Speyside Power-to-Gas Project Feasibility Study

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Summary

- Distilleries emit CO_2 in the fermentation process and by burning fuel
- H_2 can be produced from wind power by electrolysis
- CO_2 and H_2 can be used to produce methane (Sabatier Process or new biological processes)
- 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)
  - Proximity to gas National Transmission System

Whisky Regions

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Approach to feasibility study

- Identify 'base case' approach
  - Keep it simple
  - Adopt modest scope with potential to expand
  - Don't try to optimise the set-up (yet)
  - Keep options open on detail of technology choices
- Establish ballpark costs
- Develop economic model
- Demonstrate feasibility of concept
- Identify critical parameters that could make or break the economics
- Identify potential ways in which the concept could be developed

Step 1 - Capture CO_2 at distilleries

- Target cluster of 15 distilleries near Rothes and Aberlour in Speyside
- Total alcohol production = c. 64 million litres (CO_2 in base case)
- Total gas consumption > 500 million kWh (CO_2 not in base case)

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Step 2 - Transport CO_2 by pipeline

- CO_2 pipeline could follow route of existing gas pipeline (in red) towards the gas National Transmission System (black), c. 45 miles
- CO_2 + H_2 reaction can be anywhere between CO_2 source and NTS
- Relatively low cost part of the chain

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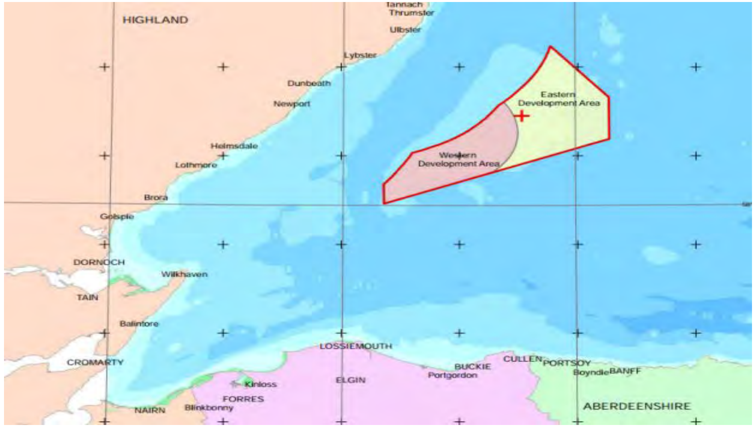
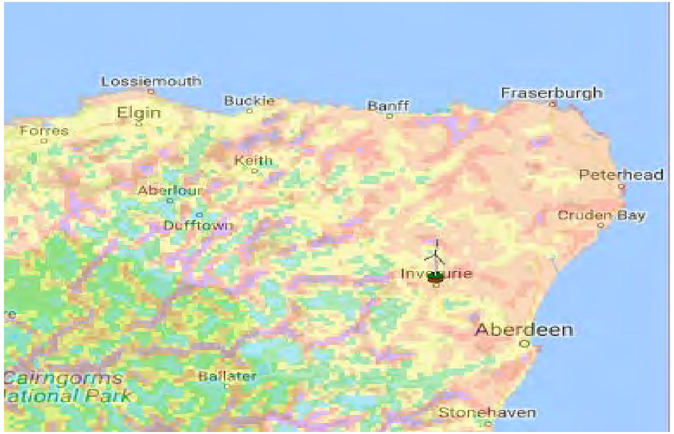
Step 3 – Use independent source of wind energy





- Independent wind farm avoids costs and subsidy payments associated with electricity grid and allows RTFC from the CH4 produced
- No back-up from grid electricity: only operate when the wind blows
- Offshore - extension to planned new wind farm?
- Onshore - good wind speeds and planning success rate in the area

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Step 4 - Produce H_2 from wind power

- With sufficiently cheap power source, electrolysis becomes an efficient method of H_2 production
- Large scale electrolysis exists already (for chemical plants, refineries etc)
- Downwards cost trajectory with technology development and scale
- Assuming 75 MW plant with 70% efficiency

