

SMART Grid Research Data

PANTERA Nano-Workshop

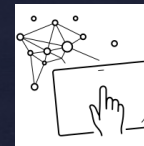
22nd February 2021 (14:00-15:30 GMT)



Prof. Eleni Mangina
School of Computer Science



Why Machine Learning needs data
to unlock the potential of Smart
Grids.



<https://people.ucd.ie/eleni.mangina/>
eleni.mangina@ucd.ie



How Big Data Analytics is Disrupting the Energy Industry

- **Big Data and Energy Utility Industry**
- **Big Data and Energy Management on the Demand side**
- **Big Data and Cheaper Energy**

Big Data analytics is driving down the cost of power generation and consumption!

Smart Grid Analytics: Why?

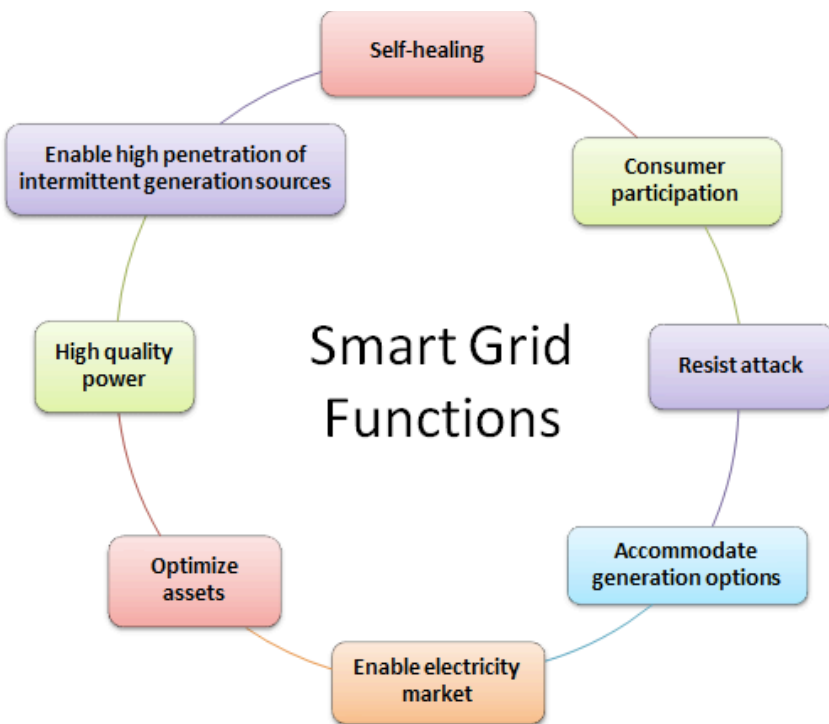
Exponential growth of data sources

- Smart network devices trigger actions that minimize or avoid power outages.
- Smart home appliances and HVAC systems keep consumers comfortable at lower cost, with no human intervention.
- Smart power generation systems optimize cost and efficiency utilising renewables, microgrids, batteries and traditional sources.

