P2G –
2 studies from Sweden

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HIPS-NET, Brussels, 24 June 2015

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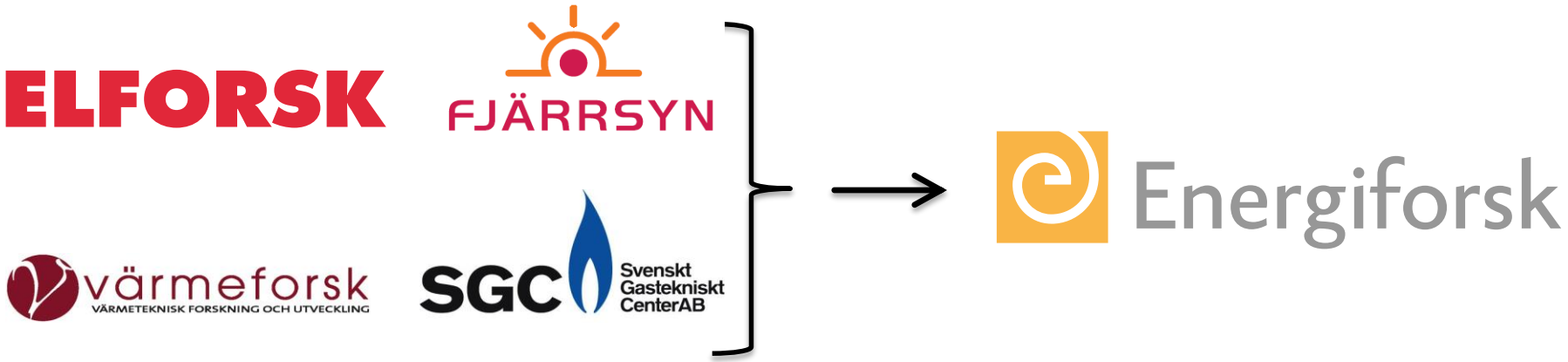
(new organization since 1 Jan 2015)



Owners : Svensk Energi AB – Swedish electric power association (30%)
Svenska Kraftnät – Power grid owner (20 %)
Svensk Fjärrvärme AB – Swedish district heating Ass.(20 %)
Energigas Sverige – Swedish gas association (15 %)
Swedegas AB – The swedish TSO (15 %)

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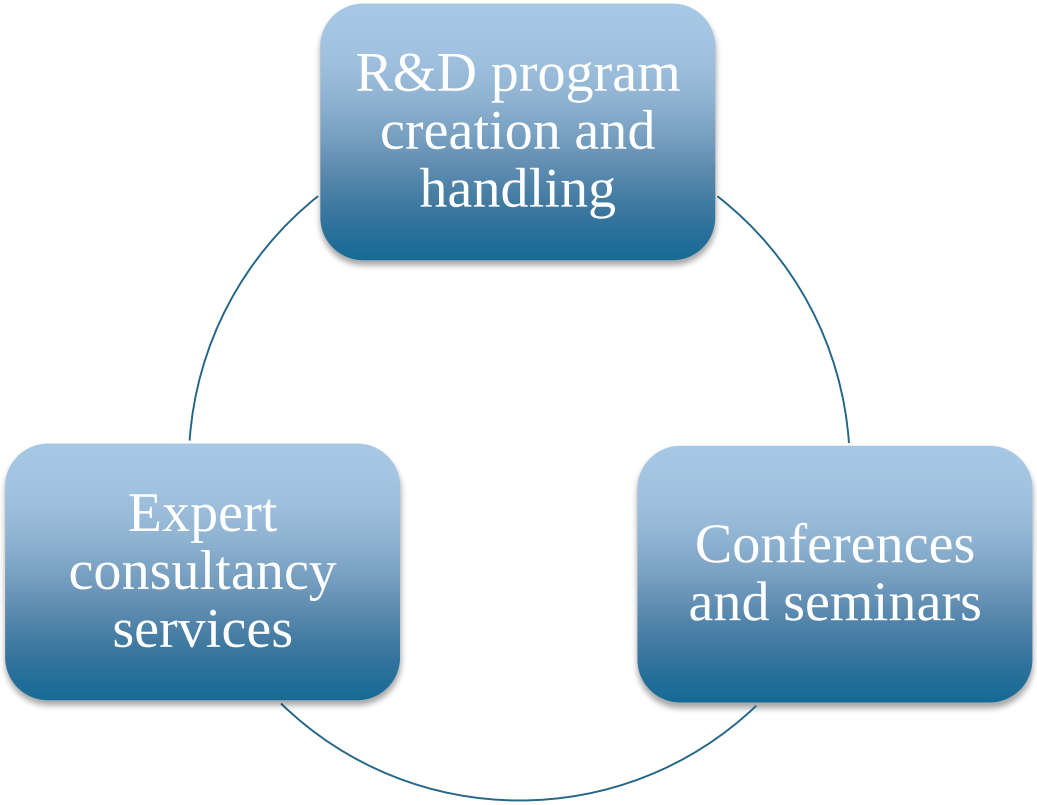
Energiforsk's working areas



