Speyside P2G Project

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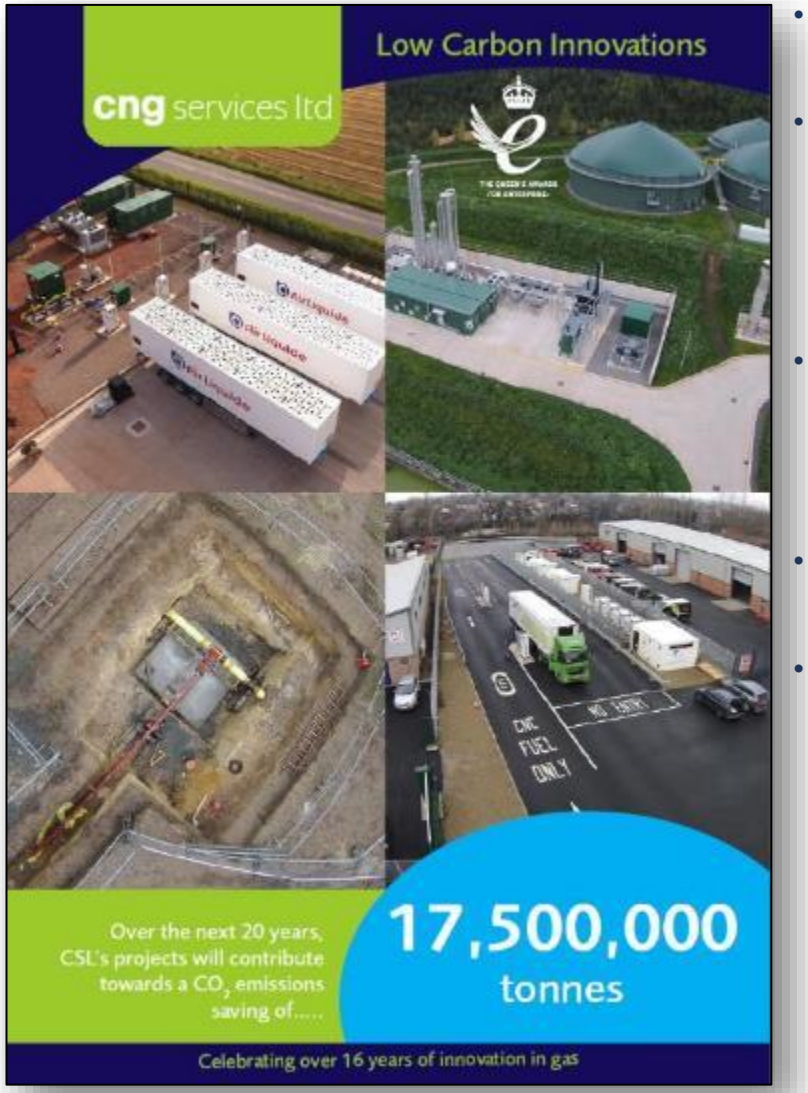

- CNG Services Limited (CSL) provides consultancy, design and build services to the biomethane industry, all focused on reducing Greenhouse Gas (GHG) emissions.
- In the past 10 years our efforts have produced a material impact with an estimated 20 year project life reduction in CO_2 emissions of 17,500,000 tonnes through:
  - Biomethane injection into the gas grid
  - Running trucks on Bio-CNG
  - Acting as developer and design and build contractor for the Highlands Bio-CNG Project
- Part owner of CNG Fuels Ltd, a company set up to build a national network of Bio-CNG stations on the high pressure grid
  - National network of CNG Stations
  - 84% saving in GHG compared to diesel
- Part owner of Barrow Shipping Ltd, GB's leading shipper of biomethane and a company that only buys and sells biomethane, no fossil gas
- CSL is an ISO 9001, 14001 and 45001 approved company and has also achieved Achilles certification. CSL is GIRS accredited for design and project management and has been certified as a competent design authority by DNVGL

