KU LEUVEN

A day in a sustainable life.

From data to decision-making: decarbonizing electricity demand.

Hussain Kazmi, PhD
Attila Balint
Jolien Despeghel

Meet π

Lives in the UK

Concerned about the environment

Already takes public transport to work, but would like to live even more sustainably

Unsplash.com

Enter the built environment

During construction phase
Building materials and source
Building type (standalone, apartment, …)

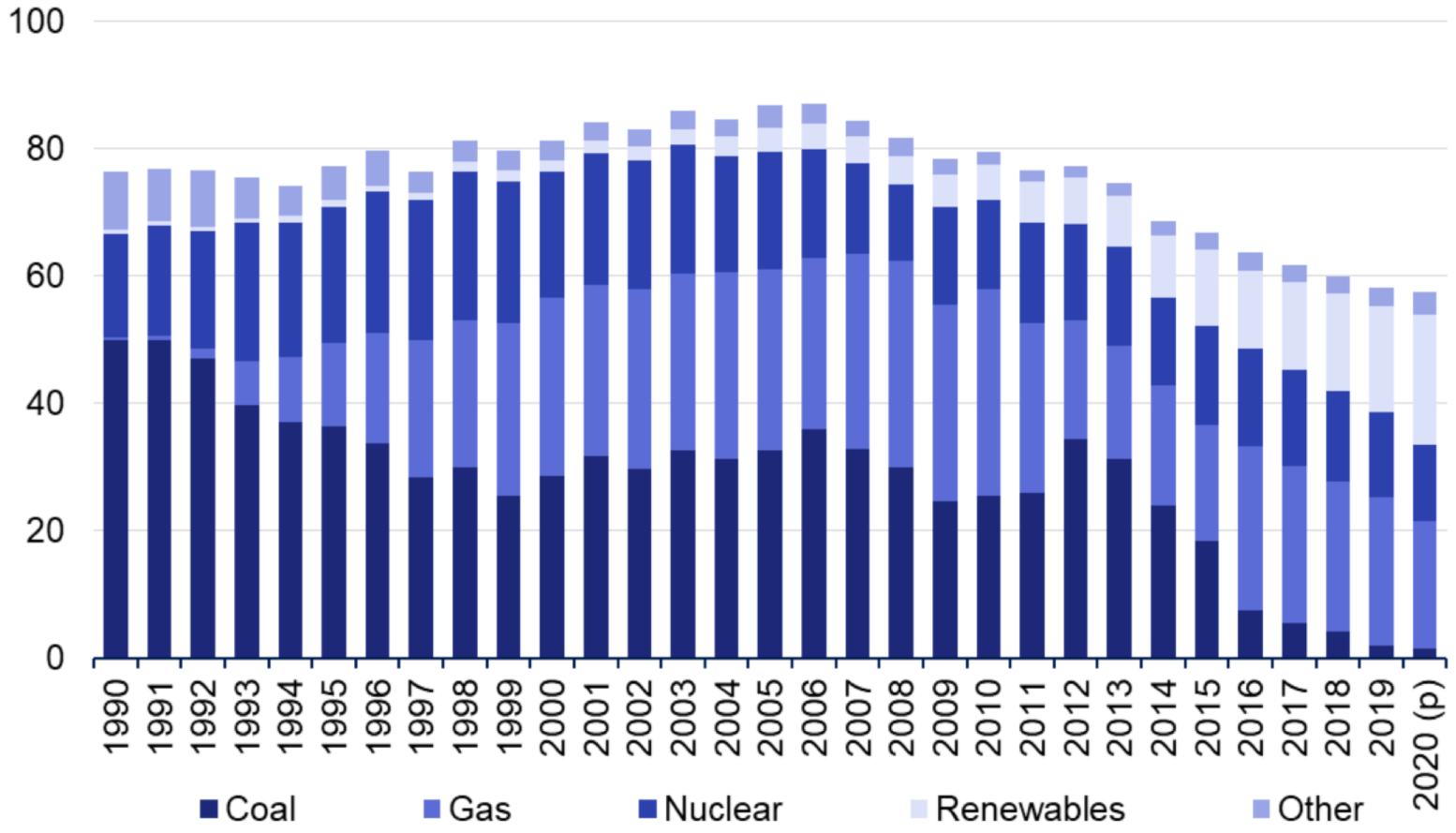
±50 tons of embodied CO_2

During operation phase
Weather conditions (geography)
Building and installation properties
Occupant behavior

