A 2030 vision for H_2 in Iceland

ÍSLENSK NÝORKA ehf

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Executive summary

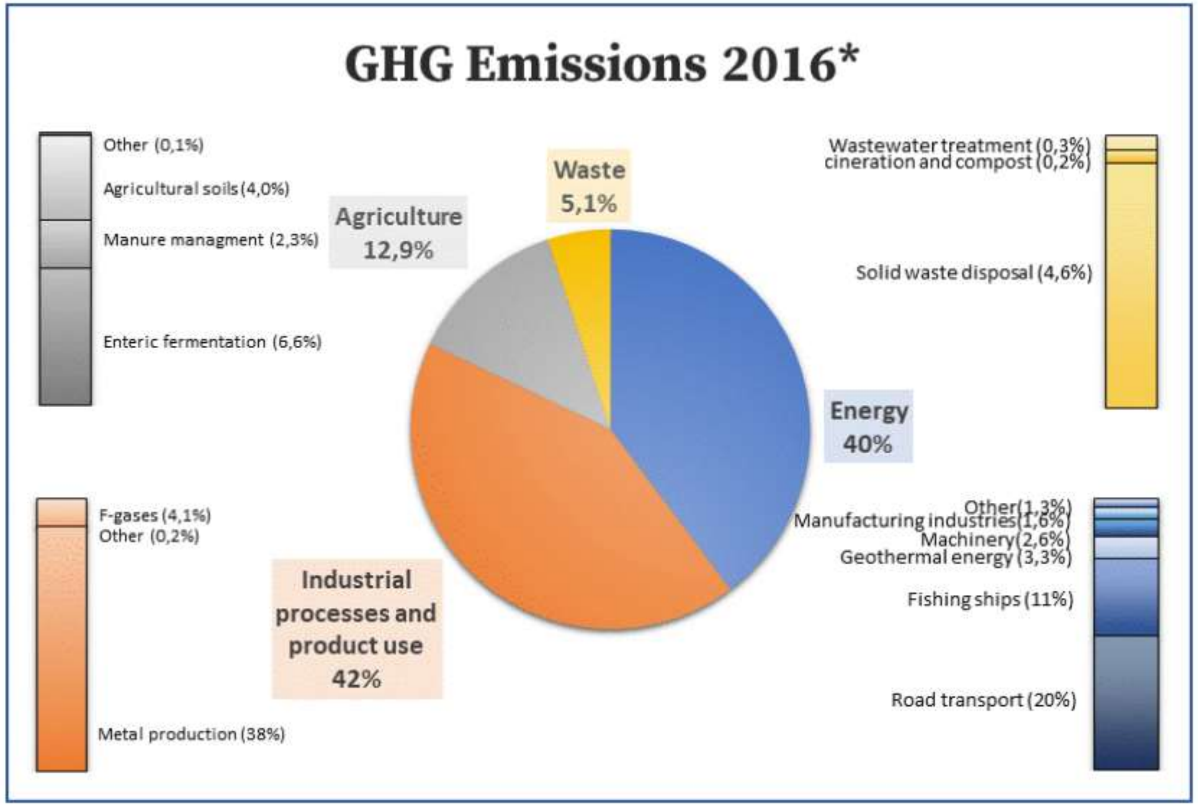
- Transport is a significant contributor to energy related GHG emissions in Iceland.
- Iceland generates nearly all of its energy from renewable hydroelectric and geothermal sources.
  - Thus all H_2 production would be from renewable sources via electrolyzers.
- Electrification of transport – specifically with BEVs – has been successful.
- Despite this success, Iceland still faces major challenges to reach the Paris Agreement, and national goals are even stricter. The implementation of hydrogen and fuel cell technologies could be a vital contributor to closing Iceland‘s GHG emission gap.
  - A full scale hydrogen roadmap should be designed to complement this hydrogen vision.
- E-fuel production and direct use of H_2 opens pathways where Iceland could become 100% sustainable with regard to fuel consumption– and further export green fuel.
- Incentives for larger vehicles and in the marine sector need to be implemented, whether similar to current incentives for vehicles or whether they take on a different form.
  - Investment grants for early adopters would kickstart deployment.
- E-fuel projects need to be supported to provide green solutions to substitute fossil fuel in all relevant sectors.
  - Government should stimulate such production.
- Benefit schemes are needed for transport sectors using zero emission technologies, such as taxis and other high utilization vehicles.
- Incentives for green fuel in marine applications are also needed.

Actions are needed now
It took 10 years from the introduction of the first OEM produced BEVs in Iceland (2009), until 1,5% of the total passenger vehicles fleet became zero emission (2019).

- **Introduction**
- Context
- Hydrogen production & applications
- Action plan & conclusions

Introduction

- The Government of Iceland aims to achieve the national goal regarding greenhouse gas emissions set by the Paris Agreement in 2016, a 29% emission reduction by 2030 compared to 2005 levels.
- Already >80% of the total energy consumption in the country is based on renewables: geothermal and hydro.
- The main sources of GHG emissions (excluding land use) are fossil fuels for passenger vehicles and ships, industrial processes and agriculture. Road transport accounts for about 20%, fisheries for 11%, heavy industrial processes and chemicals for 42%, agriculture for 13% and waste management for 5%.
- Transport (road, marine and air) is the most important sector to focus on for reduction in fossil fuel consumption.
- No single alternative fuel can provide a solution for all transportation modes so multiple pathways need to be explored.



* without LULUCF

Introduction

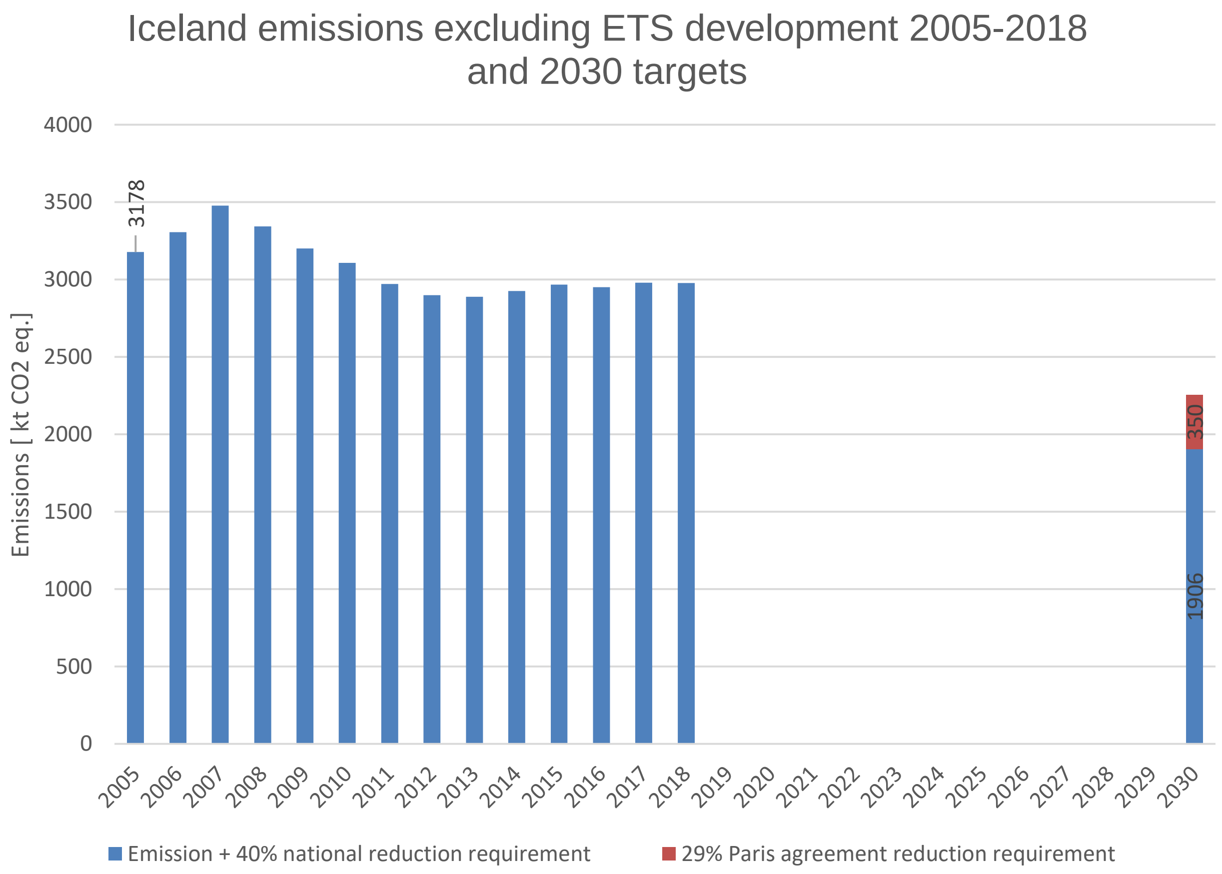
- Hydrogen is a key element for storing electricity and a key building material in all electrofuels.*
- This 2030 hydrogen vision introduces primary opportunities and lists necessary pathways. The vision is a predecessor of a *2050 Hydrogen Roadmap for Iceland* planned to be completed by 2025.
- Iceland has set the national target of carbon neutrality by 2040.
  - Without hydrogen, it is unlikely that this target will be met.
- This document has been produced for policy and decision makers in the Icelandic and European energy sector, public and private.

