

Energy Systems Integration using Hydrogen

The Role of Scotland's Gas Network in reaching Net-zero

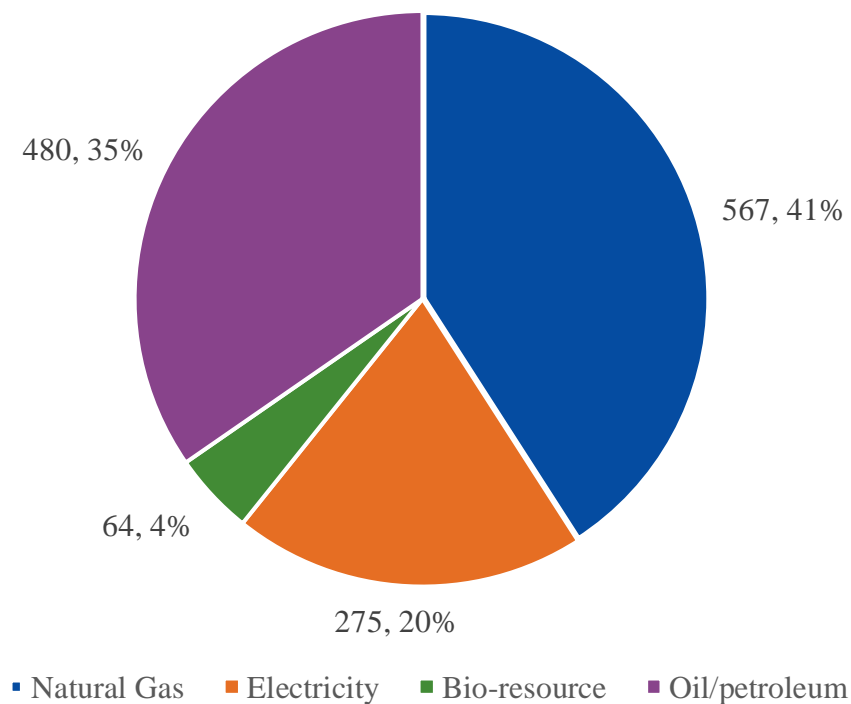
Adam Frew

11 March 2022

UK Natural Gas Consumption

What do we use it for?

End User Energy Demand (TWh)