Certificate Number 17464
ISO 9001
ISO 14001
ISO 45001

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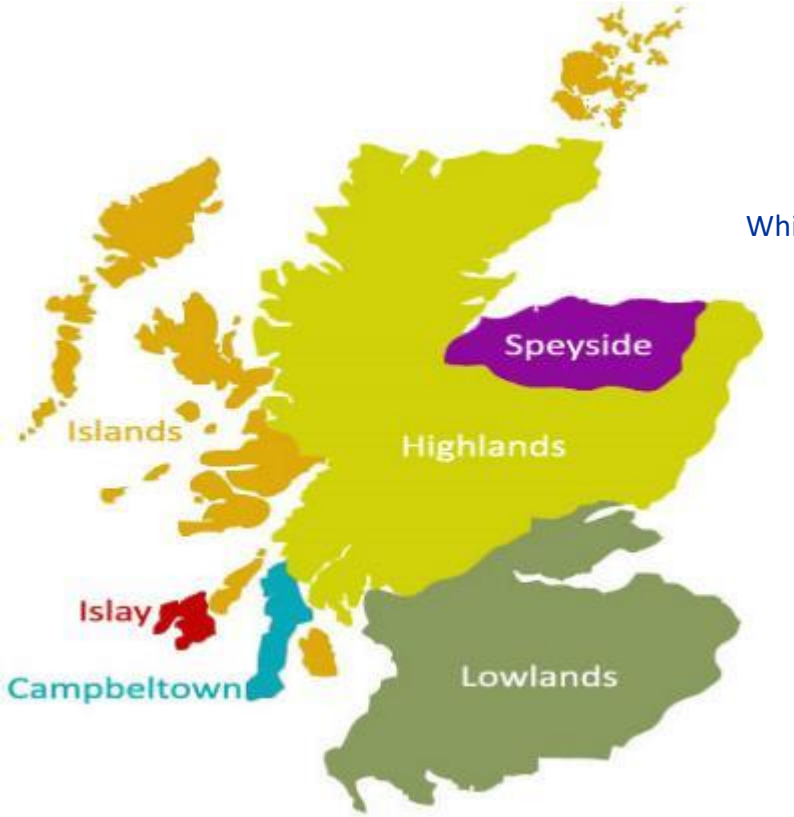
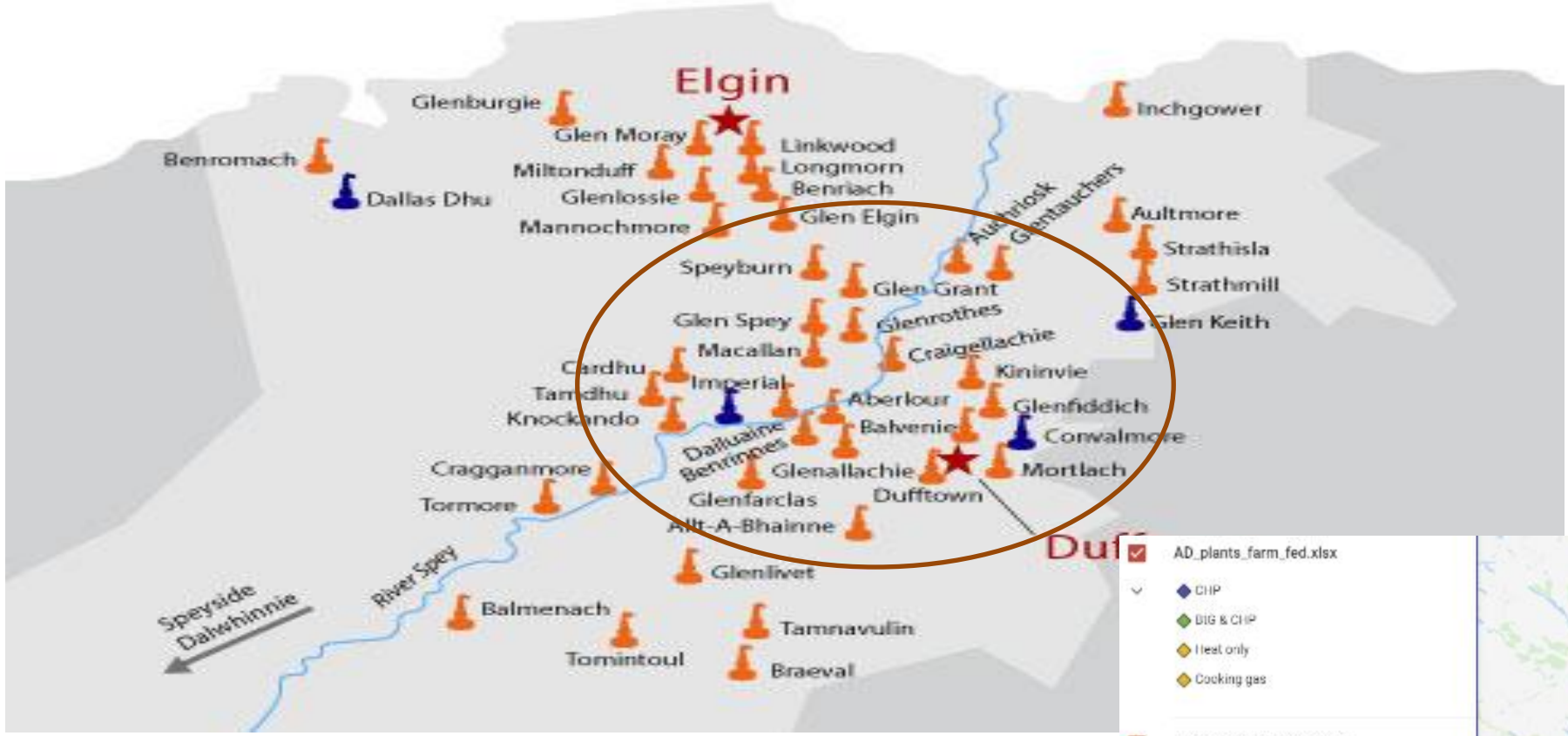
Summary

