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FUTURE USE OF FINLAND'S INFRA

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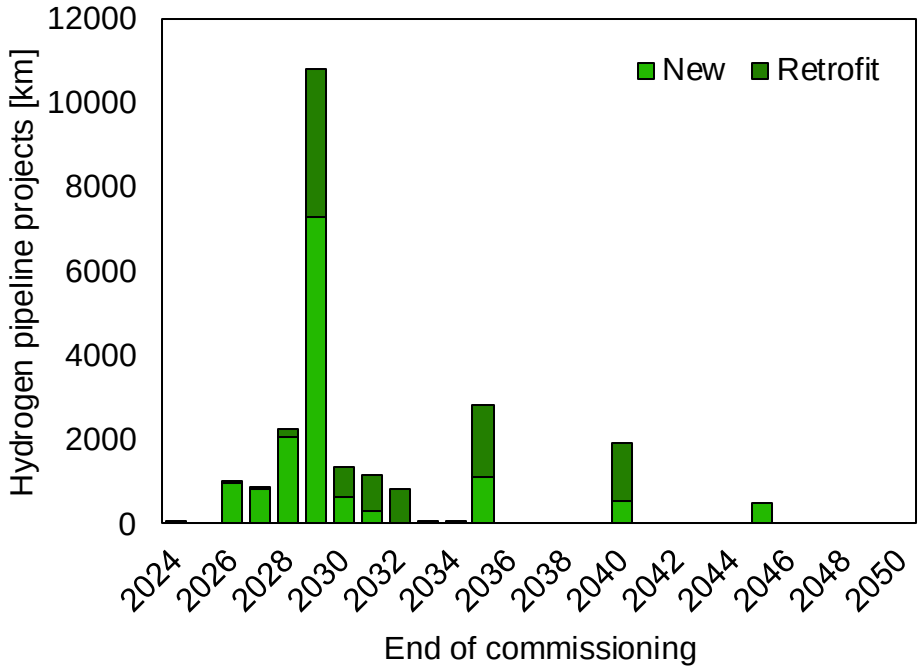
USE OF EXISTING NATURAL GAS PIPELINES FOR THE TRANSPORTATION OF HYDROGEN

- Repurposing of natural gas pipelines for hydrogen transportation has been seen as a cost-effective and rapid solution for the demand for hydrogen infrastructure
  - Estimated cost for a repurposed pipeline is 0.2−0.6 M€/km and for a new-built pipeline 1.4−3.4 M€/km[1]
- Some actors suggest blending hydrogen with natural gas instead of transporting pure hydrogen

[1]Jens, J., Wang, A., van der Leun, K., Peters, D., Buseman, M., 2021. Extending the European hydrogen backbone. Utrecht, the Netherlands

EXPERIENCES FROM OTHER COUNTRIES

- Several experiments have been conducted on the blending up to 20 vol-% of hydrogen to natural gas and injecting the mixture to existing pipeline
  - No severe issues have been reported
- Some projects have successfully repurposed a natural gas pipeline to 100% hydrogen but there is a very limited number of examples
  - Gasunie converted a 40 bar and 12 km natural gas pipeline to hydrogen in 2018 in the Netherlands and the pipeline has been operating since then
- There are ambitious plans for building of hydrogen pipelines



https://energy.ec.europa.eu/consultations/consultation-list-candidate-projects-common-interest-all-2infrastructure-categories_en
https://ec.europa.eu/eusurvey/runner/Consultation_PCIcandidates_hydrogen