**IoT &
Smart Grid
Analytics:
an impactful
synergy**

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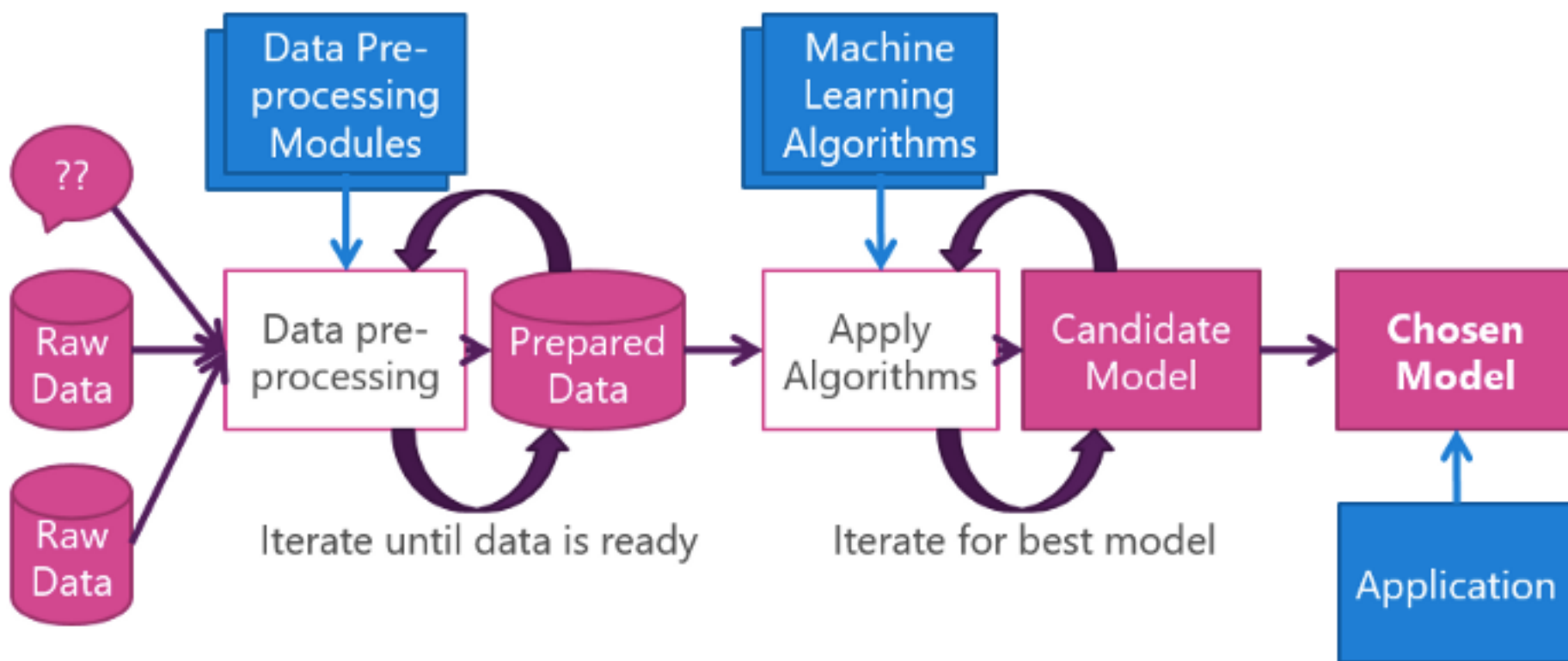
Machine Learning: Can it create a.. Smarter grid?



- Unlocking and utilising flexibility from the demand of power consumption (grid balance)
- Minimise consumer energy costs
- Optimisation techniques and forecasting based on Big Data availability
- **Data... Data...**