±2.5 tons of operational CO_2 / year
100+ tons over lifetime

Unsplash.com
https://citu.co.uk/citu-live/what-is-the-carbon-footprint-of-a-house

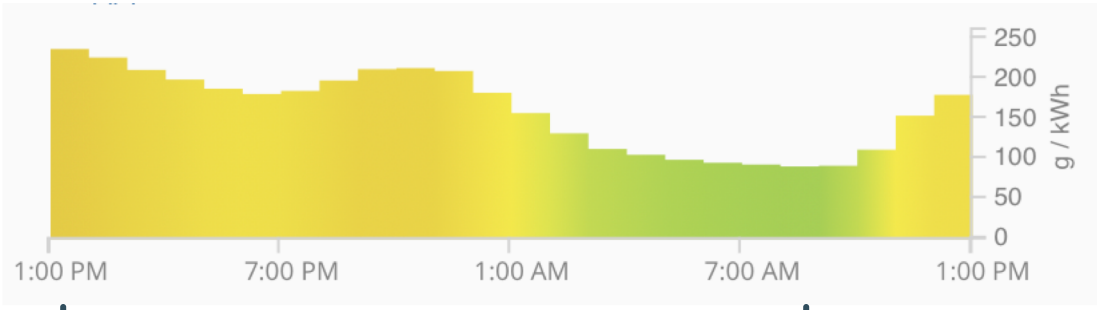
Electricity source mix



2020 UK greenhouse gas emissions, provisional figures, National Statistics