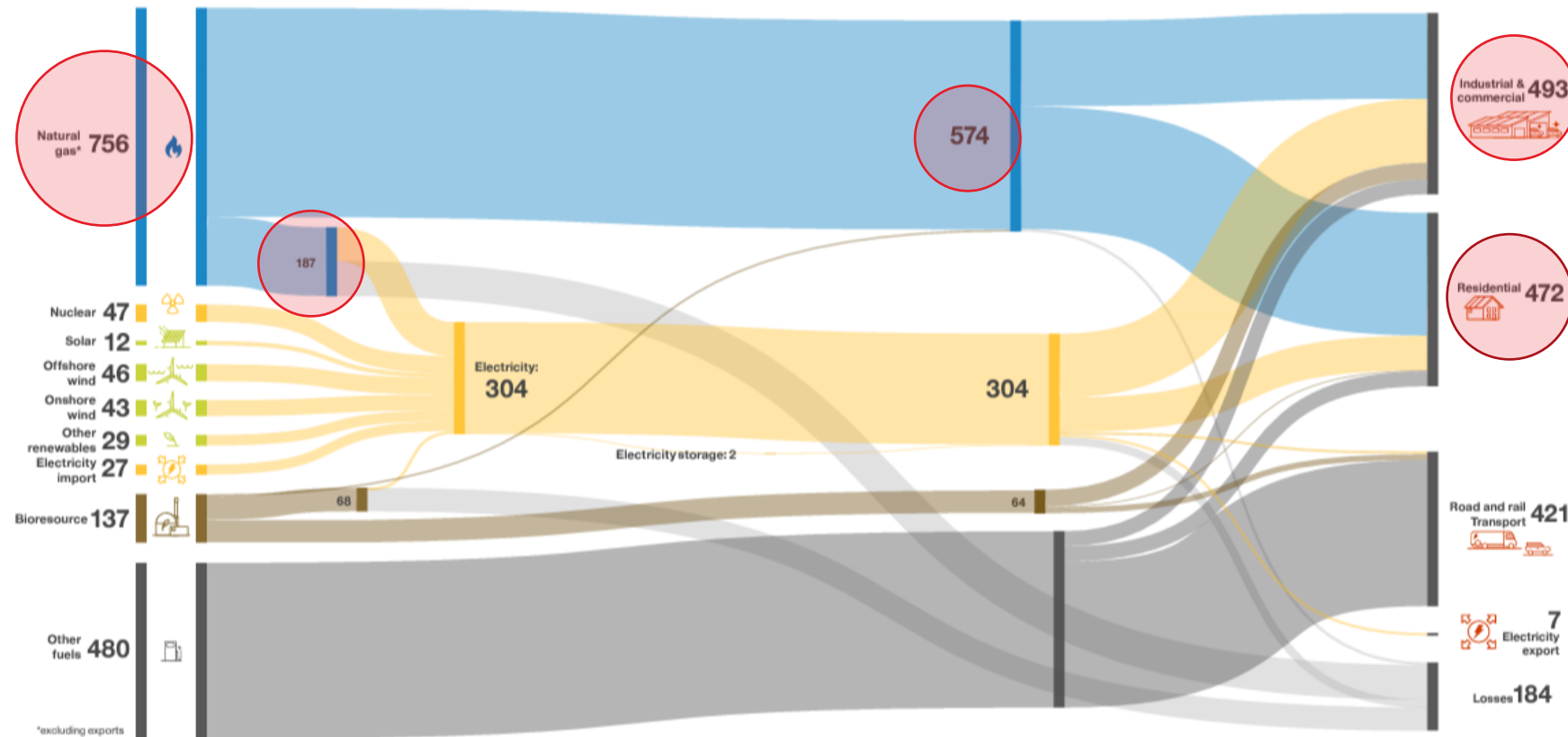


2020 Energy Flows

Source: National Grid ESO Future Energy Scenarios July 2021

UK Natural Gas Flows

What do we use it for?