- Distilleries emit CO_2 in the fermentation process and by burning fuel (mostly gas)
- H_2 can be produced from wind power by electrolysis
- CO_2 and H_2 can be used to produce methane (Sabatier Process)
- Speyside is the ideal location:
  - Cluster of distilleries where CO_2 could be captured
  - Existing gas pipeline; potential route for CO_2 pipeline
  - Good area for wind turbines (offshore or onshore)
  - Gas pipeline network



Whisky Regions

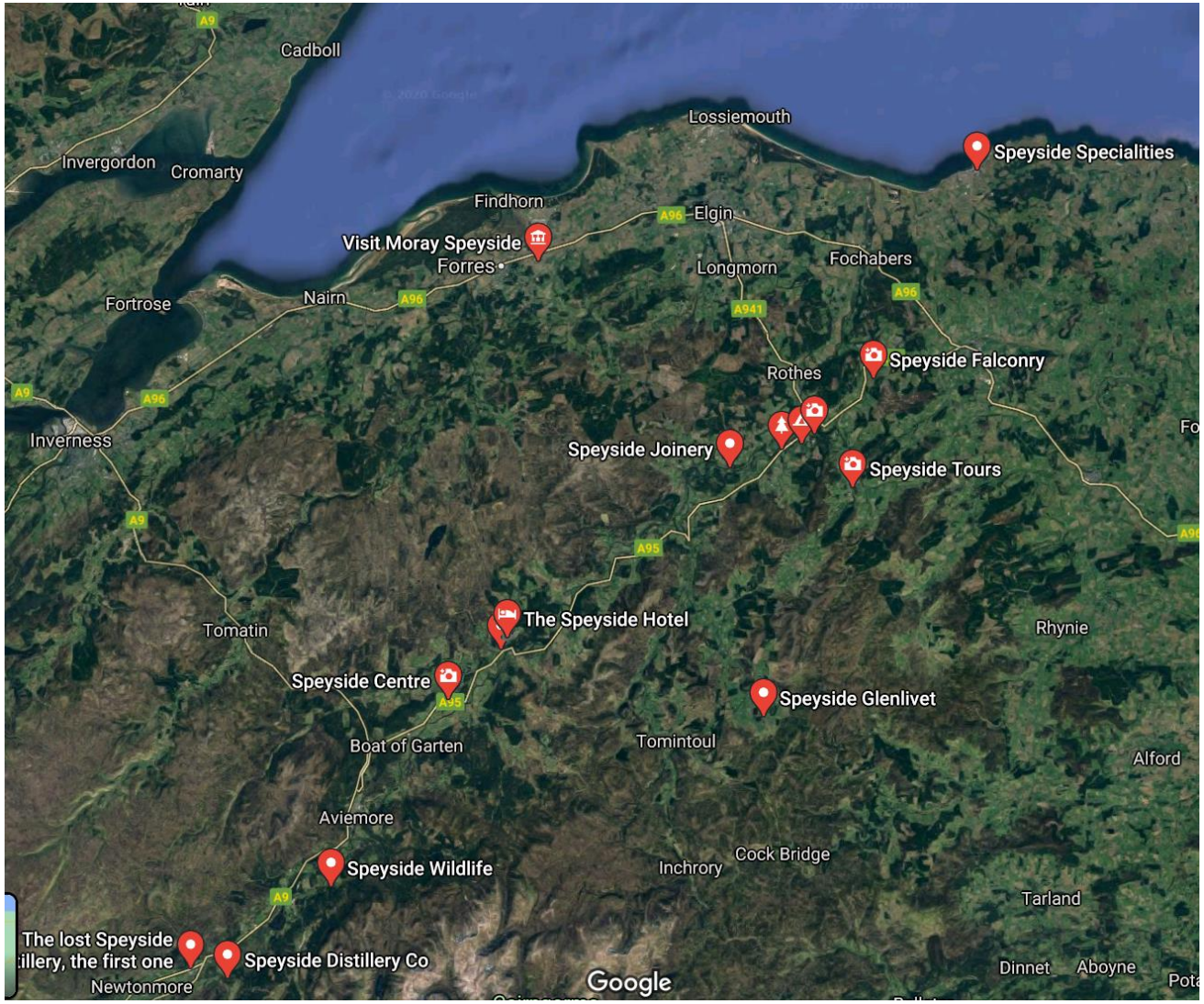
Step 1 - Capture CO2 at distilleries
2 CO2 sources, whisky making process and gas used to raise steam