Carbon intensity of electricity mix

Situation on 27th October, 2021

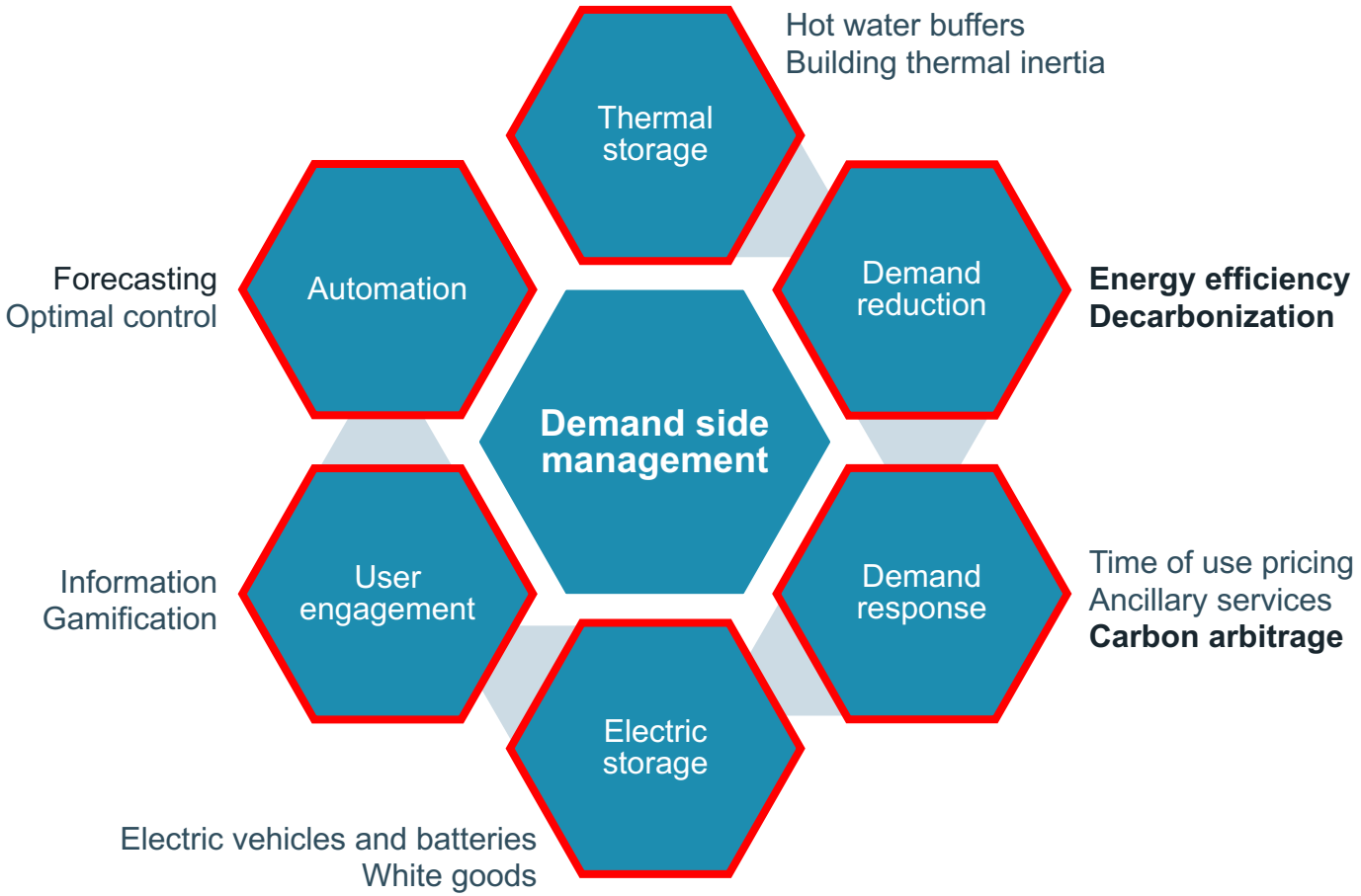


A lot more natural gas
Overall: ±240 g CO_2

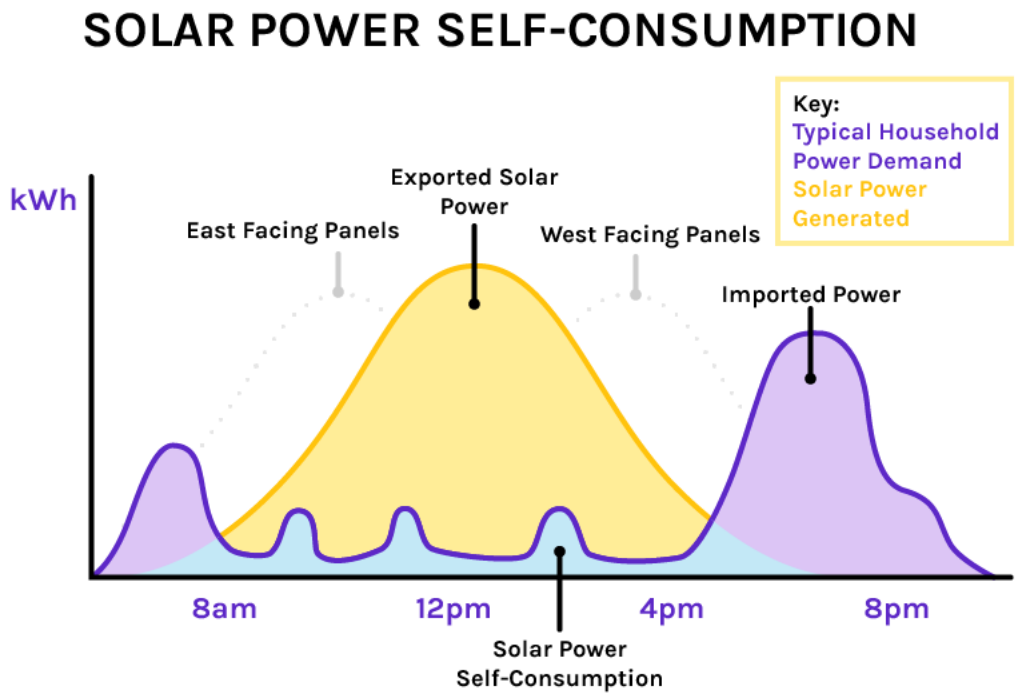
Mostly renewables via wind
Overall: ±85 g CO_2