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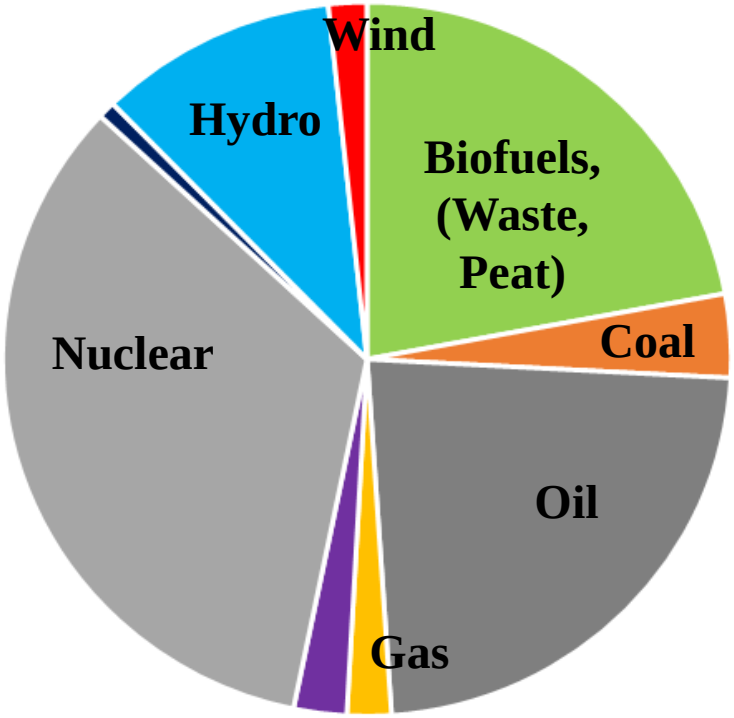
P2G in Sweden?

Total energy supply in Sweden – 579 TWh (2013)



Present

- Hydro and nuclear power production
- Biofuels mainly for heat
- Oil for transport (92 % fossil)
- Wind and gas marginal system relevance

Future

- Replacement of old nuclear power start 2025
  => increased wind ?
- Fossil free transports 2030
  => liquid & gas biofuels ?
- Large country with regional differences
  => regional solutions