The pioneer in hydrogen - Iceland:
FC bus in harsh Icelandic winter testing 2004

***Electrofuels** are potential carbon-based fuels (liquid or gaseous) produced from carbon dioxide (CO_2) and water using electricity as the primary source of energy. Also known as *power-to-gas/liquids/fuels or synthetic fuels.*

Introduction

- Iceland has set ambitious targets for emission reduction and implemented various measures contributing to these goals. However, the outlook seems that Iceland's climate targets will not be met at the current pace.
- Though GHG emissions in Iceland have been somewhat reduced in recent years, as shown by the figure to the right, there are significant challenges ahead in order to reach the emissions targets for 2030.
- Compared to 3178 kt CO_2 equivalents emitted in 2005, Iceland must reduce emissions to **1906 kt CO_2 eq** (or below) **by 2030**, according to the national 40% reduction requirement.
- Under commitment related to the Paris agreement, Iceland must achieve a 29% reduction by 2030 compared to 2005 levels.
- This document will show that the national target will not be achieved without the implementation of hydrogen and fuel cell technology.



Reference: Environment Agency of Iceland, 2020 https://ust.is/loft/losun-grodurhusalofttegunda/losun-eftir-flokkum/

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Context

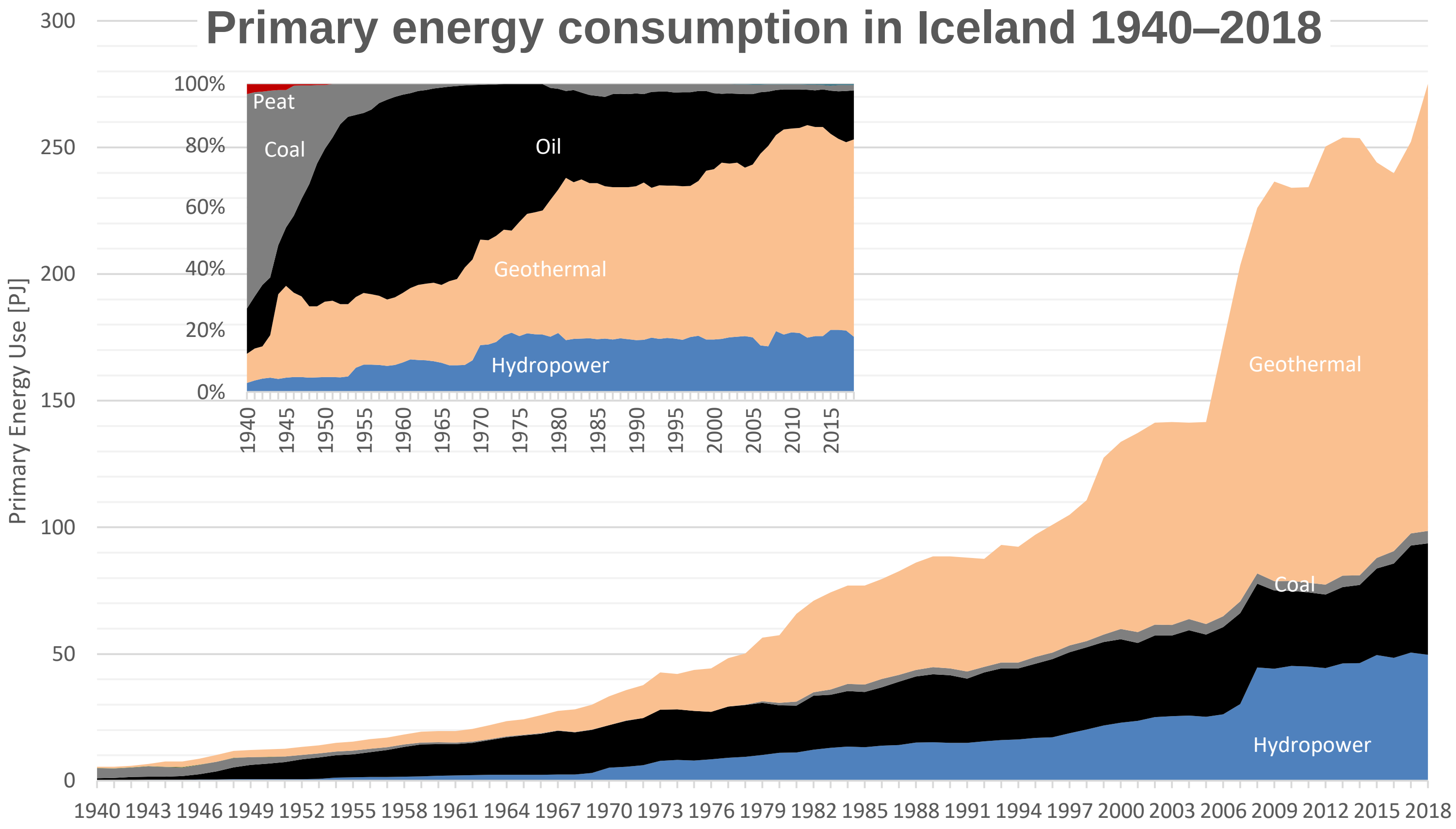
Iceland's transition away from fossil fuels

Iceland has a long history of renewable energy utilization; a notable step involved the energy transition of district heating from burning coal and oil to harnessing geothermal energy in the 1960s.

In total, approximately 86% of Iceland's consumption of primary energy comes from renewable sources.

Today, power generation is almost entirely from renewable energy sources, with 70% coming from hydropower and 30% from geothermal power.

Transport comprises the bulk of fossil fuel consumption and related emissions.