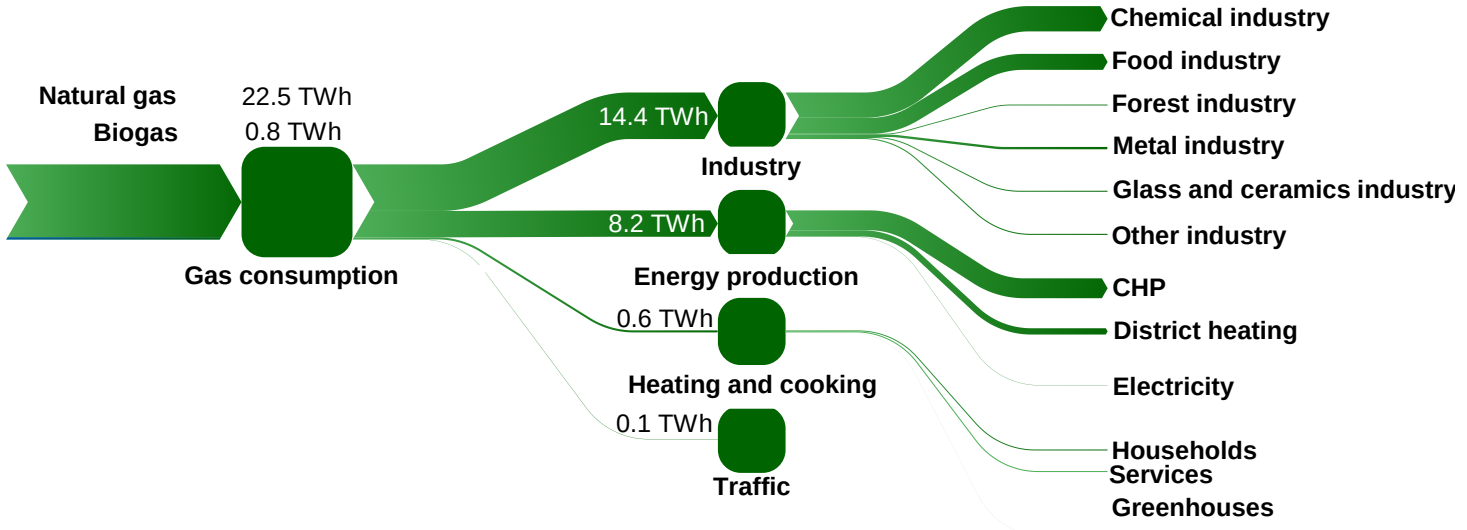
CHALLENGES IN THE USE OF EXISTING INFRA

- Influence on gas characteristics
  - Wobbe index
  - Heating value
- The impacts on the gas infrastructure
  - Pipeline materials
  - Controls
  - Metering systems
  - Fittings, valves, gaskets
- Transport capacities
  - Volumetric heating value, pressure, flow rate
  - Compressors
- The impacts on end-user infrastructure
  - Domestic appliances: heaters, etc.
  - Industry: gas turbines, chemical processes, etc.
- The impacts on the automotive sector
  - Methane number (knocking)
  - Tolerance of high-pressure storage tanks
- The impacts on underground storages
  - Microbial reactions
  - De-mixing
  - Effects on geothermal conditions
- Safety
  - Leakage detection: odorization, detectors
  - Wide flammability range
  - Invisible flame

More information: Lehner, M., Tichler, R., Steinmüller, H., Koppe, M., 2014. Power-to-Gas: Technology and Business Models. Springer, Austria. https://doi.org/10.1007/978-3-319-03995-4

CURRENT NATURAL GAS USERS IN FINLAND

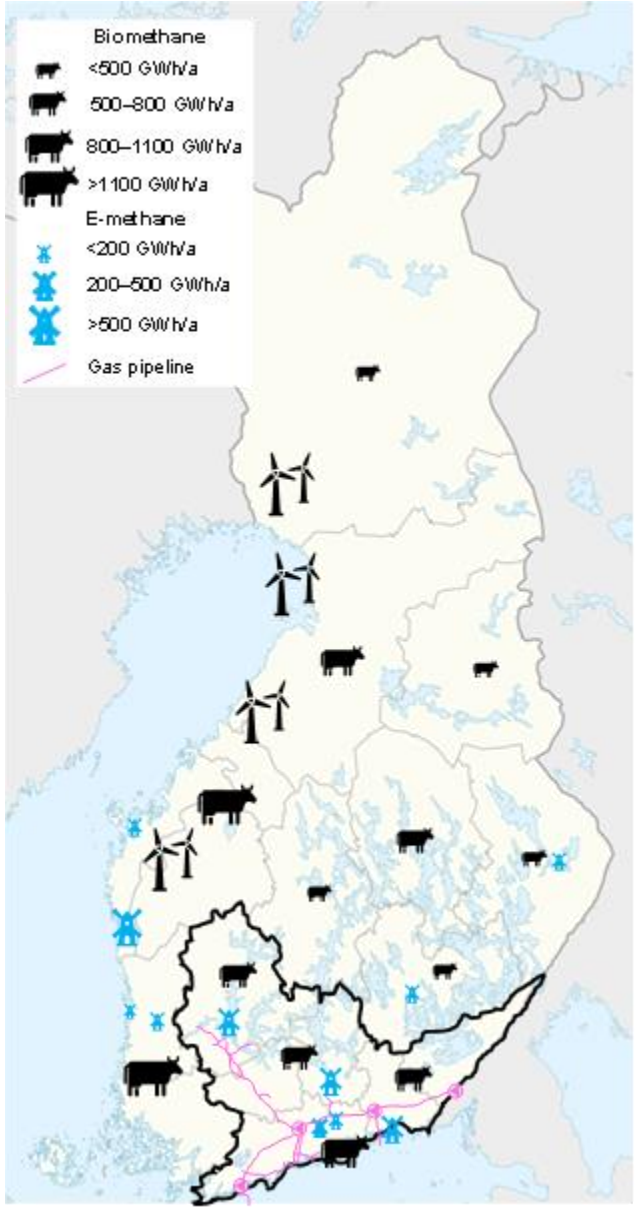
- Natural gas is currently mainly used in energy production and as a raw material in industry in Finland
- Both converting existing pipeline to hydrogen and blending of hydrogen with methane affect the current users
  - Need to modify processes and equipment
  - Need for deblending
  - Benefit for users that currently produce hydrogen from methane