Source: Energiläget 2013, Swedish Energy Agency

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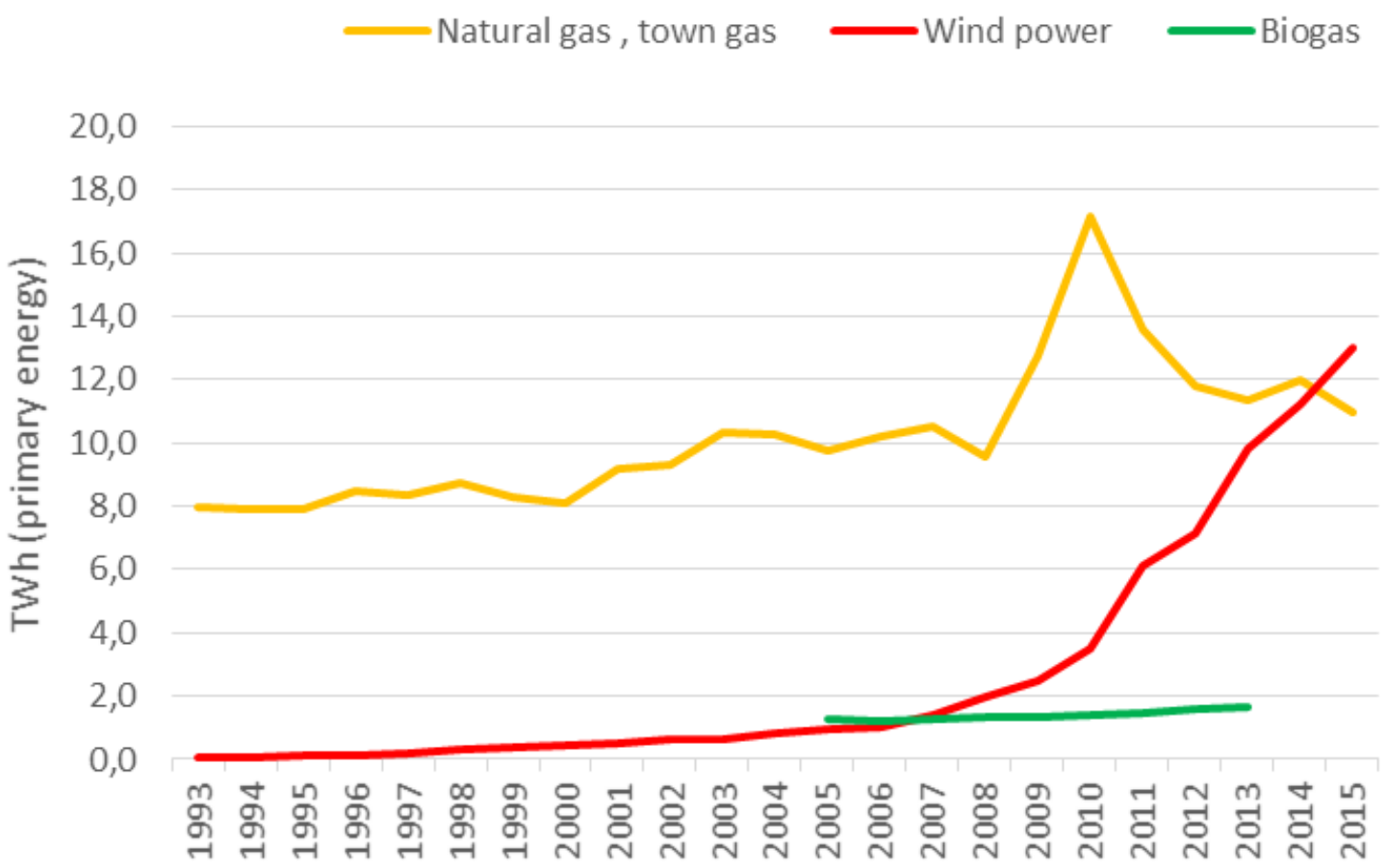
Development wind power and gas



Source: Swedish Energy Agency; www.energimyndigheten.se

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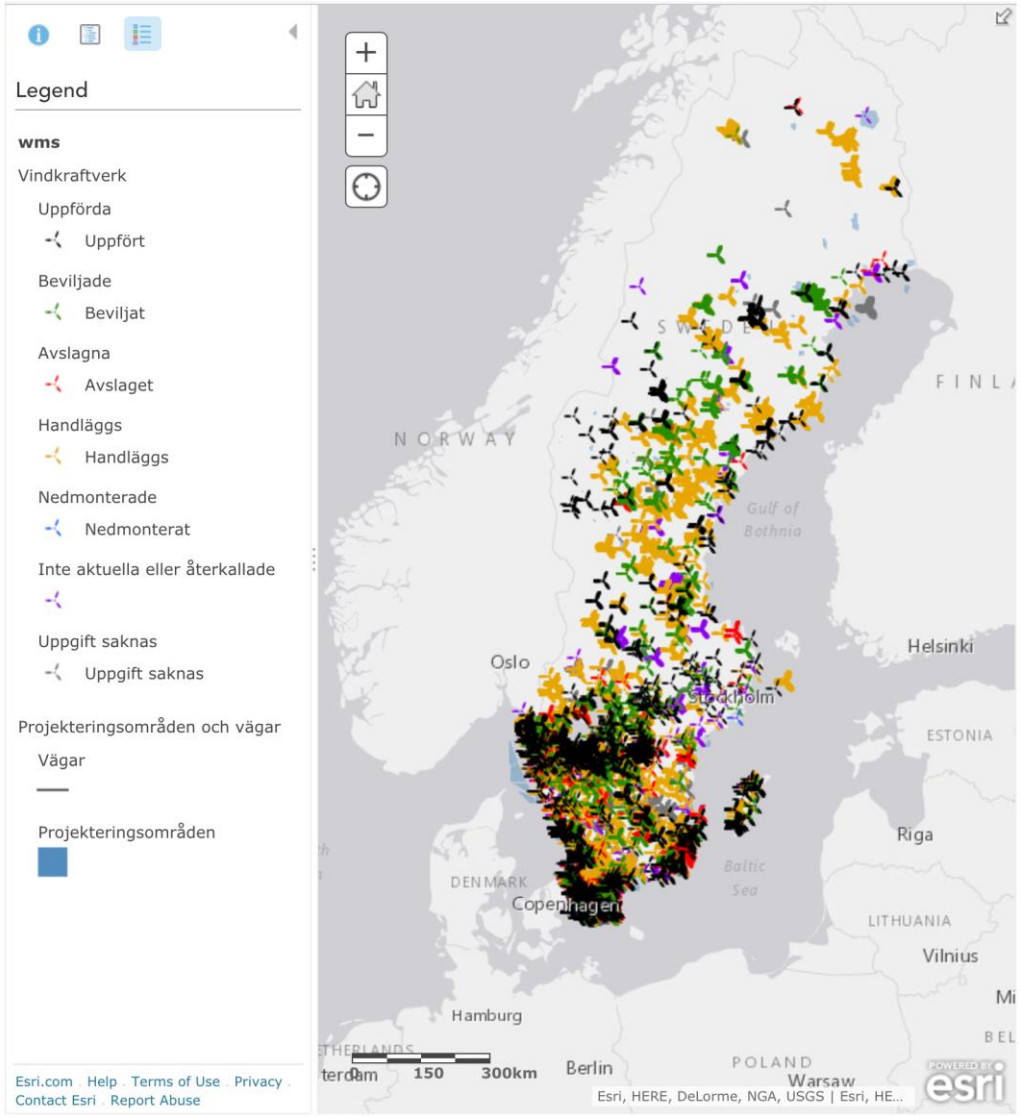
Wind turbines in Sweden