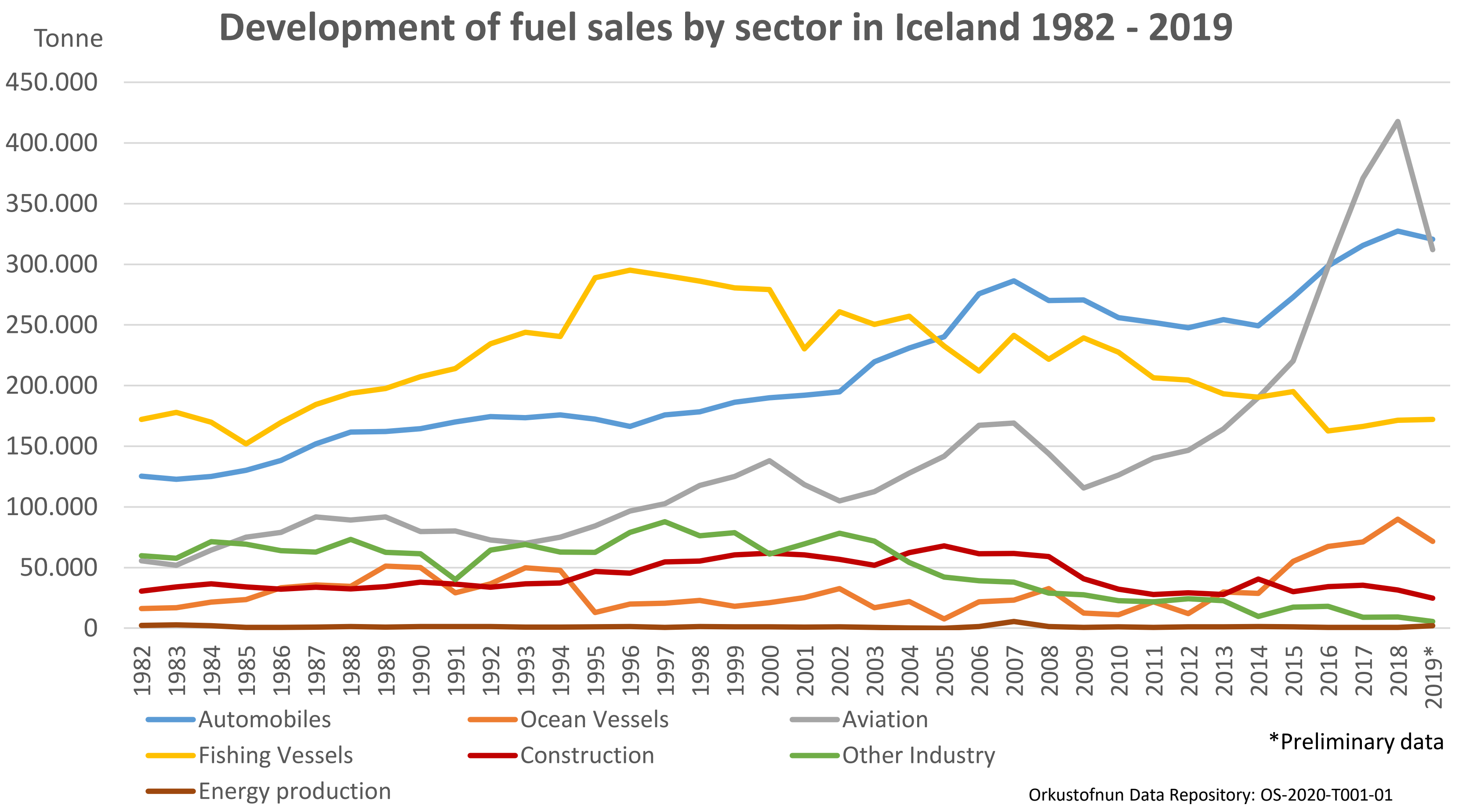


Reference: NEA Data Repository: OS-2019-T003-02

Context

Iceland fossil fuel consumption trends by sector

- Icelandic consumption of fuel has been rising in most sectors, fisheries (yellow in this figure) being a notable exception, due to increased engine efficiency and restructuring of fishing methods.
- In the figure to the right, it is evident that the share of aviation (grey) and passenger vehicles (blue) has increased significantly since 2000.



Context

International commitment to emission reduction

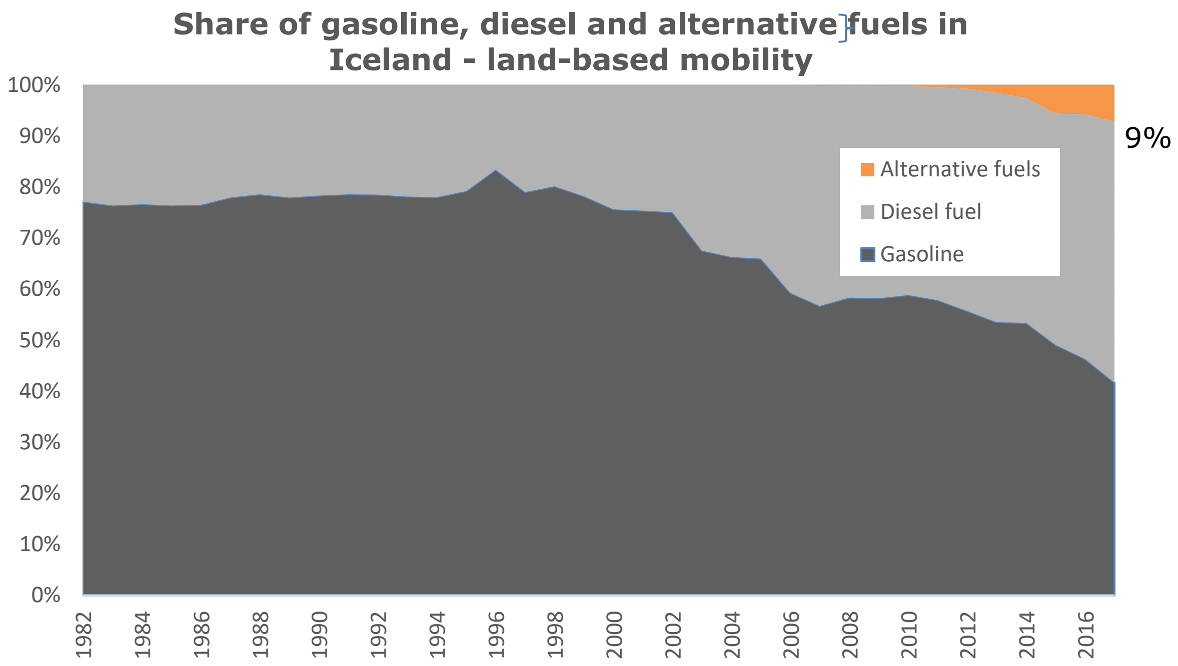
- Iceland aims to be part of a collective delivery by European countries to reach a target of 40% reduction of greenhouse gas emissions by 2030 compared to 1990 levels.
- Iceland signed the Paris Agreement on April 22, 2016 and it was subsequently ratified by the Alþingi, the Icelandic Parliament on September 19, 2016. Iceland‘s Nationally Determined Contributions (NDCs) involve the emissions reduction target of 40% by 2030, compared to 1990. Furthermore, Iceland and Norway aim to align with the EU target of 40% emission reduction by 2030 (based on 1990 levels) by:
  - Achieving a 43% emission reduction total with industrial process under the EU Emissions Trading Scheme by 2030 (based on 2005 levels);
  - Achieving a 30% emission reduction from sources outside of the EU Emissions Trading Scheme (based on 2005 levels).
- The Icelandic government decided to take the national goals a step further. In late 2017, Prime Minister Katrín Jakobsdóttir accounced the national target of carbon neutrality by 2040.
- In 2018* Iceland introduced its climate action plan for 2018–2030 outlining the pathway toward achieving national climate goals and international commitments. The plan covers various actions and means to reach these goals but does not set sector-specific targets. Rather it names desirable scenarios for emission development in the following major contributing sectors:
  - Road transport – scenario for 35% emission reduction by 2030 (compared to 2005 levels)
  - Fisheries – scenario for 45% emission reduction by 2030 (compared to 2005 levels)
  - Agriculture – scenario for 10% emission reduction by 2030 (compared to 2005 levels)
  - Waste – scenario for 40% emission reduction from waste by 2030 (compared to 2005 levels)
  - Hydrofluorocarbons (HFCs) – scenario for 70% emission reduction of HFCs by 2030 (compared to 2005 levels)

* A revised version of the climate action plan was made public on June 23, 2020.

Context

National goals related to increasing the share of non-fossil fuels

- A Parliamentary resolution on energy transition for land and marine transport was approved by Alþingi on May 31, 2017.
- The objective of the strategy for energy transition is to increase the share of renewable energy in land transport from 6% in 2016 to 10% by 2020 and 40% by 2030. An additional goal is to increase the share of renewable energy in the fisheries and marine sector from 0.1% in 2016 to 10% by 2030.
- For land transport, the share of non-fossil fuels has been slowly rising in the past decade.
- The first incentives for alternative fuel vehicles were implemented in 2012 (excise tax and VAT exemption) and 2013 (5% renewable fuel sales obligation).
- At the end of 2019, the share was 9.5% for land transport[1] (mainly passenger vehicles) and 0.1% for marine transport. The energy transition for heavy transport is still in its very first stages.



