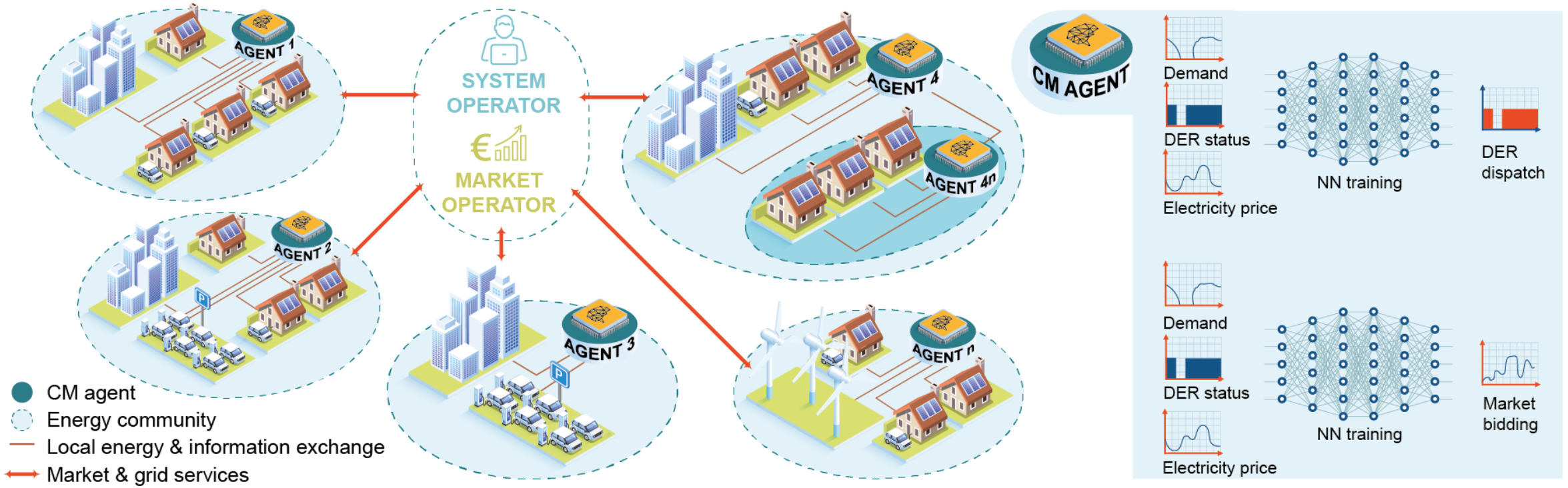
inside the training procedure. Exploiting advances in automatic differentiation [11] that are implemented in Tensorflow [12], we can directly compute derivatives of neural network outputs during training, such as the rotor angle, and build neural networks able to accurately capture the rotor angle and frequency dynamics. Our approach (i) requires less initial training data, (ii) can result to smaller neural networks, while (iii) demonstrating high performance.

Physics-informed neural networks introduce a novel technology that may lead to a new class of numerical solvers [10] as well as dynamic state estimation techniques [13]. Within power systems, they have the potential to solve systems of differential-algebraic equations at a fraction of computational time required for conventional methods, are able to directly determine the value of state variables at any time instant t_1 (without the need to integrate from t_0 to t_1), and can handle

G. Misyris, A. Venzke, S. Chatzivasileiadis, “Physics-informed neural networks for power systems” *Proceedings of IEEE Power Energy Society General Meeting* (2020)

Current Research

AUTONOMY



Overview of the autonomous community energy manager concept and market/grid interactions.

“Smart Grid” vs. “Strong Grid”

Lack of ambition and attention risks making electricity grids the weak link in clean energy transitions

News
17 October 2023

First-of-its-kind global study finds the world must add or replace 80 million km of grids by 2040, equal to all grids globally today, to meet national climate targets and support energy security

Main Takeaways

Huge potential for AI in power and energy (e.g., orchestrating of vast numbers of highly-distributed energy resources)

But….

- *How to make it safe, reliable, trustworthy?*
- *Need to ensure that benefits are accessible for individuals and communities*
- *We need to have a “strong grid” before we can have a “smart grid”*

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Go raibh maith agaibh
Thank you

For more info visit:
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