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2 new Swedish P2G studies

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Locational study – Power to gas

- Performed within one of **Energiforsk national R&D programs**

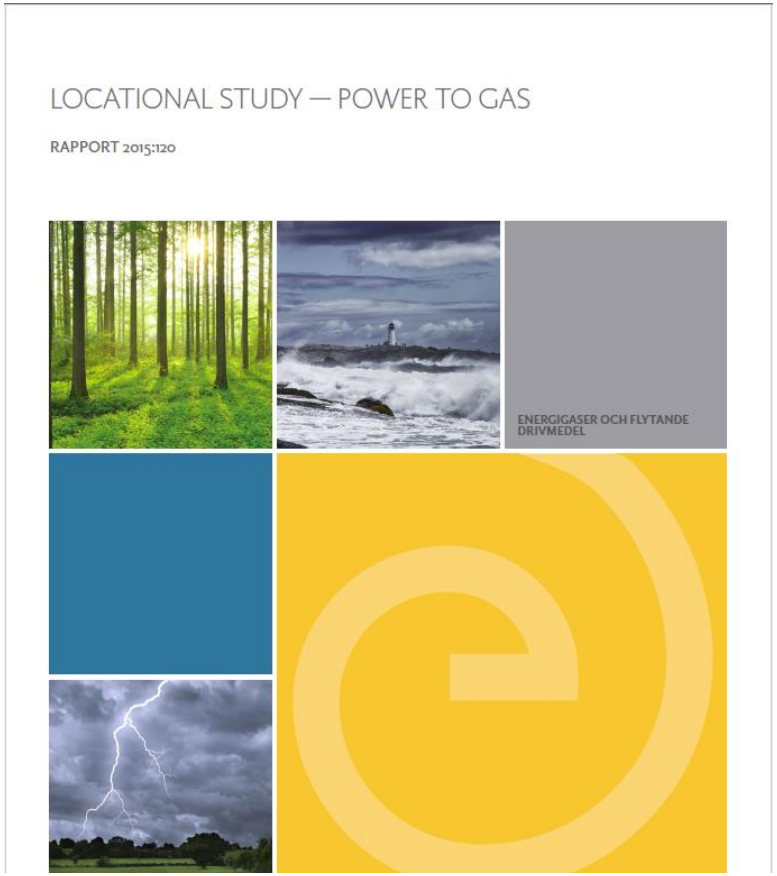
  (main author: Karin Byman , ÅF)

- Financed by the Swedish Gas Industry

- Investigating **conditions suitable for building a first demo and possible commercial size P2G plant in Sweden**

- **3 regions** representing selected locations with potential beneficial conditions for a P2G