The Machine Learning Pipeline

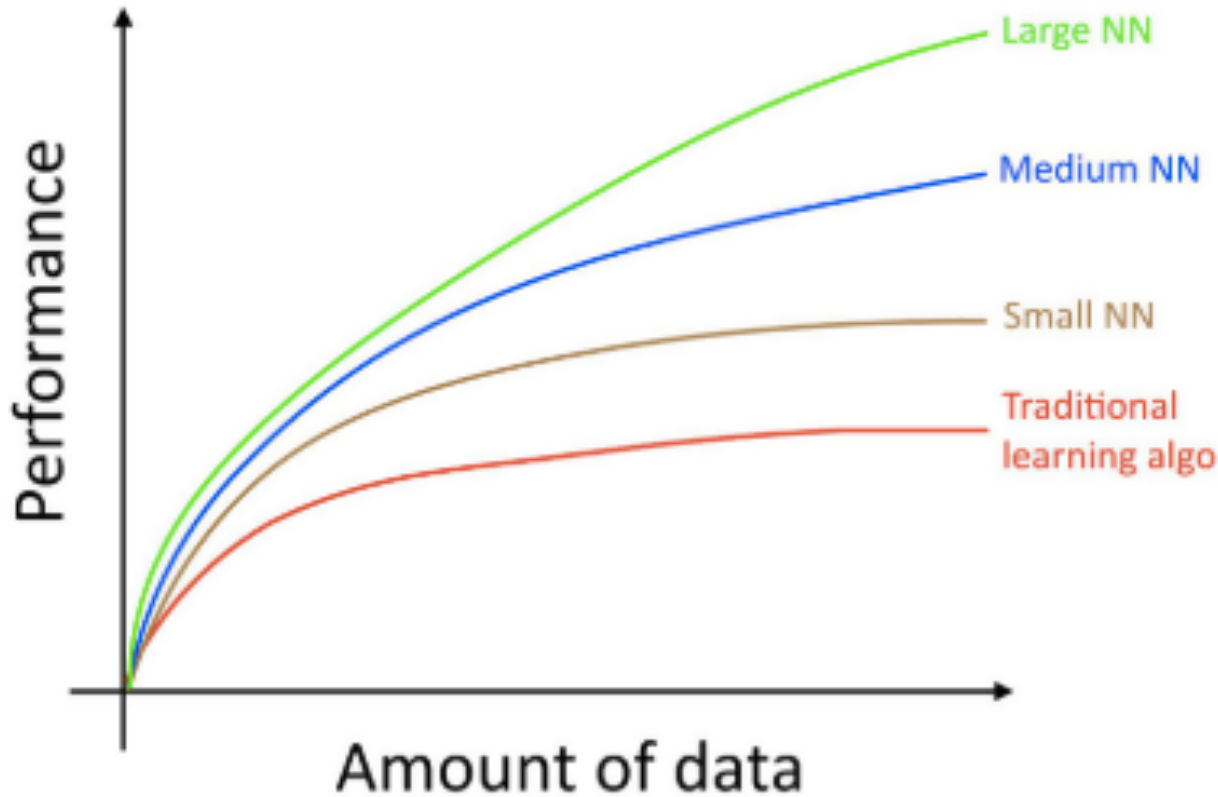
Why data is important..



Data Engineering in the Machine Learning Pipeline

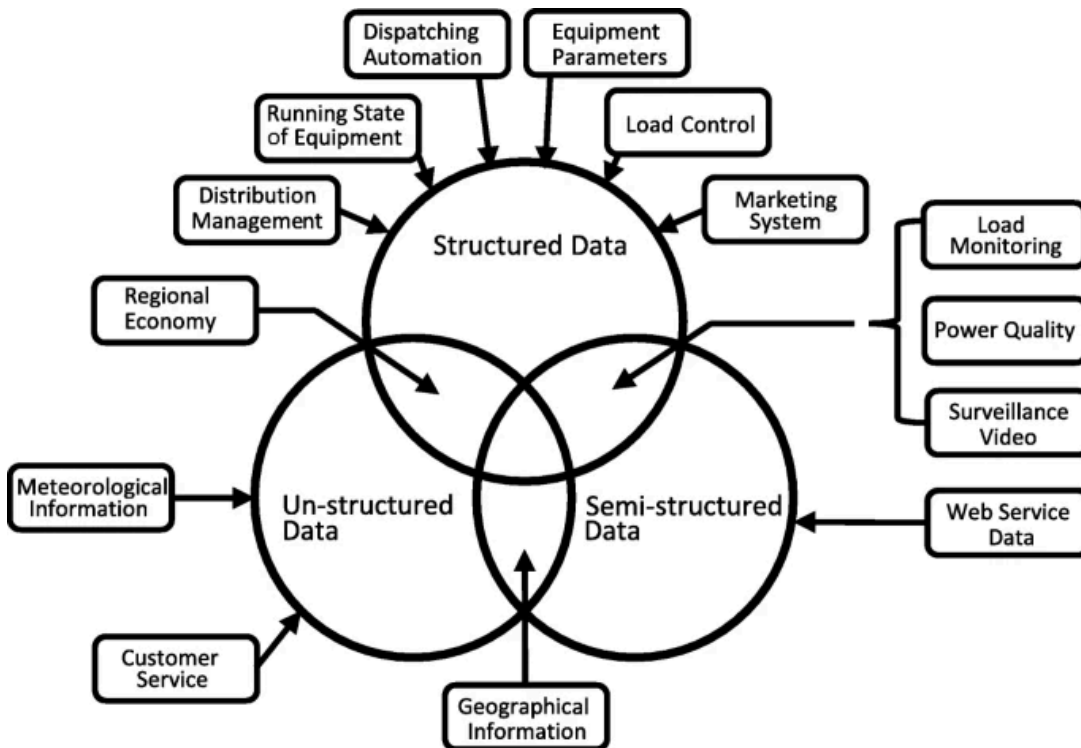
<https://medium.com/kansas-city-machine-learning-artificial-intelligence/importance-of-data-engineers-ddf1ffa4dc86>