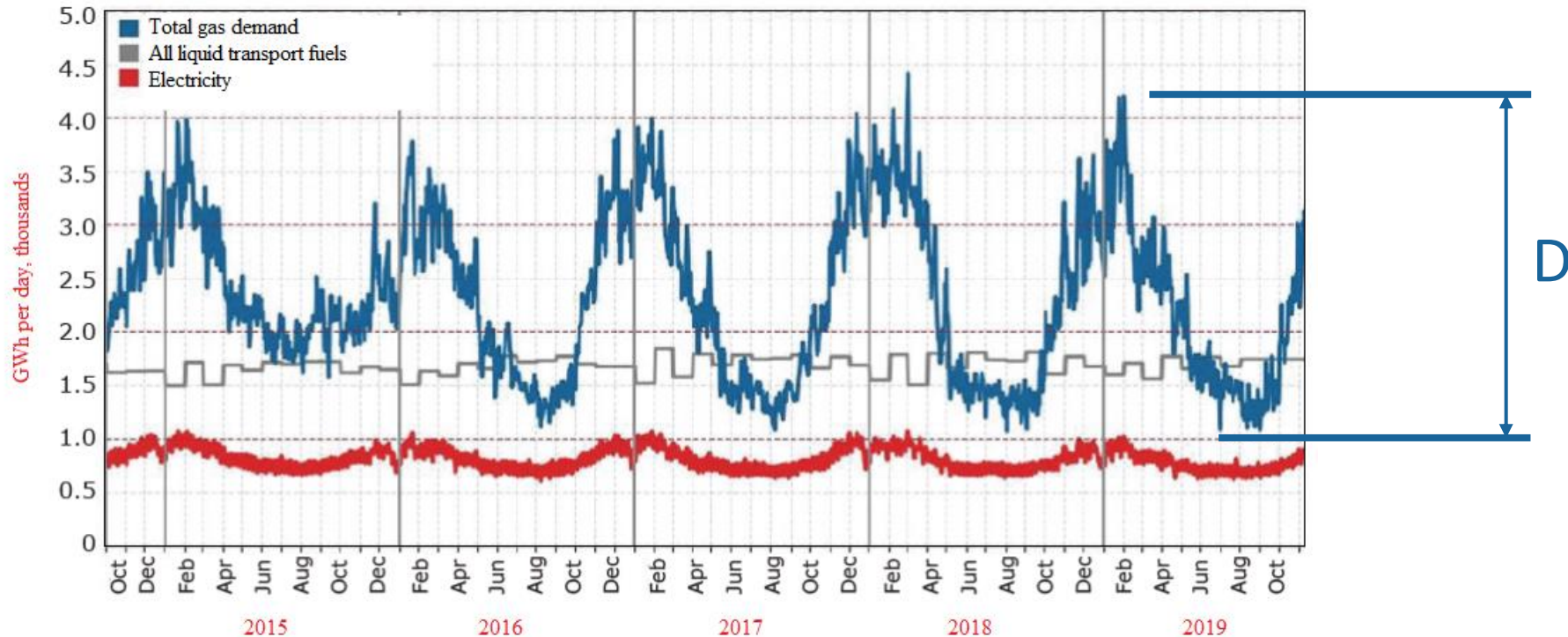


2020 Energy Flows

Source: National Grid ESO Future Energy Scenarios July 2021

Scotland's Gas Network

Annual Seasonality of Gas Demand



Source: National Grid, Elexon and BEIS. Charts are licensed under an Attribution-No Derivatives 4.0 International license. By Grant Wilson, University of Sheffield, UK