Natural gas consumption in Finland in 2021. In 2023, the consumption was only 11.9 TWh.

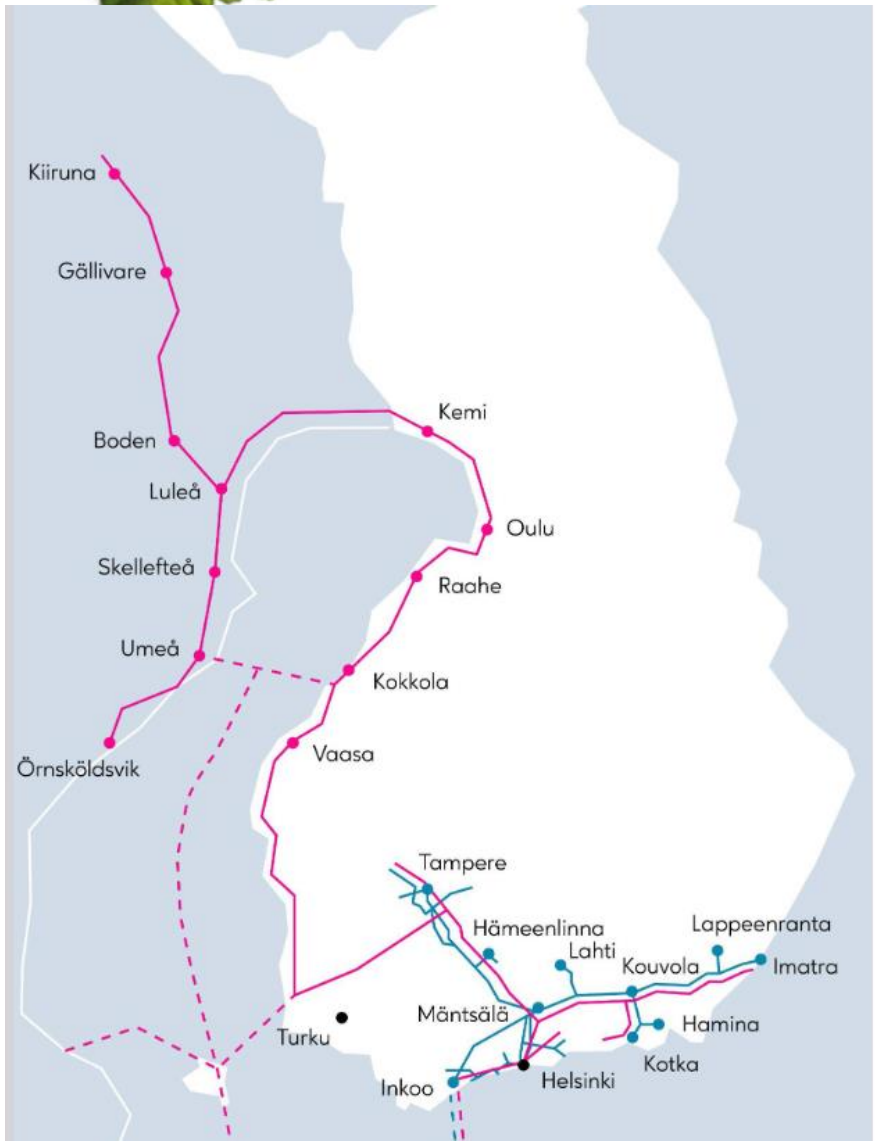
FINNISH RESOURCES

- In Finland, hydrogen production (renewable energy resources) and existing natural gas grid may have a geographical mismatch
- Current natural gas grid can be used for the transportation of renewable gases (e-methane, biomethane)
  - Most of the biomethane production potential is not located near the pipeline
  - Some e-methane plants are planned to be built near the pipeline