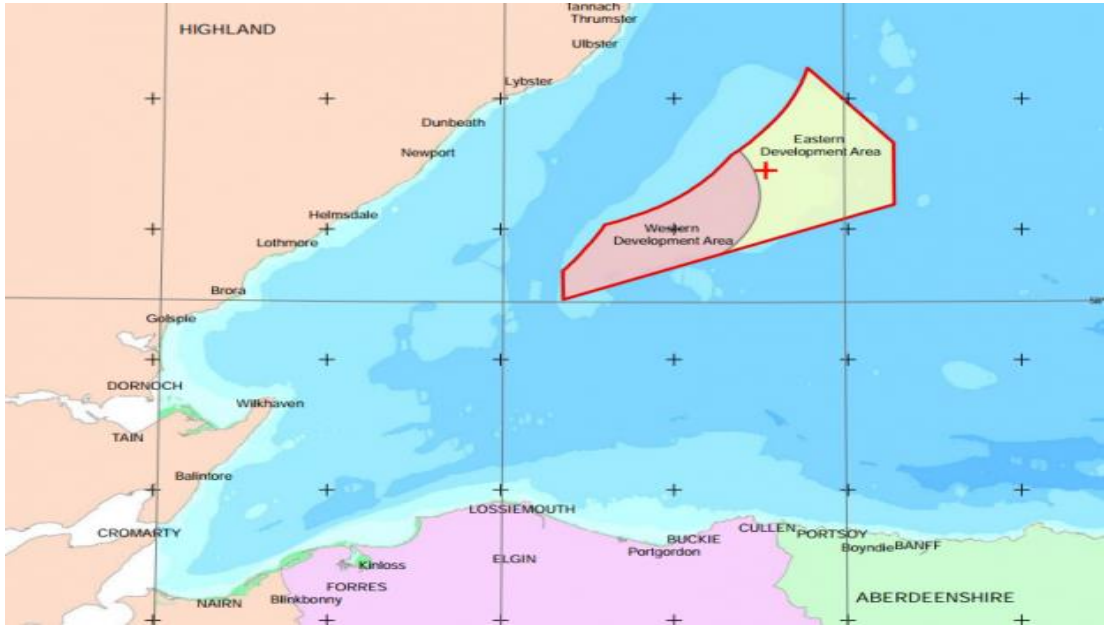
- Target cluster of 15 distilleries near Rothes and Aberlour in Speyside
- Total alcohol production = c. 64 million litres CO2
- Total gas consumption > 500 million kWh
- Also – sites making biomethane eg Buckie