Significant measures are needed for Iceland to increase further the share of alternative fuels and, simultateously, contribute to meeting its climate goals.

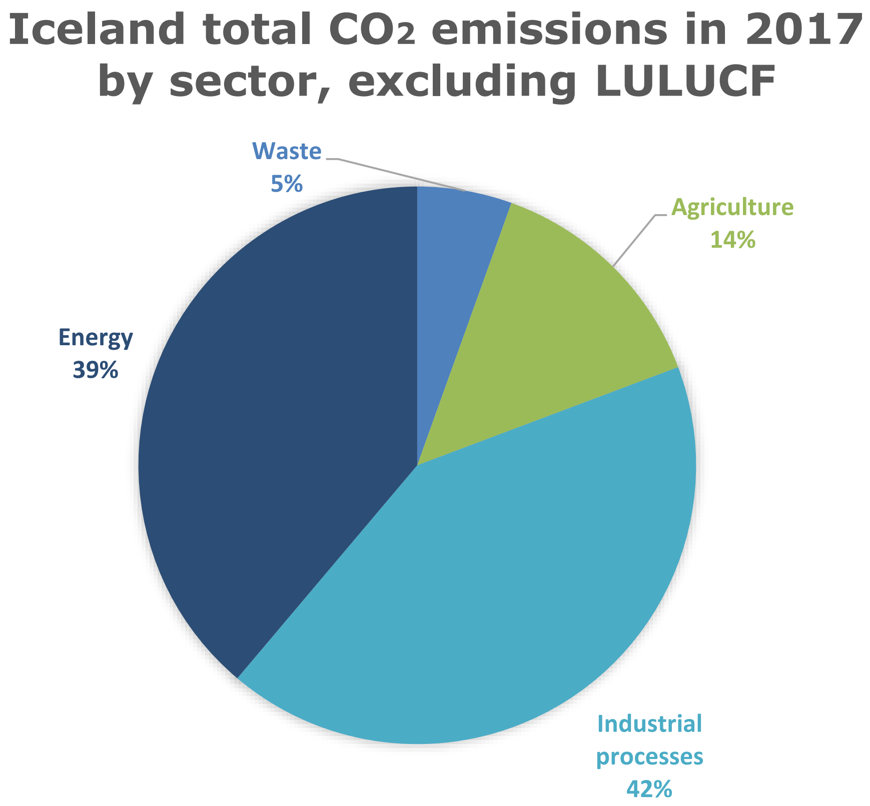
The further adoption of battery electric vehicles alone will not achieve sufficient emission reduction by 2030.

1 Tentative results for 2019 from the National Energy Authority.

Context

Iceland GHG emissions

- The figure on the right displays the division of CO_2 emissions in 2017 between key sectors.
- It should be noted that a significant share of industrial processes, or 90% in 2017, are due to metal production, a sector whose emissions covered by the EU Emissions Trading Scheme (ETS). These emissions are thus not taken into consideration as part of this hydrogen vision.
- It is clear from the figure that the energy rated sectors, where transport and fisheries accounted for 79% of the GHG emissions, are major contributors to Iceland‘s total emissions. Transport and fisheries are also great consumers of fossil fuels.
- Thus, this hydrogen vision focuses solely on these sectors contributing to energy related emissions.

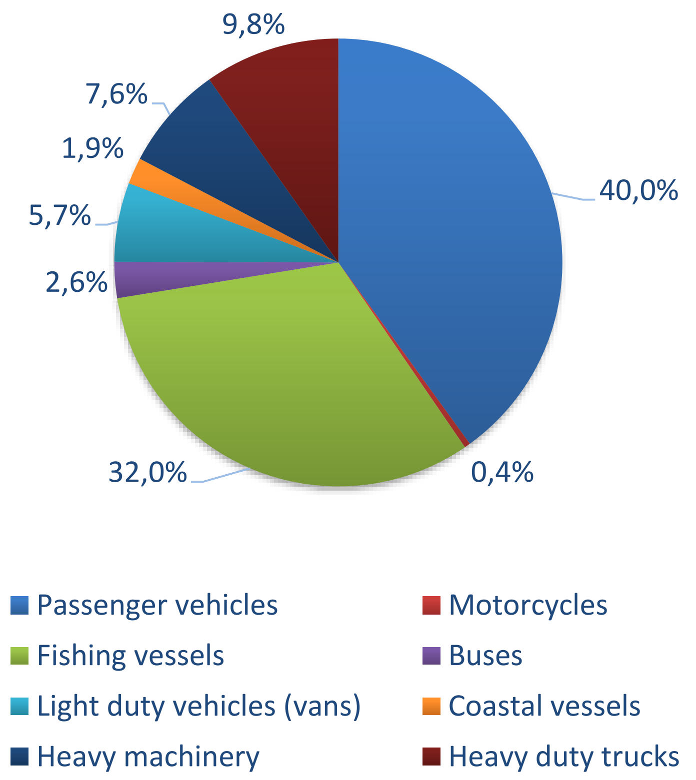


Context

Iceland transport emissions

- Emissions due to passenger vehicles made up 40% of Icelandic transport emissions in 2017, as seen in the pie chart on the right.
- Fishing vessels are also large fossil fuel consumers.
- Although fossil fuel consumption of international aviation (covered above) has quadrupled since 2000, this category will not be addressed specifically as part of the hydrogen vision. Airline flights within Europe are covered by the EU's emissions trading system (ETS) and will be discussed as part of Iceland's 2050 hydrogen roadmap.
- For transport emissions in Iceland, there are significant challenges ahead, specifically with regard to reducing CO_2 emissions from land and marine transport.

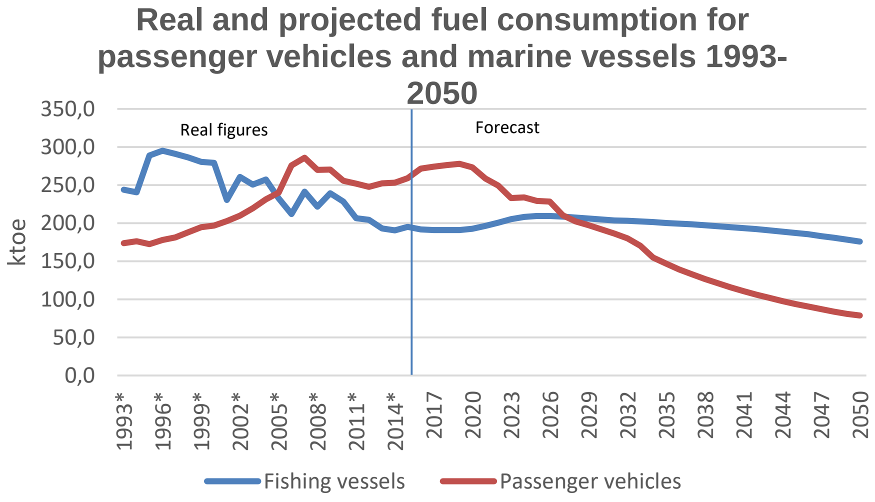
Iceland CO_2 emissions in 2017 by transport sector, land and marine