https://app.electricitymap.org/zone/GB

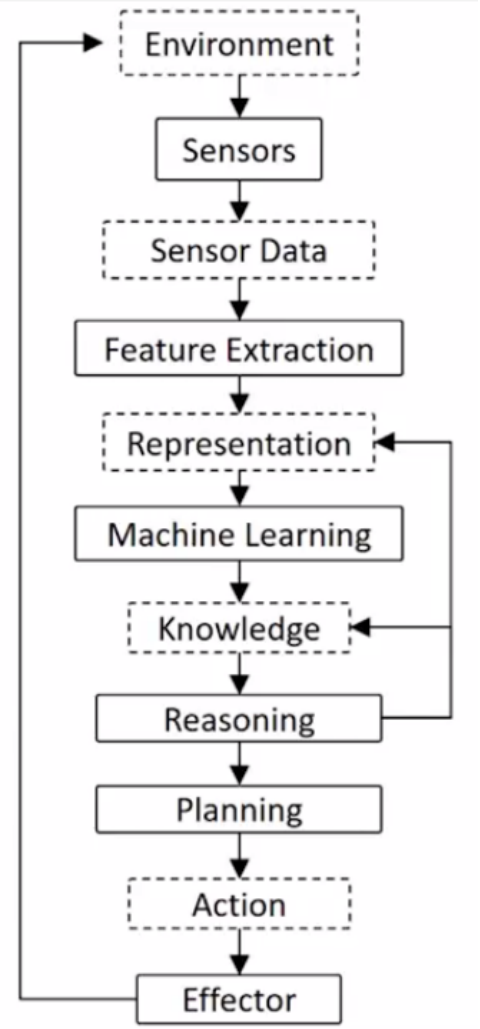
Demand side management



Self-consumption



The data pipeline



Electricity, meteo and meta-data, …

Create a (forecast) model for (controllable and non-controllable) demand based on historical data and exogenous variables (ambient conditions, meta-data etc.)

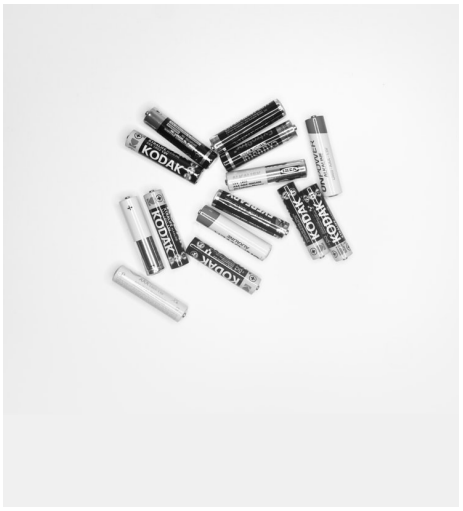
Obtain (create?) forecasts for price signal (i.e. carbon intensity)

Use the forecasts to create an optimal plan for the future that maximizes an objective while satisfying predefined constraints

Elements of the optimization

Household electricity demand

Grid electricity supply (carbon intensity)



Household electric storage (flexibility)

Unsplash.com

Constrained optimization

Minimize some costs

subject to some constraints

by changing variable, x

How to decarbonize

Control variable

Objective Minimize $\sum_{N_h}(p_{el}.P_{\mathrm{g}})$

Constraints subject to

$$\frac{dE_{\mathrm{b}}}{dt} = P_{\mathrm{b}}$$

$$E_{\mathrm{b}} < E_{max}$$

$$-P_{max} \leq P_{\mathrm{b}} \leq P_{max}$$

$$P_{\mathrm{g}} = P_{\mathrm{b}} + P_{\mathrm{c}}$$

Different approaches

- Random guessing / grid search
  - Pros: ???
  - Cons: Bound to fail for long time horizons (high dimensionality)

Different approaches

- Random guessing / grid search
  - Pros: ???
  - Cons: Bound to fail for long time horizons (high dimensionality)
- Derivative-free optimization
  - Pros: Applicable in almost any setting, may result in near-optimal solution
  - Cons: Requires lots of (recurring) computation, no guarantees

Different approaches

- Random guessing / grid search
  - Pros: ???
  - Cons: Bound to fail for long time horizons (high dimensionality)
- Derivative-free optimization
  - Pros: Applicable in almost any setting, may result in near-optimal solution
  - Cons: Requires lots of (recurring) computation, no guarantees
- Convex optimization
  - Pros: Accurate and fast
  - Cons: May be infeasible with complex models or require convexification

Other considerations

- Forecasts for electricity demand and carbon intensity?
- Actual control of the battery
- Dimensioning the battery
- Local generation with solar PV
- …