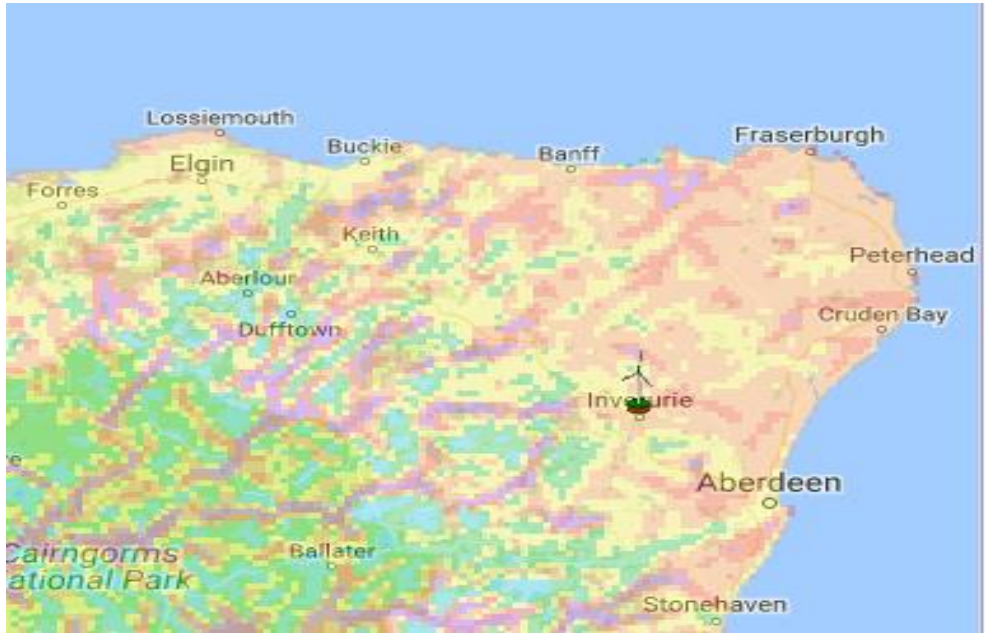
Step 2 - Transport CO2 by pipeline to “Sabatier” Process Site

- CO2 pipeline to a site in Speyside area where the Sabatier Process will take place to make CH4
- Relatively low cost part of the chain