Context

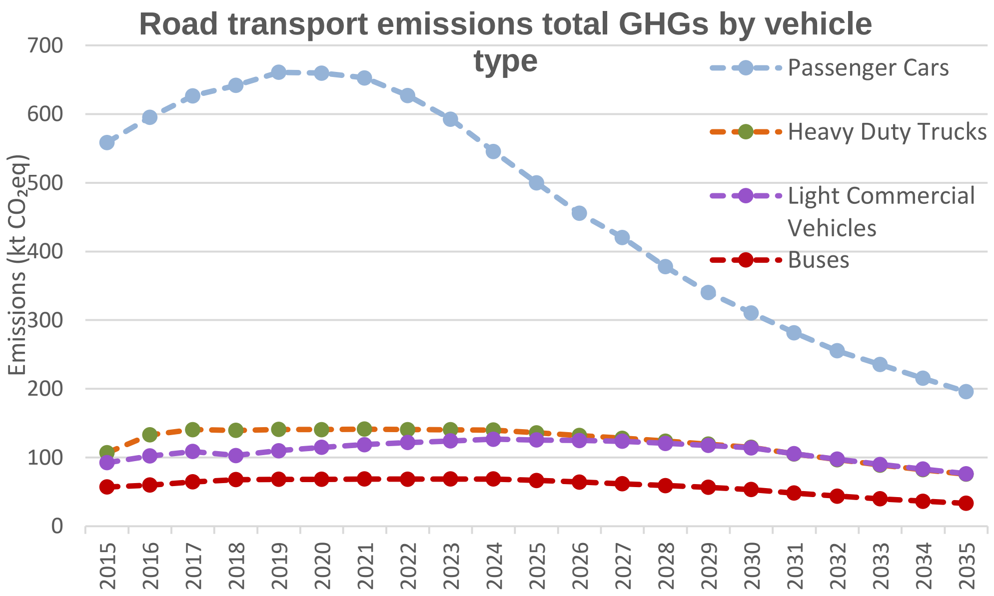
Icelandic forecast for fuel consumption and emissions due to road transport

The figure below displays Iceland's official fuel consumption forecast for fishing vessels and passenger vehicles 2016-2050 and actual figures for the period 2000-2015. The official fuel use forecast projects that passenger vehicle oil consumption (red) will be reduced by one third by 2030 compared to 2017 levels due to electrification of the fleet. Little change is expected for fishing vessels (blue) until after 2035, with the *most optimistic scenario predicting 16% renewable fuels by 2030*.



Reference: Fuel use forecast 2016-2050. https://orkustofnun.is/gogn/Skyrslur/OS-2016/OS-2016-02.pdf

According to The Environment Agency of Iceland's 2019 report on policies and measures and projections, emissions due to passenger vehicles are expected to decrease by half by 2030 compared to 2017 levels (as evident in the figure below), and this is also attributed to incentives and measures to support the electrification of the vehicle fleet.

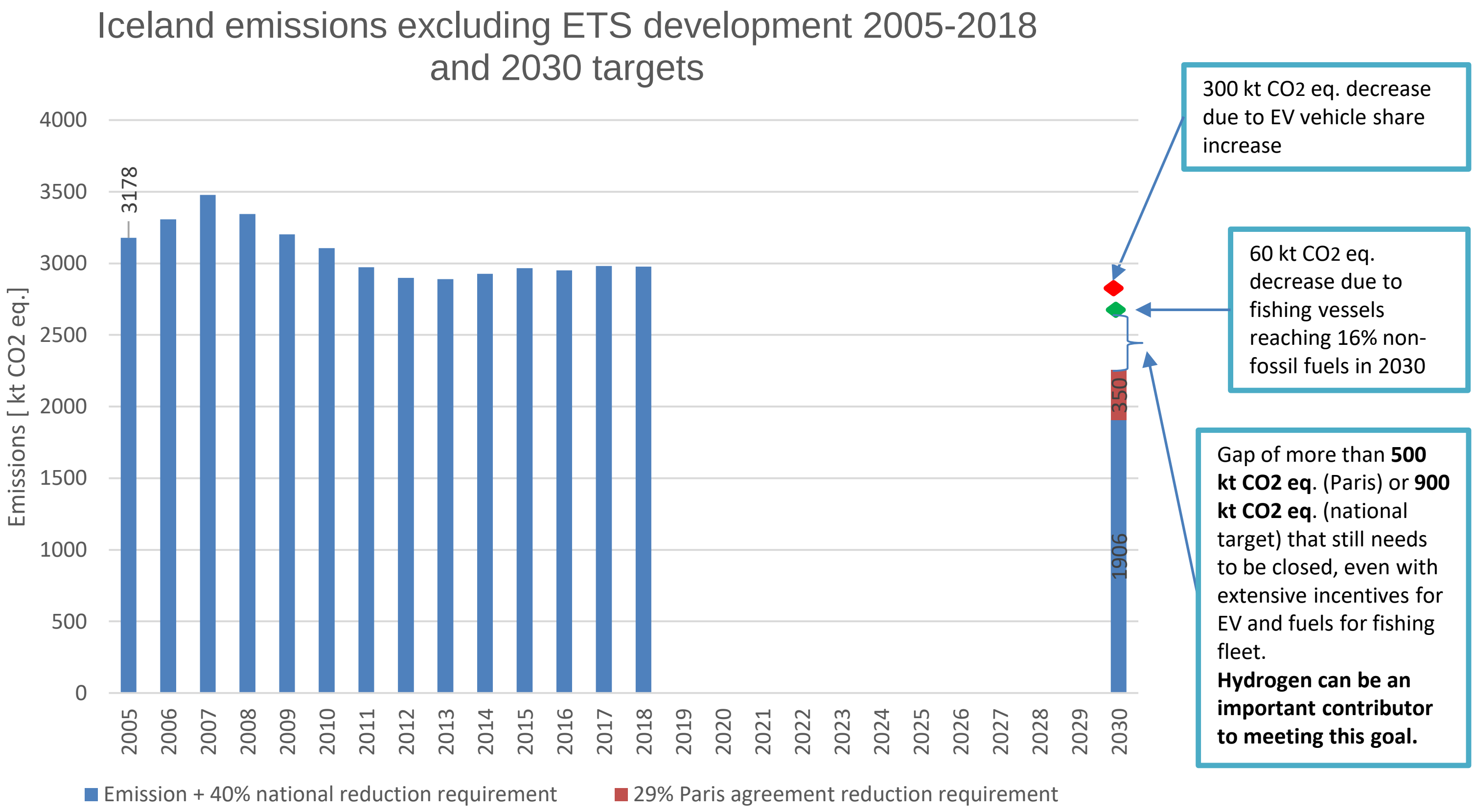


Reference: Iceland's Report on Policies and Measures and Projections, 2019.
https://ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/PaMs%20final%20April%202019.pdf

Trends in Icelandic transport with existing governmental measures

According to EAI projections, emissions from road transport are projected to peak in 2020 and then steadily decline, dropping below 1990 levels by 2035. This reduction in emissions is due to the rapid electrification of the vehicle fleet from 2015. By 2025 it is expected that approximately 20% of all road vehicles will be electric, rising to 55% by 2035.

However, the reduction of emissions due to passenger vehicles by half by 2030 (by 300 kt CO_2 eq.) and by 16% for fishing vessels is not sufficient to fulfill Iceland’s international commitments for GHG reduction.



Source: Environmental Agency of Iceland https://ust.is/loft/losun-grodurhusalofttegunda/skuldbindingar-islands/

Context

The GHG gap is over 500 kt CO_2 eq. – assuming fossil fuel consumption is the sole contributor towards emission reduction in Iceland*

- The trend indicates a gap of over 500 kt CO_2 eq. to reach Iceland's Paris Agreement emission targets in 2030.
- This includes a massive introduction of BEVs during the current decade until 2030.
- Hydrogen and e-fuels (based on hydrogen production) can fill the gap.
- To close the gap a considerable amount of hydrogen is needed:

  550 kt CO_2 eq. GHG emission = ~240 million litres gasoline

  240 million litres gasoline can be replaced by ~ 40.000 tonnes of H_2

  Based on 6 L gasoline consumption per 100 km for passenger vehicles versus 1 kg H_2 per 100 km driven

  For production of 40.000 tonnes of H_2 2.200.000 MWh are needed

  At 8.000 hr/yr utilization this would require approximately 255 MW renewable electricity capacity

Note: for the national 2030 target, the gap is 900 kt CO2 eq.

Where 900 kt GHG emission = ~400 million litres gasoline
400 million litres gasoline can be replaced by ~ 70.000 tonnes of H_2

*For the purposes of this hydrogen vision, fossil fuel consumption is the main focus. The Government has implemented numerous policies and measures to support emission reduction in sectors other than transport and fisheries, for example: afforestation, soil reclamation, waste treatment and F-gas phase down. Such measures will also contribute to reducing the gap. Calculations shown here assume that reduced GHG is derived solely through the reduction of fossil fuel consumption.