Hydrogenics electrolysis plant in Ukraine

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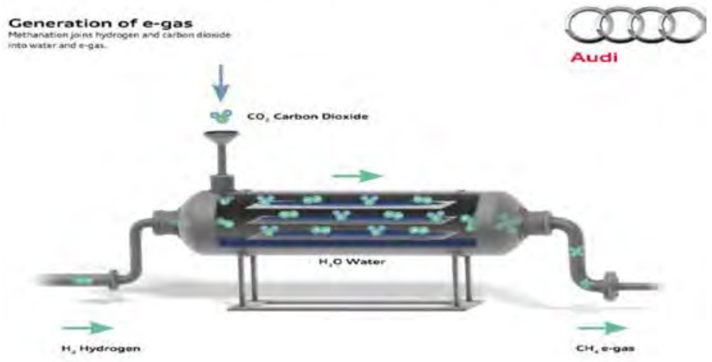
Step 5 - React CO_2 with H_2 to make CH4

- $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$, hence 1 unit of CO_2 and 4 units of H_2 will produce one unit of methane
- Well-established catalytic process technology (Sabatier process) or emerging biological process technology with potential for cost reduction
- Base case production of c. 4,000 m^3/hour CH_4
- Total efficiency of P2G process c. 56%
- Total annual CH_4 production: 170,000 MWh



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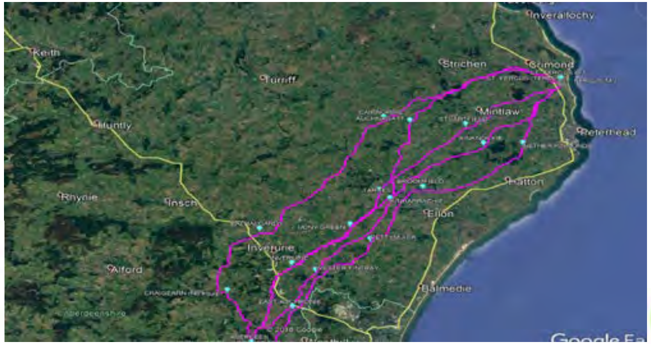
Step 6 - Inject methane into NTS

- The National Transmission System (NTS) provides a practically limitless sink for the methane produced in this project
- NTS feeders from St Fergus have plenty of capacity following UKCS decline
- H2 injection limited to 5% (volume) or 2% (energy)
- CV and Wobbe of 100% CH_4 both within NTS spec - can be injected without enrichment
- The CH_4 produced <u>might</u> qualify for Renewable Transport Fuel Obligation certificates as a "Development Fuel"



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Summary of Base Case economics

CH4 produced	170,000	MWh p.a.	enough to supply 13600 houses
Initial capex	£118	million	or £8680 per house
Annual opex	£17	million	or 10p/kWh
RTFO value	20	p/kWh (1st 10 years)	
	10	p/kWh (2nd 10 years)	
Discount rate	5	%	
NPV over 20 years	£46	million	

- Annual revenue critically dependent on value of RTFO certificates
  - £37m with RTFO certificate value at 20 p/kWh
  - £3m with no RTFO certificate value
- Economics also sensitive to wind energy price and P2G technology capex
- Assuming low(ish) discount rate on basis that project would need support to de-risk

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Comparison with alternatives

- Potential alternatives are:
  - Air source heat pumps with gas boiler back up
    - Similar capex, lower opex (although P2G project not optimised)
    - Less renewable than P2G
  - Water source district heating
    - Likely to be more renewable than ASHP, but still reliant on grid electricity
    - Very high capex

	Capex	Opex	Renewable
Speyside P2G			
ASHP with gas back-up			
WSHP district heating			

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Conclusions and next steps

- No apparent technology barriers to P2G project in Speyside area
- Easy access to steady stream of CO2, good wind resources and NTS for the CH_4
- Economics critically dependent on the future of the RTFO (or similar) scheme, 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 economic than WSHP district heating; better environmentally than ASHP with gas back-up
- More detailed feasibility study required to analyse opportunity fully
  - Discussions with potential partners
  - Potential EU funding

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