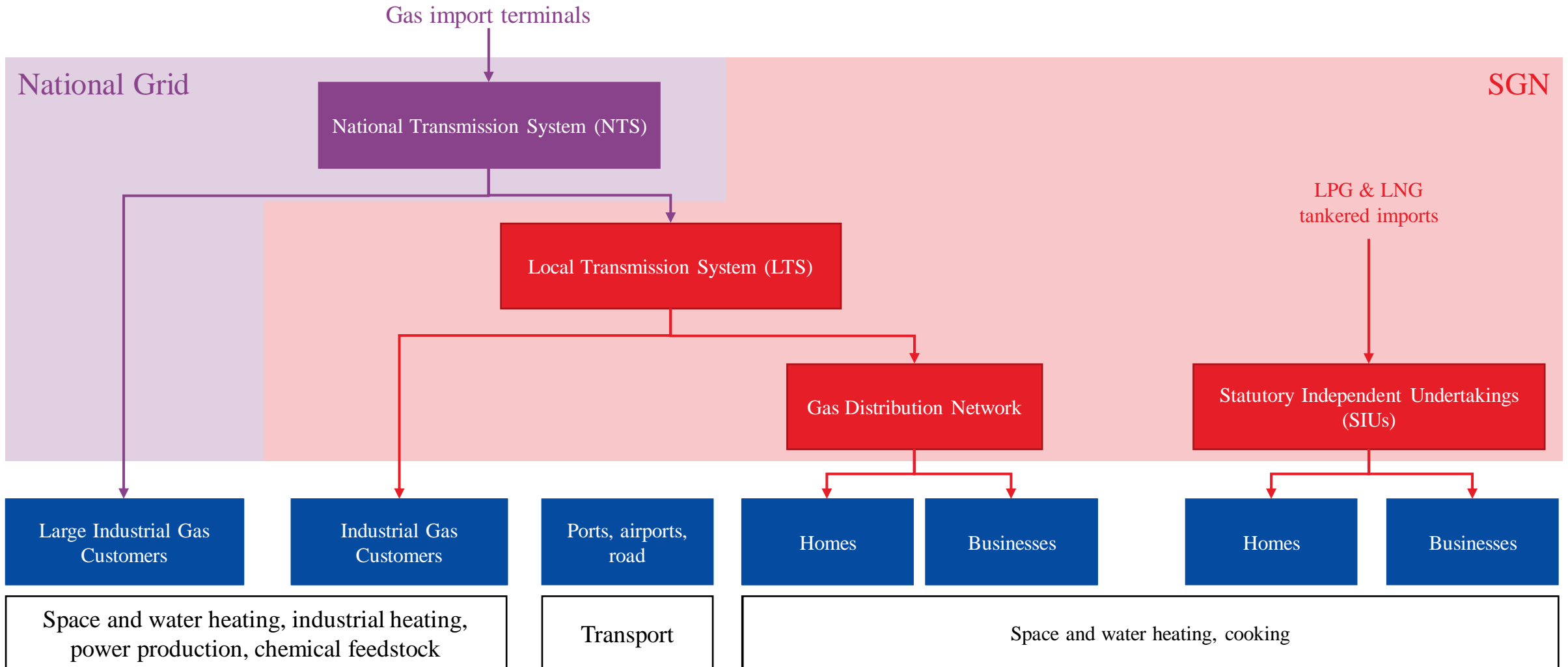
A Decarbonised Gas Network

Role and Rationale Considerations

- Decarbonising existing end-users of natural gas via electrification may not be appropriate, desirable or practicable.
- A gas network can both store and transport energy, reducing the need to over-size renewable power generation.
- A decarbonised network could be expanded upon to facilitate transport, power and industrial decarbonisation.
- Scotland's abundant renewable energy could be exported via gas pipelines as hydrogen to nearby markets.
- CO₂ disposal and sequestration from difficult-to-decarbonise and negative emitters could be achieved via gas networks.