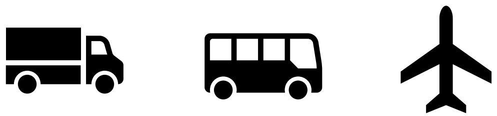
Context

It is clear that the implementation and adoption of a mix of technologies and fuels will be required for Iceland to fulfill its international commitments and achieve national emission reduction targets.

In Iceland, the following sectors are the greatest consumers of fossil fuels and are significant contributors to total national GHG emissions. Hydrogen and other electrofuels could play an important role in sectorial energy transition to power various types of mobility.

For land mobility,
EVs, FCEVs and Power to X will prove important technologies for emission reduction and energy transition.

For heavy duty applications such as trucks, buses and coaches and aviation, hydrogen will also play a role.



Marine transport will require a mix of hydrogen rich fuels as a bridging technology from fossil fuels, including ammonia, hydrogen and methanol.

Pictured: A past reality

- Introduction
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Role of H_2 in Iceland

- As of 2020, Iceland has two H_2 production sites:
  - Svartsengi geothermal power plant (operated by Carbon Recycling International): 1500 Nm^3/hr production capacity. All the H_2 has been used for methanol production (e-fuels) both for local and export market.
    - Currently there is no other industrial use of H_2.
  - Hellisheiði geothermal power plant (operated by ON Power): 150 Nm^3/hr production capacity. All the H_2 has been used for transport activities mainly within the H2ME-2 project*.

HRS Vesturlandsvegur

HRS Miklabraut

HRS Keflavík

Hydrogen Mobility Europe

24 vehicles delivered so far under H2ME project: Hyundai ix35, Hyundai Nexo, Toyota Mirai

NOTE
Though Hellisheiði is currently the only hydrogen production site in Iceland delivering H_2 for FCEV vehicles, the National Power Company recently announced plans for a 10 MW hydrogen production facility at its 16 MW Ljósifoss Power Station, 70 km outside Reykjavík.

*This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No. 671438 and No 700350. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe Research and Hydrogen Europe.

Opportunities

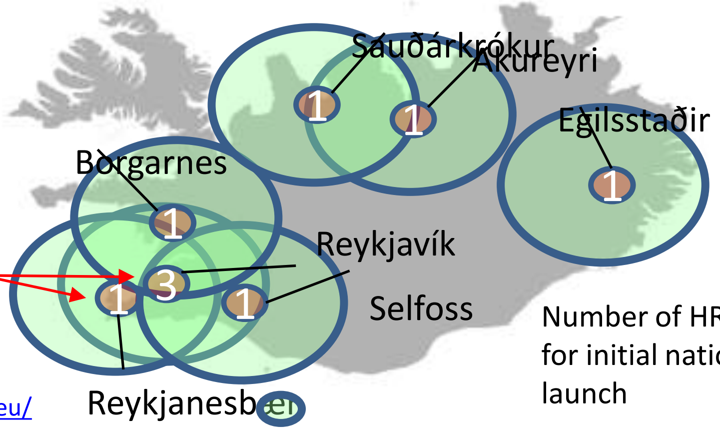
- Hydrogen will be one of the key fuels for all different transport modes
  - BEVs and batteries in general provide a great opportunity for many sectors but are unlikely to be able to decarbonize all transport modes.
  - Specifically battery electric vehicles are well suited for:
    - The compact car segment
    - Vans, specifically within city distribution and service
    - Buses for shorter routes
    - Propulsion of ferries and small boats
- Hydrogen can be the main element to complete all other segments:
  - FCEVs, specifically larger vehicles and long range vehicles, including taxis
  - Cargo vans with heavier loads requiring longer range
  - Buses (rapid transport) and coaches, for which short refueling times and long range are required
  - Other heavy duty vehicles, especially trucks
  - All fuel needs for the marine sector
  - Future opportunities for aviation fuels
- Finally, hydrogen and/or e-fuels can play a vital role as back-up energy solutions and to replace fossil fuel electric generation at off-grid locations, isolated farms and smaller islands.

Barriers and pathways

- The vision does not only see hydrogen for direct use in fuel cells, though this is the most efficient use.
  - Fuel cells have not reached the same maturity as internal combustion engines and it will still take some time.
- Storage and availability are still in development phase.
  - It will take time and investments to provide global hydrogen infrastructure and storage methods, specifically looking towards marine fuel use.
- Using hydrogen directly in aviation is also some years away.
- Still hydrogen holds the key to solving all the fuel needs of these applications as the main building block in e-fuels.
- E-fuel production will also provide the *economies of scale* for hydrogen production, with the effect of allowing hydrogen to be sold at prices competitive with fossil fuels.
- All hydrogen produced will be from renewable resources – Iceland's grid consists only of hydro and geothermal electricity and fulfills CertifHy* (Guarantees of Origin need to be provided).

H2ME Hydrogen Mobility Europe

Currently 3 stations



Number of HRS for initial national launch

New infrastructure for a national network is needed

*CertifHy Guarantee of Origin for Green Hydrogen https://www.certifhy.eu/

Production capacity/needs

- Depending on pathways and which fuel is needed for different applications (H_2 directly or e-fuels) the electricity needs are 100–150 MW (slide 15 shows 110 MW but if e-fuels are a large part of the fuel extra energy is needed).
  - National targets would require three times more hydrogen.
- This corresponds to around 15.000 tonnes of H_2 production per/yr.
  - Assuming purely electrolytic production.
- This would represent less than 5% of current installed capacity in Iceland.
- H_2 production has the advantage of flexibility and grid balancing and as such can impact the electricity market in a more positive way than users requiring constant power.
- Increased expected efficiency and potentially plug-in technology with H_2 (hydrogen range extended vehicles) can reduce the energy demand.

NOTE
It should be noted that the future can bring complex scenarios or require a mix of solutions to the market. Here only a simplified example is used, i.e. where H_2 replaces gasoline in passenger vehicles. Different scenarios can influence such calculations as well as composition of H_2 vehicles, be it passenger, heavy duty, buses or other types.

Economies of scale

- Price parity with fossil fuel can be reached today in Iceland if production capacity of H_2 is brought to scale. Different scenarios should be examined.
- Larger scale projects
  - Fleets of heavy duty vehicles, buses or vehicles with high utilization (taxis and alike)
- Power to X (PtX) is a very interesting pathway to increase production beyond small demos
  - Various utilization of e-fuels is possible and simultaneously H_2 production reaches economies of scale.
- Other pathways and benefits are also possible.
  - Utilizing other resources from the hydrogen production will greatly impact economics of hydrogen applicatioins. There are great values in the complete hydrogen production cycle which can influence economics of multiple industries:
    - Heat from the electrolyzers
    - Oxygen from the electrolyzers (fish farms specifically)
    - Seasonal energy production (wind, solar, hydro storage)
    - Grid balancing

Renewable geothermal power plant:
H_2 production and various PtX pathways

Large scale PtX

Taxi/rental

Ships

Fuel cell

Trucks

Buses

Vans

Direct use

Renewable resources

Geothermal
Hydro
Wind
Etc.