Big Data... Is there a magic number?



Big Data in the Smart Grid

- Data Collection techniques
- Data Communication
- DATA ANALYSIS



Data Sources in Smart Grids

Zhang et al., Big data analytics in smart grids: a review,
<https://doi.org/10.1186/s42162-018-0007-5>

Review: Applications of Big Data Analytics in Smart Grid

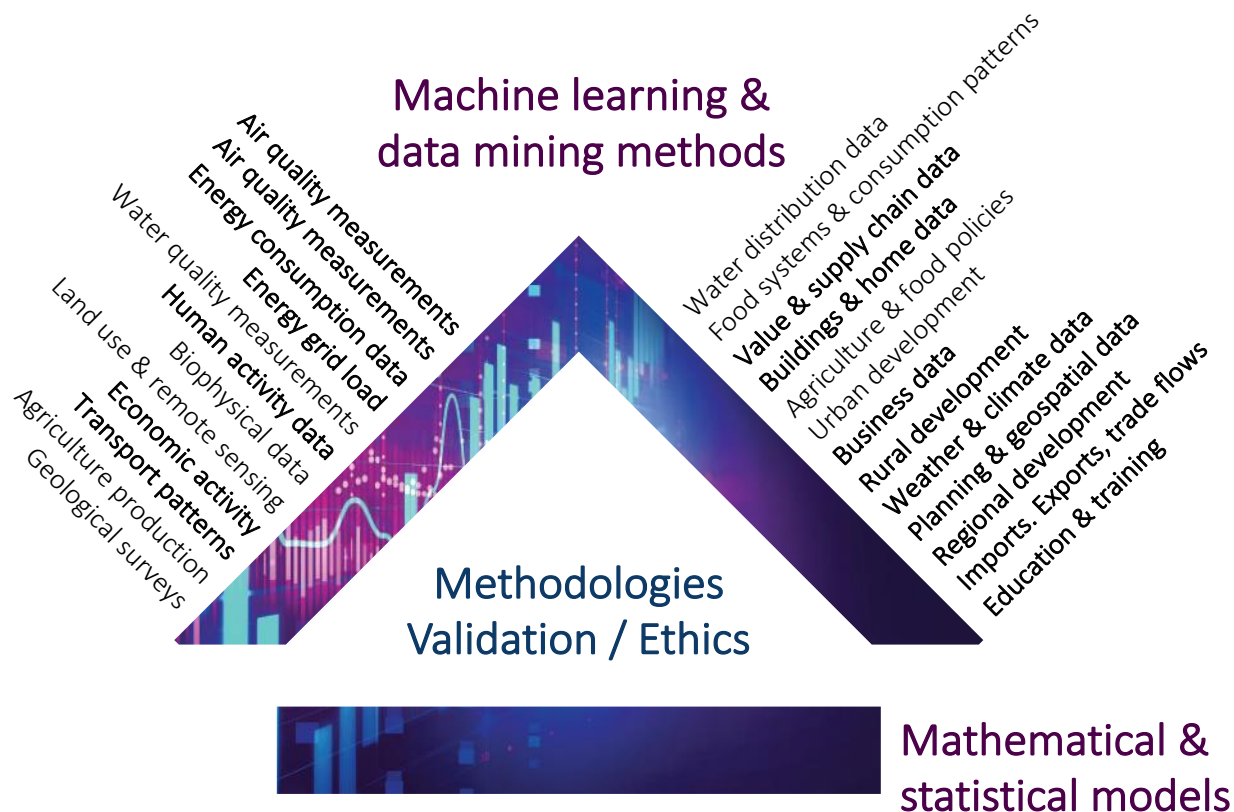
- Fault detection
- Predictive maintenance/condition based maintenance
- Transient stability analysis
- Electric device state estimation/health monitoring
- Power quality monitoring
- Topology identification
- Renewable energy forecasting
- Load forecasting
- Load profiling
- Load disaggregation
- Non-technical loss detection

While data is important for unlocking the Smart Grid potential... what are the difficulties?