Step 3 – Wind energy

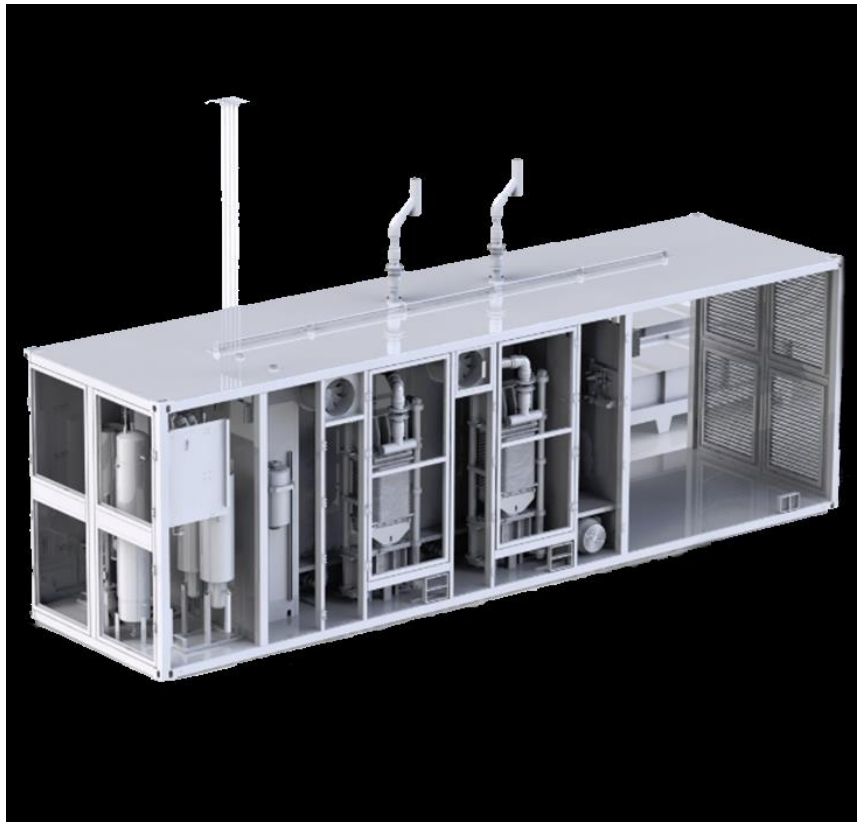




- Independent wind farm
- Offshore - extension to planned new wind farm?
- Onshore - good wind speeds and planning success rate in the area

Step 4 - Produce H2

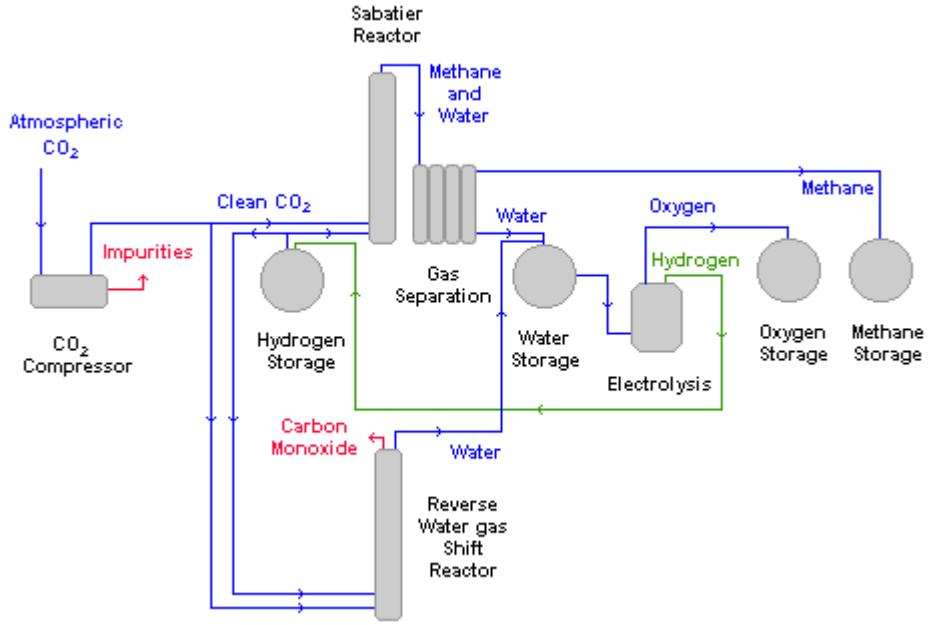
- With sufficiently cheap power source, electrolysis becomes an efficient method of H2 production
- Large scale electrolysis exists already
- Downwards cost trajectory with technology development and scale

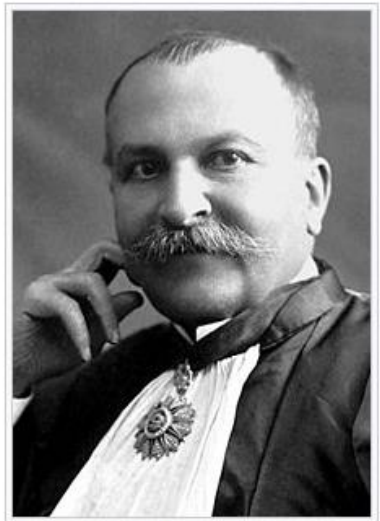


ITM Electrolyser

Step 5 - React CO2 with H2 to make CH4

- CO2 + 4H2 -> CH4 + 2H2O, hence 1 unit of CO2 and 4 units of H2 will produce one unit of methane
- Well-established catalytic process technology (Sabatier process) or emerging biological process technology with potential for cost reduction
- Total efficiency of P2G process c. 56%