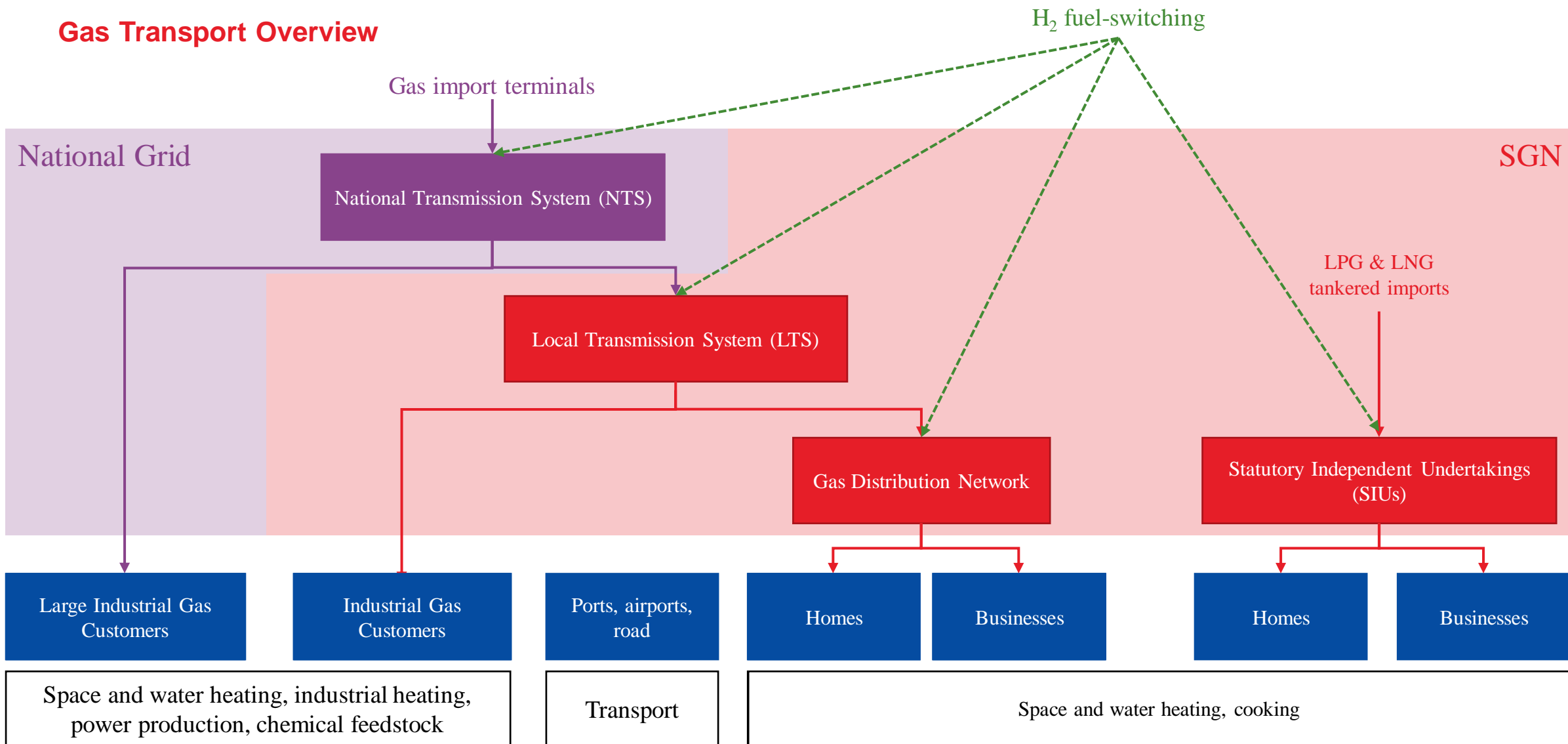
Scotland's Gas Network

Gas Transport Overview



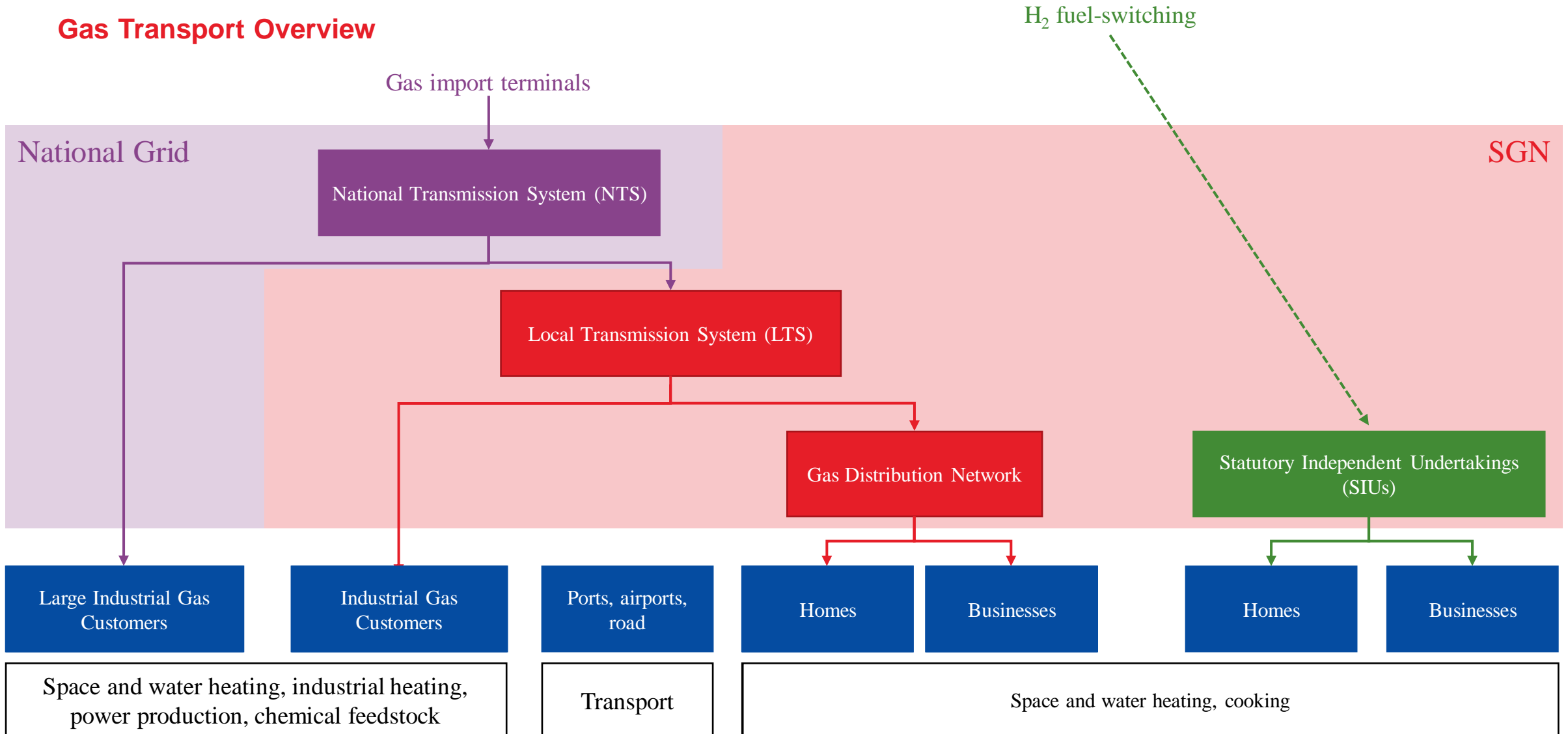
Scotland's Gas Network