- **3 chosen technology tracks** evaluated for each location



http://www.energiforsk.se/rapporter

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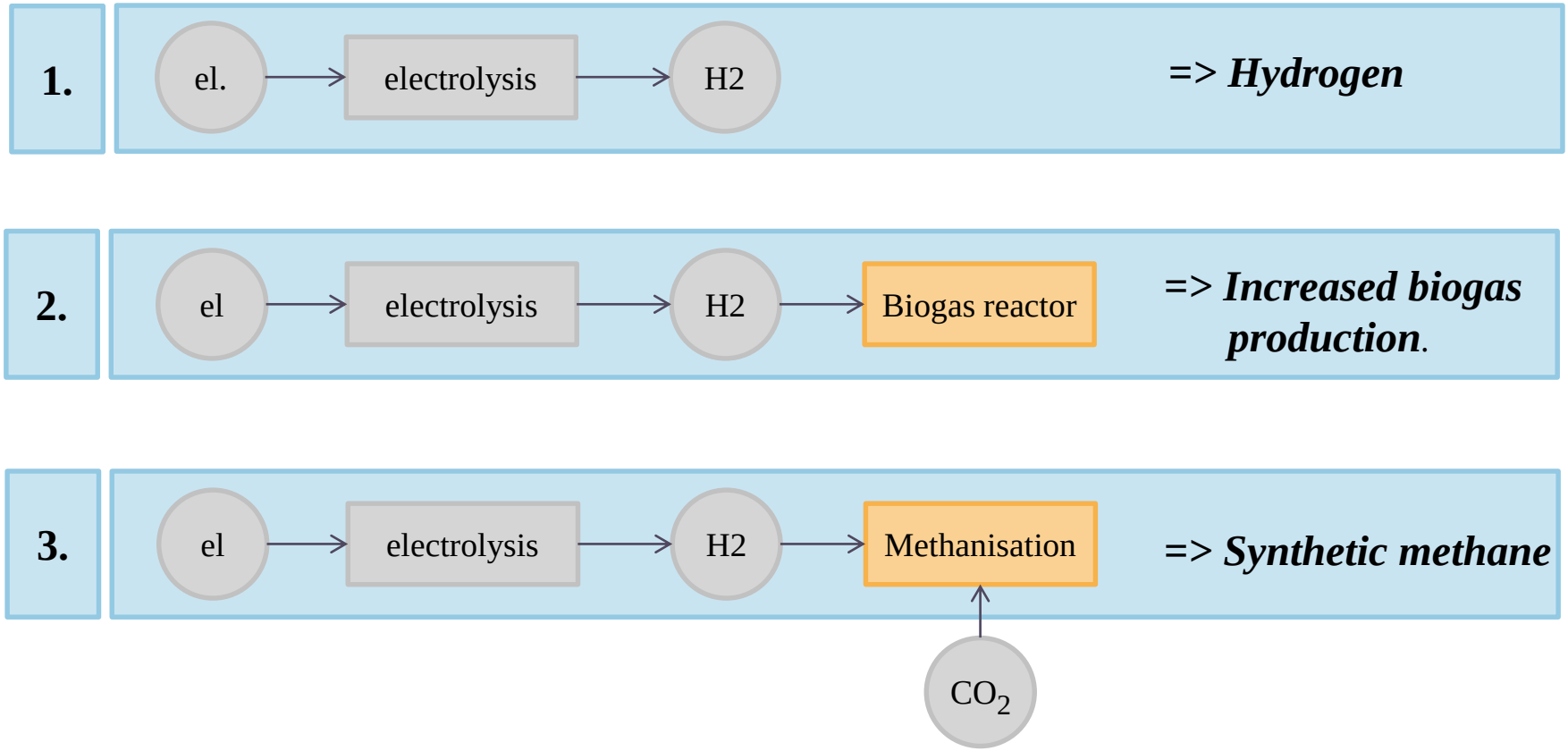
Evaluated technology tracks



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The 3 selected sites

national gas grid

Piteå

- Ambitious wind power development but low regional demand due to excess hydro power
- Heavy mining industry, with large CO_2 footprint
- Regional research center fluid biofuels (DME, MeOH)

P2G: 1) H_2 used as feedstock in existing biofuel demo (gasifier)

Falkenberg

- Access to national gas grid
- Ambitious wind power development (conditions similar to Dk & Ger)
- Existing H_2 filling station

P2G: 1) H_2 to the gas grid
2) H_2 to the filling station

Visby/Slite - Gotland Island

- Ambitious wind power development (1 GW, 2020)
- Limitations in power transmittance to main land
- Large cement industry (CO2) and biogas production

P2G: 1) H_2 fed into biogas reactor
2) H_2 combined with CO2 for synthetic methane