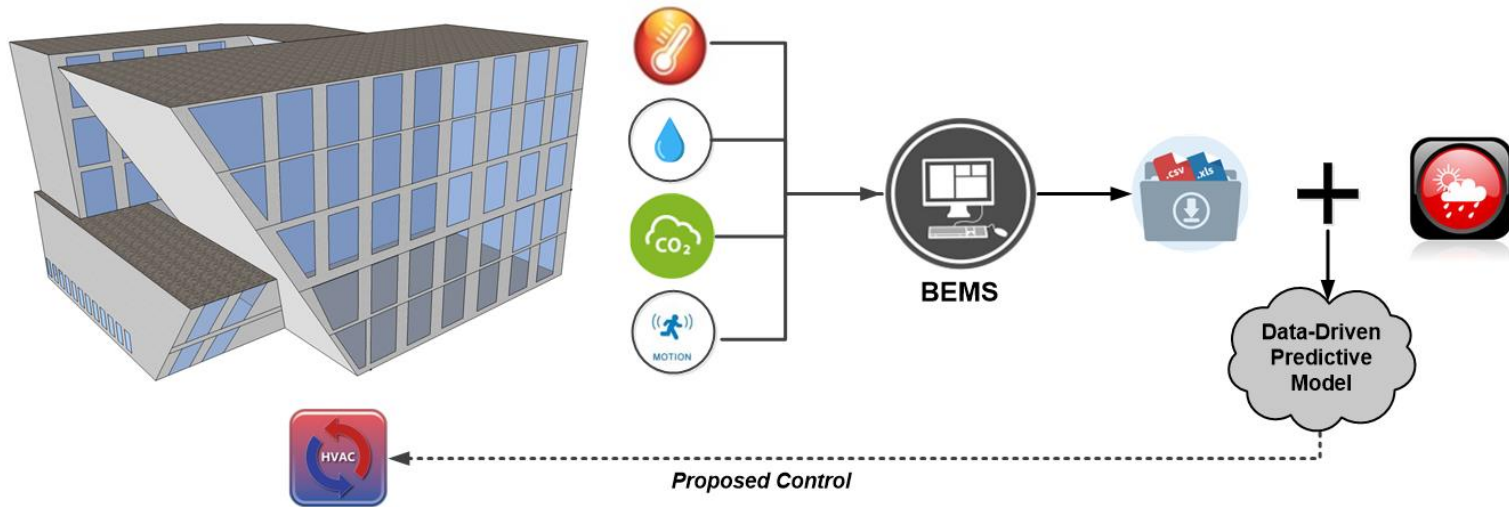
- Big data with multiple types and structures from plethora of sources
- Lack of standard data format for the information software and database structures
- Interoperability of different information and communication systems deployed in the smart grids
- Lack of data sharing among applications due to isolated storage of the databases in various
- Confidential datasets create barrier to researchers
- Synergy is required: Computer Science and energy systems experts.