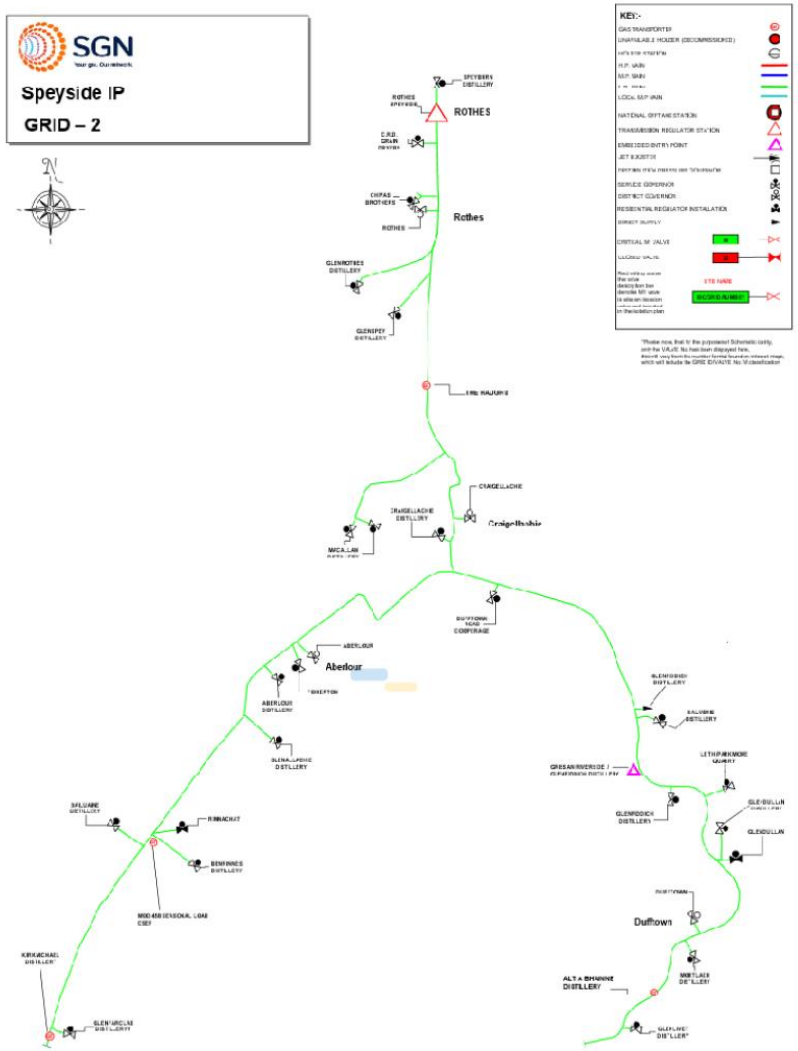
Paul Sabatier (1854-1941) winner of the Nobel Prize in Chemistry in 1912 and discoverer of the reaction in 1897

The **Sabatier reaction** or **Sabatier process** produces methane and water from a reaction of hydrogen with carbon dioxide at elevated temperatures (optimally 300–400 °C) and pressures (perhaps 30 bar [1]) in the presence of a nickel catalyst. It was discovered by the French chemists Paul Sabatier and Jean-Baptiste Senderens in 1897. Optionally, ruthenium on alumina (aluminium oxide) makes a more efficient catalyst. It is described by the following exothermic reaction.[2]

$$CO_2 + 4\,H_2 \xrightarrow[\text{pressure + catalyst}]{400\ ^\circ C} CH_4 + 2\,H_2O \qquad \Delta H = -165.0\ \text{kJ/mol}$$

Step 6 - Inject methane into SGN grid that supplies the distilleries

- The SGN 7 bar network links most distilleries



Summary of Base Case economics

Feasibility study to establish:

- Capex
- Opex
- Income
- CO2 benefit

Conclusions and next steps

- No technology barriers to P2G project in Speyside area
- Easy access to steady stream of CO2, good wind resources and SGN grid for the CH_4
- Economics critically dependent on cost / tonne of CO2 and also sensitive to cost of wind energy and P2G process capex
- Options available to optimise project, e.g.:
  - Sizing/storage
  - Technology choices
  - Oxygen capture
- More detailed feasibility study required to analyse opportunity fully
  - Discussions with potential partners