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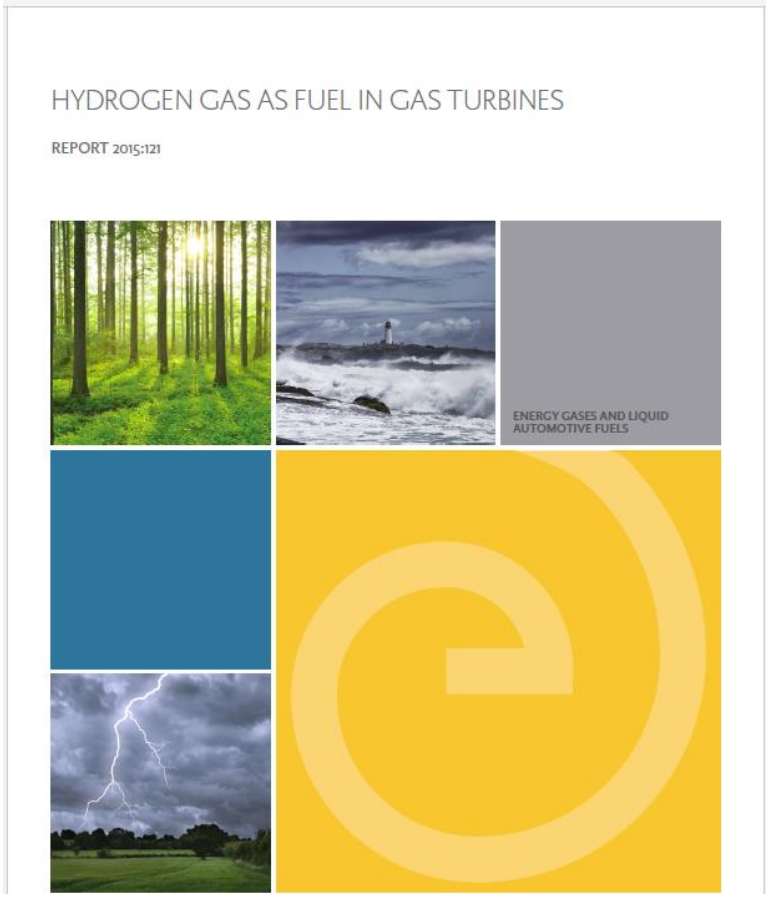
Hydrogen gas as fuel in gas turbines

- Performed and coordinated within one of **Energiforsk national R&D programs**
- Continuation of **previous research** SGC report 2013:256 ; “Co-firing with hydrogen in industrial gas turbines”
- **Carried out by**: Combustion Physics, Lund University,
  Siemens Industrial Turbomachinery AB, and
  Göteborgs Energi
- Aim: **Understand effect on gasturbines of adding H_2 to natural gas with different qualities or to raw biogas** (flammability and flame velocity).

  Kinetic modelling (Chemkin), labtest with laminar flames and different synthetic gas mixtures (Methane, Ethan, Propane, CO_2, H_2) .



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Selected findings and conclusions

- H_2 promotes flammability and velocity of methane (natural gas), but the effect differs depending on which other gases are present.
  => Effect is not linear to one gas.

- Heavier hydrocarbons (Ethan, Propane) decreases flame velocity of natural gas, but addition of H_2 counteract some of this effect
  => Possible impact of increased addition of H_2 to gas grid with fluctuating gas qualities

- CO_2 decreases reactivity of gas but can be compensated by addition of H_2
  => Could enables combustion of raw biogas or natural gas with CO_2 contamination

- Kinetic modeling using the San Diego Mechanism fits reasonably well with laminar flames at 1 atm
  => Important finding for further optimization and determination of limiting mixtures also at pressure relevant for gasturbines

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Gas activities Energiforsk

- **3rd IBBA Workshop 2015** - Pretreatment of lignocellulosic substrates for biogas production
  (9th)-10th of September 2015, in Malmö, Sweden
  www.ibbaworkshop.se

- **International Seminar on gasification 2016**
  Industrial and technical focus directed towards biomass and waste gasification for the production of various bio-fuels, bio-chemicals, heat- and power and other related topics.
  www.gasification.se

- **H2020-projects**
  Interreg project (Dk, N, S) - **Biogas2020 – Start 1 july**
  Platform for Biogas research and development in S, Dk and N
  12 universities and institutes, 10 official organisations and regions,
  5 knowledge center and 3 private companies,
  11,9 mil €

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Thank you for your attention!

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