Challenge-driven data analytics

Data Science for the Power sector – an impactful synergy

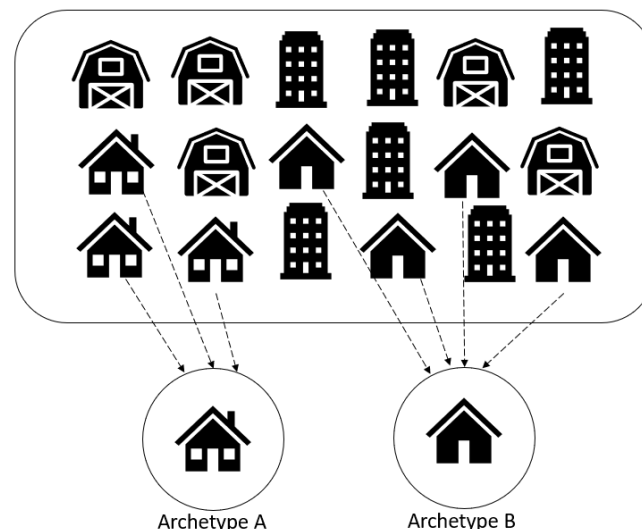
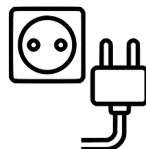


Case Study: Data Driven Predictive Models for Commercial Buildings



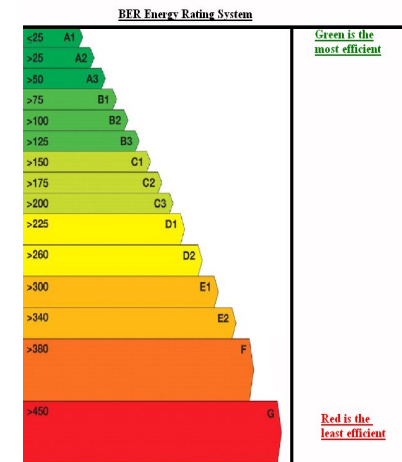
Case Study: Building archetypes for urban energy modelling

- Building-types that represent similar technical, operational and geometrical characteristics of a large group of buildings
- Energy modelling for urban scale is a **complex task** and requires a lot of extensive data.
- Urban Building Energy Modelling (UBEM) involves segmenting a building stock into archetypes.



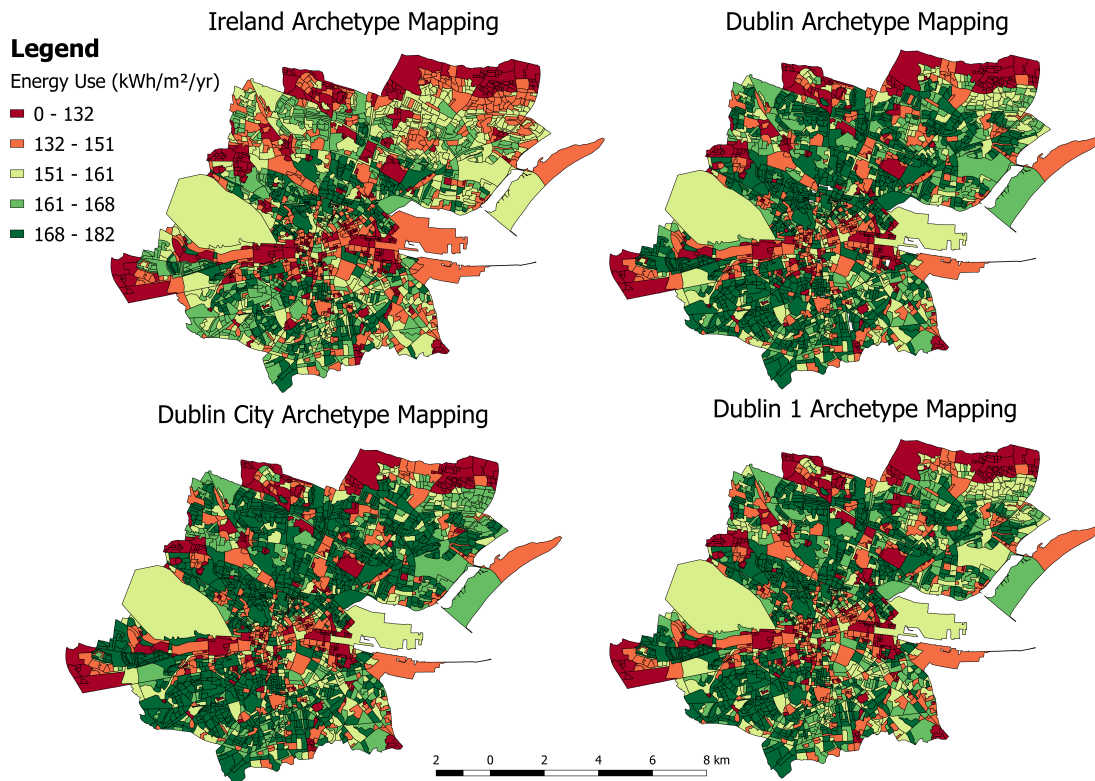
Case Study: Building archetypes for urban energy modelling