Large scale H_2 production >10 MW scale

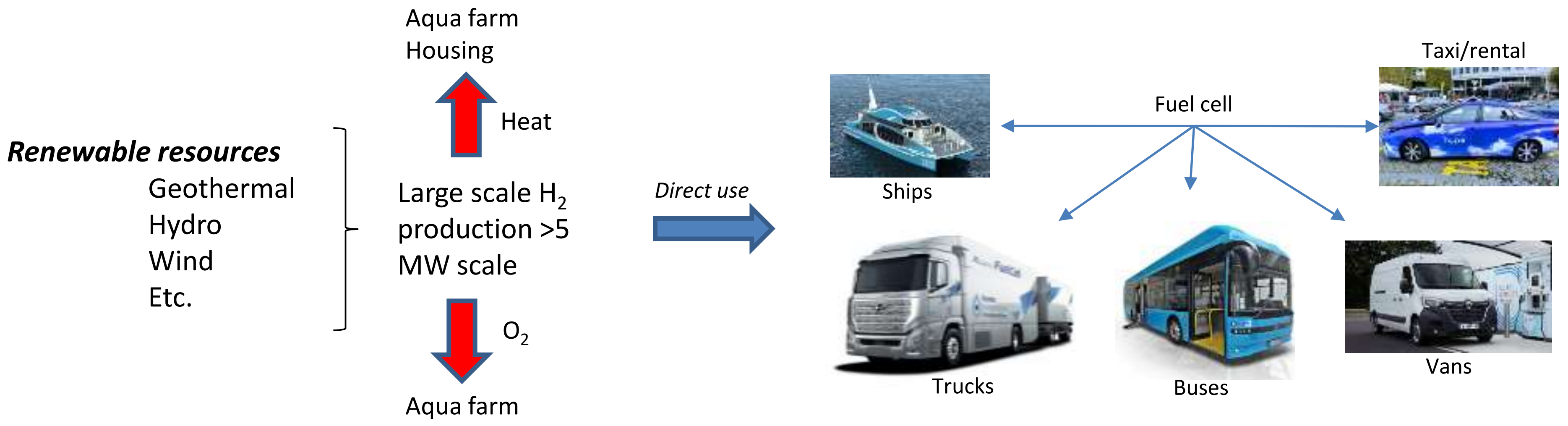
ELECTROFUELS (renewable)

Ammonia
Synthetic methane (green gas)
Methanol
Blue Crude
DME

Export market

Marine fuel
Any application where H_2 can not be directly used

Alternative "large" scale H_2 production



Hydrogen competitive with fossil fuel

- With economies of scale hydrogen production will reach competitive prices with fossil fuel.
- Calculations have shown that with scale > 5 MW hydrogen cost will come close to parity with fossil fuel based on cost per km driven.
- With even larger scale or combined with a PtX installation H_2 will quickly reach parity with fossil fuel.
- With hydrogen vehicle cost reductions specifically in larger categories, Iceland can speed up the transition from fossil fuel to zero emission technologies in all vehicle segments earlier than most other countries.
- With support of first projects now, a general introduction of H_2 vehicles can become commercial before 2030 and therefore drastically support Iceland´s GHG emission targets for 2030.

New HRS opening in Iceland 2018:
3 stations are now in and around Reykjavík

Buses and coaches

Current situation

- Fuel cell buses have been demonstrated in various cities over many years. Further technology development and demonstration is underway (e.g. via the JIVE projects) and plans for commercialization of the sector are in place (based on increased scale of deployment).
- Iceland requires city buses in urban centres (Reykjavík and Akureyri), inter-city buses that travel round the island, and tourist buses (coaches).
- Fuel cell buses are well suited to delivering services in Iceland due to their long range (ability to run all day without refuelling), and short refuelling times.

Vision to 2030

A phased programme of hydrogen fuel cell bus and coach trials and implementation resulting in the replacement of all diesel buses with zero emission alternatives by 2035:

- City buses (total fleet = 120): deploy first fleet (50+ buses) by 2025, transition all city buses in Iceland to hydrogen by 2035.
- Inter-city buses and coaches (total fleet >2200): trial of first fleet(s) in 2025 – 2030 period. Phased transition to 100% hydrogen fleet by 2040.

Challenges and risks

- Limited availability of fuel cell buses (as of 2020).
- No fuel cell coach on the market.
- Investment costs.
- Lack of local expertise for FC bus repair and maintenance.
- Requirement for new refuelling infrastructure to serve new vehicle fleets.

Actions for local stakeholders

- Follow developments in the fuel cell bus and coach sector.
- Finalize alternative fuels strategy for all city buses, commit to zero emission replacement programme.
- Plan first trials of inter-city buses & coaches.
- Consider needs of inter-city buses & coaches in planning national HRS network.

Trucks and vans

Current situation

- Fuel cell trucks and vans are being demonstrated in a handful of locations and OEMs are developing solutions. Demonstration will greatly expand during the next few years, specifically planned for Switzerland and Norway. OEMs foresee a great production increase during this decade.
- Most of Iceland's truck routes are relatively long and pass through mountainous regions requiring long range and rapid refuelling.
- Fuel cell trucks and vans are well suited to delivering services in Iceland due to their long range (ability to run all day without refuelling), and short refuelling times.

Vision to 2030

A phased programme of hydrogen truck and van trials and implementation. Truck and van TCO should reach diesel parity by 2030 resulting in great shift from diesel to hydrogen during the next decade:

- Trucks (total fleet = 12483): deploy first fleet (25+ trucks) by 2025, transition to major shift following 2030.
- Vans (total fleet = 28059): deploy first fleet (50+ vans) by 2025. In 2030, 50% of all new sales should be zero emission.

Challenges and risks

- Limited availability of fuel cell trucks (as of 2020).
- Fuel cell tractor trailers very limited on the market.
- Investment costs. TCO can be reached with incentives.
- Lack of local expertise for repair and maintenance.
- Requirement for new refueling infrastructure to serve new vehicle fleets.

Actions for local stakeholders

- Follow developments in the fuel cell truck and van sector.
- Finalize and implement incentive programmes for zero emission commercial transport (incl. vans).
- Encourage, and support, key stakeholders to first trials.
- Consider needs in planning national HRS network.

High utilization vehicles

Current situation

- Fuel cell taxi fleets are being introduced in various cities around Europe. The largest fleets are in Paris and now Copenhagen will follow with a large fleet deployed from 2020.
  - Trials have given good results and are showing great potential for growth.
- Fleet operators for vehicles which need long distance and/or fast refueling are searching for solutions.
- Vehicles currently introduced to the market can mostly cope with the demand from the operators now.

Challenges and risks

- Vehicle availability and lifetime still an issue. Vehicles provide a demanding cycle, up to 100.000 km per year.
  - Maintenance facility and spare parts security needs to be very high.
- Limited infrastructure distribution reduces usage and security of supply.
- Still relatively high investment cost.

Vision to 2030

Fleet introduction should start.

- Marketing for high mileage with hydrogen is beginning.
- More infrastructure is needed, specifically at tourism “hot spots” and around the ring road to secure supply and availability of fuel.
- Public key stakeholders should get involved at an early stage to demonstrate the potential of the technology.
- 30% of all taxis should be zero emission by 2030 where H_2 could be the key fuel of choice.

Actions for local stakeholders

- Incentives need to be implemented.
  - Priority lanes/parking for zero emission vehicles.
  - Issue new taxi licenses only for zero emission usage.
  - Priority access to certain parts of major cities (Reykjavík).
- Direct financial support for construction of new infrastructure.

Marine applications

Current situation

- First trials are beginning and first pure hydrogen fuel cell vessels will be demonstrated in the next couple of years. Potentials for service boats (for example aqua farms) are also being designed.
- Ship operators are searching for green alternatives and view renewable e-fuels as key for the next decade(s).
- Engine development for methanol and ammonia are very promising as well as fuel cells for direct use. Synthetic natural gas as well as "green" crude are also opportunities in the field of e-fuels based on renewable hydrogen.

Vision to 2030

All potential pathways should be investigated.

- PtX pathways should be investigated for e-fuels which can replace current fossil fuels.
- Demonstration of direct hydrogen use in marine application, either as part, auxiliary or complete propulsion fuel.
- Blend of locally made e-fuels, or hydrogen, should become at least 5% of marine fuel in Iceland before 2030.
- Implement similar policy for marine fuel as for land transport.

Challenges and risks

- Demonstrations of direct hydrogen use are just starting (as of 2020).
- Limited or no infrastructure to dispense hydrogen directly on to ships. Requirements and standards have to be researched in more depth.
- High costs (TCO) relative to diesel for direct hydrogen use.
- Knowledge limited and regulatory system not in place.