HYDROGEN PIPELINE PLANS

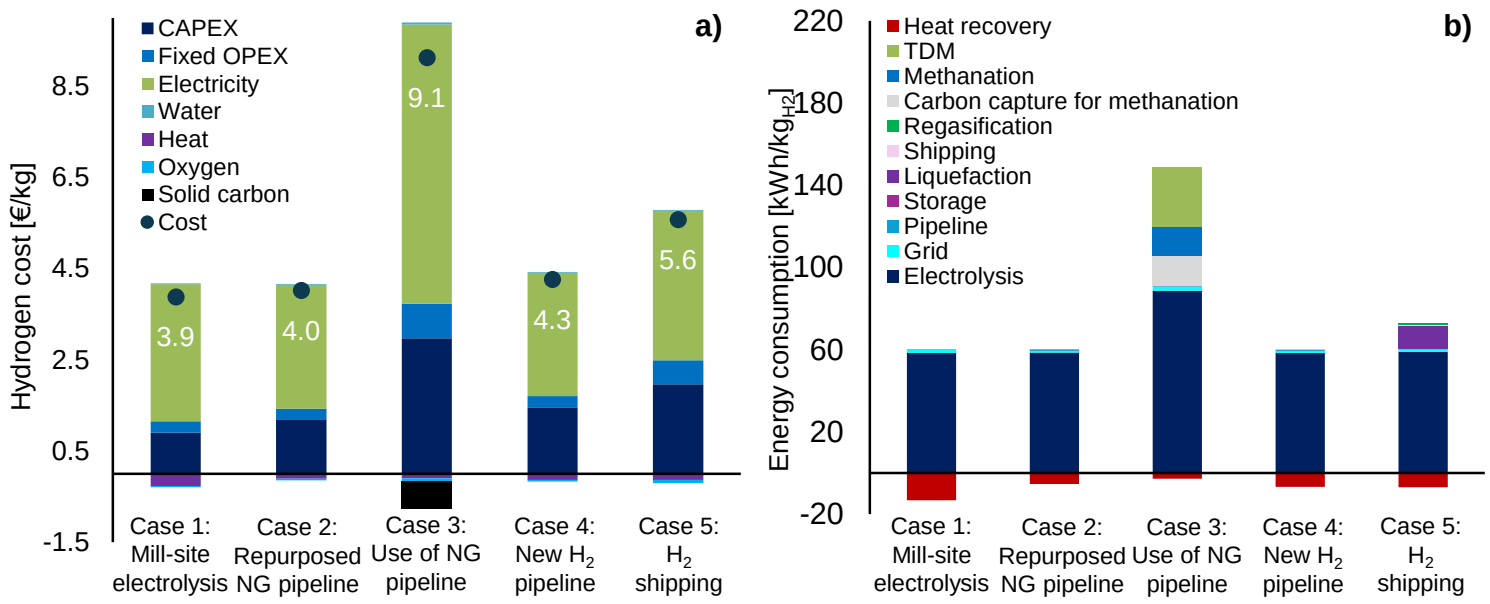
- Utilization of the Finnish renewable energy resources, possibility to act as hydrogen exporter as well as serving of industries that are interested in hydrogen requires building of new hydrogen pipelines
- There are several development projects ongoing
  - Nordic Hydrogen Route
  - Nordic-Baltic Hydrogen Corridor
  - Baltic Sea Hydrogen Collector



Gasgrid (2023). Gasgridin vetyhankkeet Suomessa ja Etelä-Karjalassa

ANALYSIS ON THE USE OF EXISTING INFRA

- Transporting hydrogen in a repurposed natural gas pipeline can decrease the transportation costs
- Converting hydrogen to methane for transportation is not reasonable
- In some cases, electricity transmission can be an interesting option



Production costs (a) and energy consumption (b) of hydrogen in different supply routes

Source: https://doi.org/10.1016/j.spc.2023.11.021

CONCLUSIONS

- The use of existing pipelines is possible but there are challenges
- Existing infrastructure may play a notable role in the transportation of hydrogen in Europe, but possibilities are limited in Finland
  - Limited coverage
  - Unfavourable location
- Existing infra can serve in the transportation of other renewable gases (e-methane, biomethane) but the volumes are rather limited
- For a large-scale the hydrogen transportation, new pipelines are needed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