- Existing Projects:
 - TABULA** -Typology Approach for Building Stock Energy Assessment
 - ASIEPI** - Assessment and improvement of the EPBD Impact
 - BPIE** (Buildings Performance Institute Europe)
- National Level archetypes.
- Lack of local level building details
- Absence of generalized method.
- Irish Energy Performance Certificate (EPC).
- 600,000 Irish buildings'** data with **203 variables**.
- The city of Dublin, which contains more than **200,000 buildings**.
- Levels
 - National -> Ireland
 - City -> Dublin,
 - Local Authorities -> Dublin City
 - Districts -> Dublin 1



Dwelling Type	Buildings	Percentage
Semi-detached house	48863	↑ 24.15%
Mid-terrace house	40257	↑ 19.90%
Mid-floor apartment	31142	→ 15.39%
End of terrace house	19767	→ 9.77%
Ground-floor apartment	19124	→ 9.45%
Top-floor apartment	18735	→ 9.26%
Detached house	15553	↓ 7.69%
House	3344	↓ 1.65%
Maisonette	3086	↓ 1.53%
Apartment	2309	↓ 1.14%
Basement Dwelling	110	↓ 0.05%

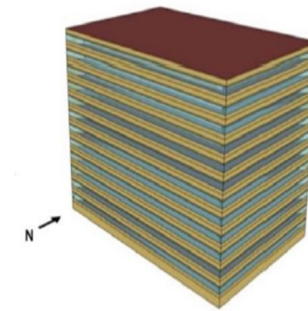
GIS Map of Dublin City Energy Use by using Year of Construction Segmentation (Semi Detached)



- **Generalized methodology** to develop archetypes of different dwelling types
- This will assist the local authorities, city planners and energy policymakers to analyse **granular level** building energy efficiency.
- The test case based on the available building stock data (EPC) of Ireland.
- The results indicate that archetypes developed at the **national level** do not produce accurate modelling results when used at the **local level**.
- The selection of an archetype level introduces **significant differences** in the calculated values of energy consumption and emissions.
- Further work would be utilising more **detailed building physics** and **quantification data**.

Harnessing energy flexibility from commercial buildings

- Lack of on-line real-life control test-bed to test advanced data-driven control strategies¹
- Developed virtual simulation test-bed for synthetic data creation and closed-loop deployment of controllers
- Limited testing with real-data from NUIG Alice Perry Building (supplied by the IRUSE³ group)
- Building Data Genome Project 2 – open data set of 3,053 energy meters²



1. Anjukan Kathirgamanathan, Mattia De Rosa, Eleni Mangina, Donal P. Finn (2020) Data-driven predictive control for unlocking building energy flexibility: A review, Renewable and Sustainable Energy Reviews, DOI: 10.1016/j.rser.2020.110120
2. Miller, C., Kathirgamanathan, A., Picchetti, B. *et al.* The Building Data Genome Project 2, energy meter data from the ASHRAE Great Energy Predictor III competition. *Sci Data* 7, 368 (2020). <https://doi.org/10.1038/s41597-020-00712-x>
3. IRUSE: Informatics Research Unit for Sustainable Engineering <http://www.iruse.ie/#>