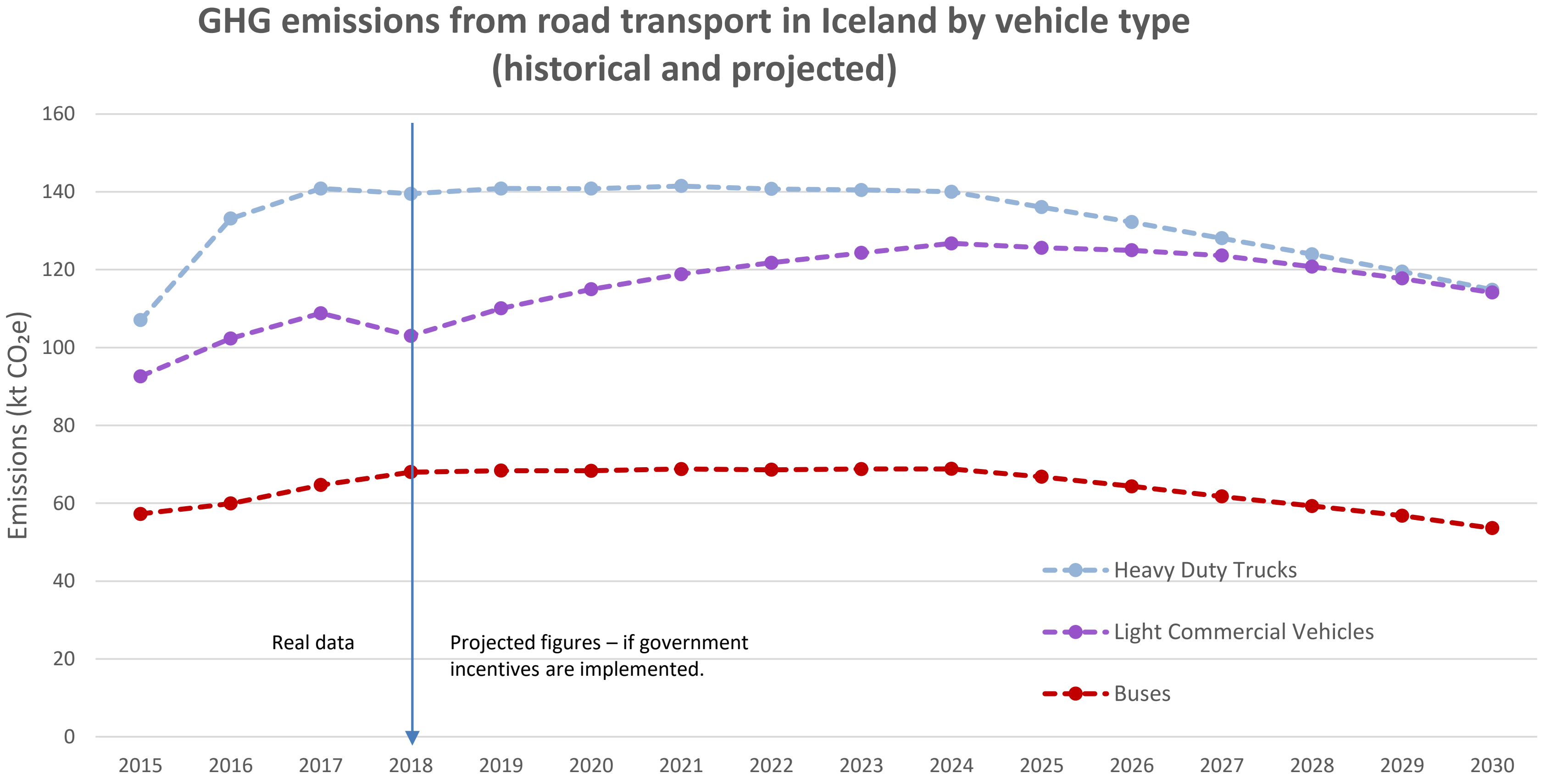
Actions for local stakeholders

- Follow developments in the ship design sector.
- Government commissioning of ships it operates.
- Implement incentive programmes for zero (or drastically reduced) emission in ships.
- Stimulate a dialogue with key international stakeholders which have targeted drastic reduced GHG.
- R&D projects evaluating different infrastructure pathways for various e-fuel solutions and for hydrogen direct applications.

Potential effect of increased H_2 introduction beyond 2020 – large vehicles

This chart to the right shows the EAI forecast for GHG emission reduction for larger vehicles. It assumes around 20% reduction by 2030. It is unlikely to be reached, even with stricter emission regulations taking effect within EU.

Hydrogen is currently visioned as a key fuel in these vehicle categories and must be implemented within 2-3 years in order to significantly contribute to 2030 targets. If successful, Iceland might be able to achieve greater progress than this optimistic development, specifically in the heavy duty segment.



Source: Environmental Agency of Iceland
https://ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/PaMs%20final%20April%202019.pdf

- Introduction
- Context
- Hydrogen production & applications
- **Action plan & conclusions**

Action plan

- The benefits of *economies of scale* need to be implemented.
  - Larger production facilities than 5 MW
- PtX pathways provide settings for such installations.
  - Feasibility studies should be implemented for various pathways – ammonia, methanol, synthetic methane, “green crude”, etc.
  - Market studies should be initiated with key stakeholders both local and international.
- Other benefits of hydrogen such as heat and oxygen should be explored with stakeholders.
- Incentive programmes should be tailored for larger vehicles – buses, coaches, vans, trucks and the like. The goal is to stimulate the local market for hydrogen and address segments not addressed today.
  - These need to be innovative, i.e. a general VAT reduction scheme does not work the same way for larger vehicles (except city buses).
  - Direct financial subsidies should be considered.
  - New green taxi licenses should be issued.
  - Incentives for marine use of ecofriendly fuels should be established.
- Increased support is needed for infrastructure, both directly for hydrogen and e-fuels.

Conclusion

- At current pace of reducing Icelandic GHG emissions, the country will not reach set climate targets.
- The government has to stimulate the use of renewable fuel, e-fuels including hydrogen, if the climate targets are to be met.
- Market behavior change takes years
  - First OEM produced BEVs demonstrated in Iceland in 2009.
  - Real market uptake 10 years later – pure BEVs still only 1.43% of total car fleet in 2019.
- Activating the market now will create a major shift at the end of the decade.
  - If the same trend will happen for heavy duty (incl. buses and marine fuel use) Iceland, even with a major H_2 and e-fuel push will not reach climate targets. Shifting from one fuel to another takes time.

New Climate Action Plan announced by the Government (23.06.2020)

Following indications that the nation will not reach the Paris Agreement The Government of Iceland has announced a 7-fold increase to previous announced action raising contribution to climate actions to 300M€ until 2024.
Most emphasis within the action plan is kicking the fossil fuel addction with renewalble energy (fuels) and key new emphasis in the action plan are larger vehicles (heavy duty) and marine fuel. This H_2 vision is inline with these emphasis and with this stimulouse package Iceland should reach the goals of the Paris Agreement and also national goals for a 40% GHG emission reduction by 2030. H2 will be an important element in reaching that goal.

Conclusion (continued)

- By direct push, the Government can change the pace but for that **actions are needed now**
  - The new climate action plan will deliver this push
- This includes:
  - Incentives for larger vehicles
  - Feasibility studies and preparations for e-fuel production, incl. methanol, methane, ammonia, synthetic diesel etc. hydrogen based fuels
  - Infrastructure support for heavy duty hydrogen vehicles
  - Incentives for e-fuels being used in the maritime sector
  - Hydrogen roadmap 2050

Iceland today:
Renewable energy is the key in keeping to sky blue

About the author

- Icelandic New Energy (INE) was founded in 1999 as a research and development company working projects related to hydrogen and fuel cells. In its 20 years INE has taken part in and led numerous projects on a local, national, regional and international level. INE has operated a hydrogen refueling station, hydrogen ICE vehicles, FCEVs, BEVs, tested fuel cells for marine application both with hydrogen and batteries and conducted various economic, environmental and social research projects in addition to serving as a consultant to government institutions both domestic and foreign.
- Today, the company‘s sole purpose is to eliminate the use of fossil fuels in Icelandic transport.
- Key owners: Government of Iceland, National Power Company, Reykjavík Energy and HS Orka

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