Virtual Smart Assets (Phase 1)

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Outline

• Background
• Process
• Result
• Future work (next Phase)
Background

• Big changes in energy consumption and generators.
• Quantify the power consumed in UK.
• Translate calculation formula into code (python).
• Analyze carbon footprint, and the resultant and carbon emission per energy use in the electricity.
• Obtain trends, conclusions and future suggestions.
• Develop a website interface (next Phase).
Background-Dataset

- Source:
  Elexon (subsidiary of UK National Grid)

- 2011-2022
  UK Power generation/demand energy dataset

- Types of generation:
  - Common generator
    Coal, solar, wind, hydro, pumped
  - Uncommon generator
    Nuclear, CCGT, OCGT
Background - Basic analysis

• For coal
  Daily & Yearly diagrams
  Figure out outliers
  Analyse trend
  Get conclusions

• For other generator
  Clean generator
Process-carbon emission computation

- **CO$_2$ emission** ($\mathcal{E}$) is estimated using life-cycle assessments with units kilogramCO$_2$ (kgCO2),

$$
\mathcal{E} = \sum_{t=1}^{N_t} E(t) \times C(t),
$$

$E =$ amount of energy generated/consumed (kWh),

$C(t) =$ **CO$_2$ intensity** based on the averaged fuel-mixed used for generation,

$t =$time step and $N_t$ is the total number of time steps.

$C(t)$ is estimated as:

$$
C(t) = \frac{\sum_{m=1}^{M} (C_m \times E_g(t))}{\sum_{m=1}^{M} E_g(t)},
$$

$E_g =$ amount of energy generated/consumed (kWh).

$C_m =$ **CO$_2$ intensity** based on the $m$ number of fuel-mixed used for generation,

$t =$time step.

Process—carbon emission computation

Example: CO$_2$ intensity across different generation fuels

<table>
<thead>
<tr>
<th>Types of energy</th>
<th>Carbon factors (gCO$_2$/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>700</td>
</tr>
<tr>
<td>Coal</td>
<td>990</td>
</tr>
<tr>
<td>Gas</td>
<td>488</td>
</tr>
<tr>
<td>Nuclear</td>
<td>26</td>
</tr>
<tr>
<td>Wind</td>
<td>96</td>
</tr>
<tr>
<td>Hydro</td>
<td>13</td>
</tr>
</tbody>
</table>
Result

For example:

• Assuming that the power consumption of a Macbook is 61W, and a user is using the Macbook continuously (unplugged) for 8 hours.

• The CO$_2$ emission from the Macbook is therefore (assuming the averaged CO$_2$ intensity is 0.35kgCO$_2$/kWh):

  \[
  61 \div 1000 \times 0.35 \times 8 \approx 0.17 \text{ kgCO}_2
  \]

• User can clearly see how much carbon is consumed when using an electrical product
Phase 1 Result

Yearly Carbon Emission Fuel Mix Percentage in 2014
Phase 1 Result

Yearly Carbon Emission Fuel Mix Percentage in **2020** (COVID)
Phase 1 Result

Average UK Electricity Carbon Intensity

2014

2019

Average Carbon Intensity of 2019
Result - Yearly Carbon Percentage (analysis)

• In 2014, **COALS** take a highest percentage of yearly carbon fuel mixes.

• The UK government urged for a gradual halt to coal power generation.

• CCGT gradually replaced coal power generation and became the main energy source.

• So, CCGT take a high percentage of yearly carbon after 2019.
Result - Difference between 2014 & 2019

• The overall level of carbon intensity is lower:

• The differences between seasons are smaller
Future work (next Phase)

- User-friendly
- Easy to understand
- Integrated
- Automatic
- Climate change awareness

Interface

Example of website Interface