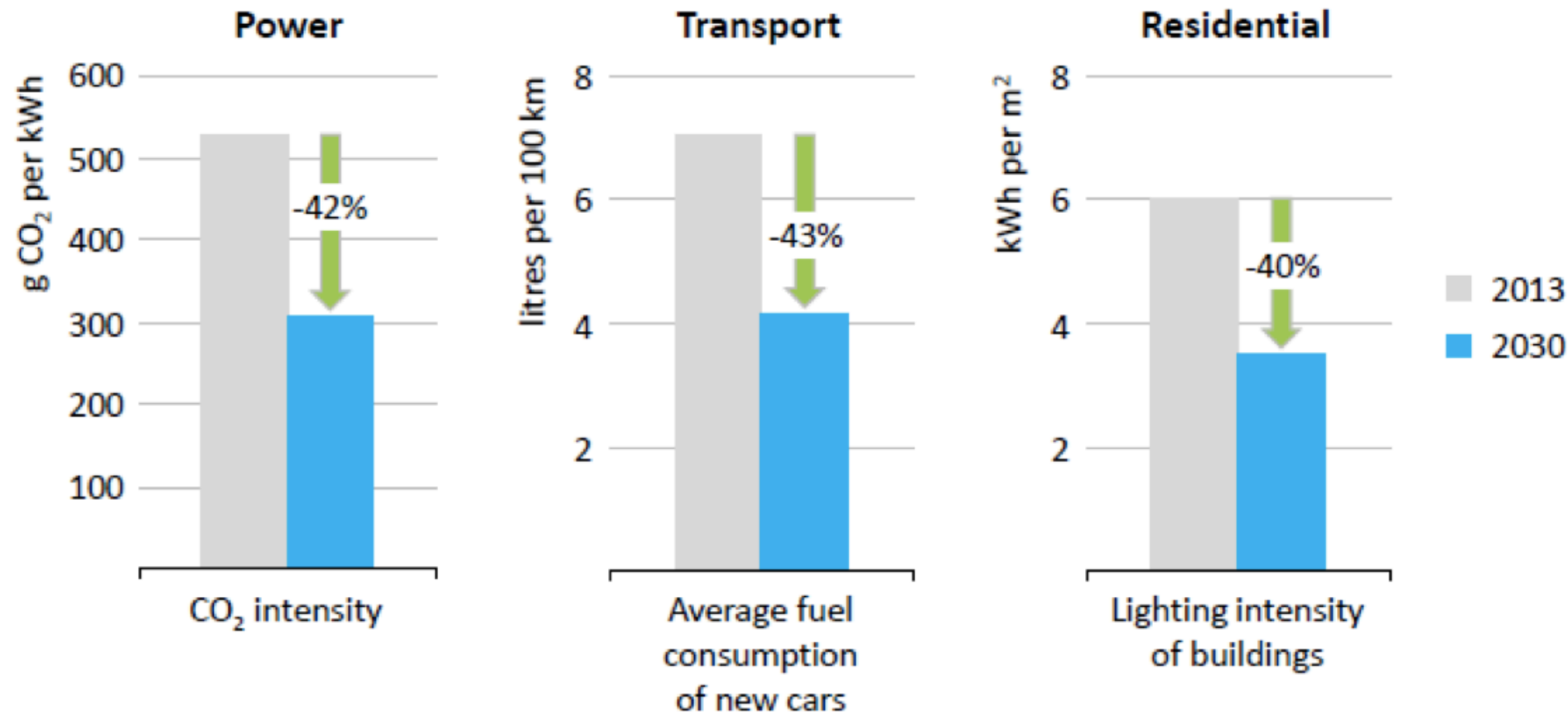
BUILDING DATA
Genome Project



THE CITYLEARN CHALLENGE
MULTI-AGENT REINFORCEMENT LEARNING FOR
INTELLIGENT ENERGY MANAGEMENT

The bigger picture...

Smart grid can provide progress required in all areas...



International Energy Agency World Energy Outlook, identified key metrics to monitor energy sector improvements (2016)



UCD
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INSTITUTE



Our Vision... Turning Big Data into Insight What a smart city looks like...

- Smart Data
- Smart Transportation
- Smart Energy
- Smart Infrastructure
- Smart IoT



Image source:

<https://enterpriseiotinsights.com/20171006/smart-cities/smart-city-connectivity-sigfox-vs-lora-tag99>