Gas Transport Overview



Scotland's Gas Network

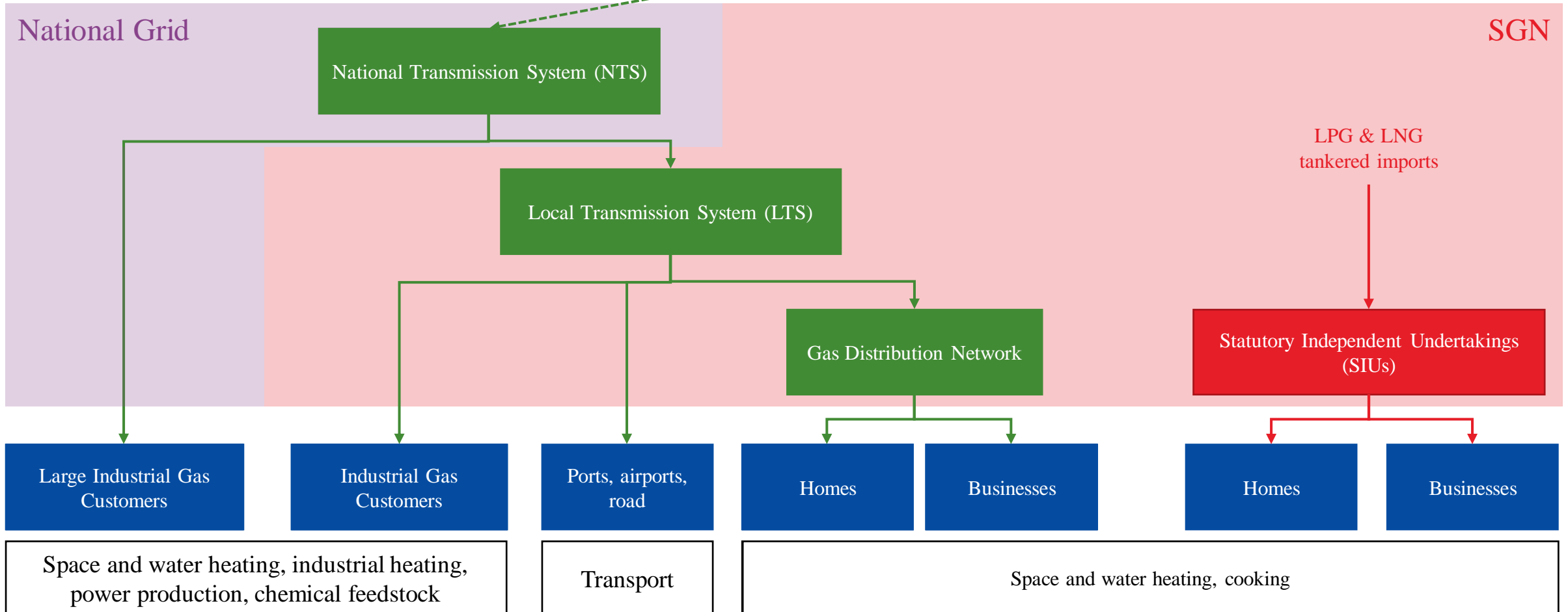
Gas Transport Overview



Scotland's Gas Network

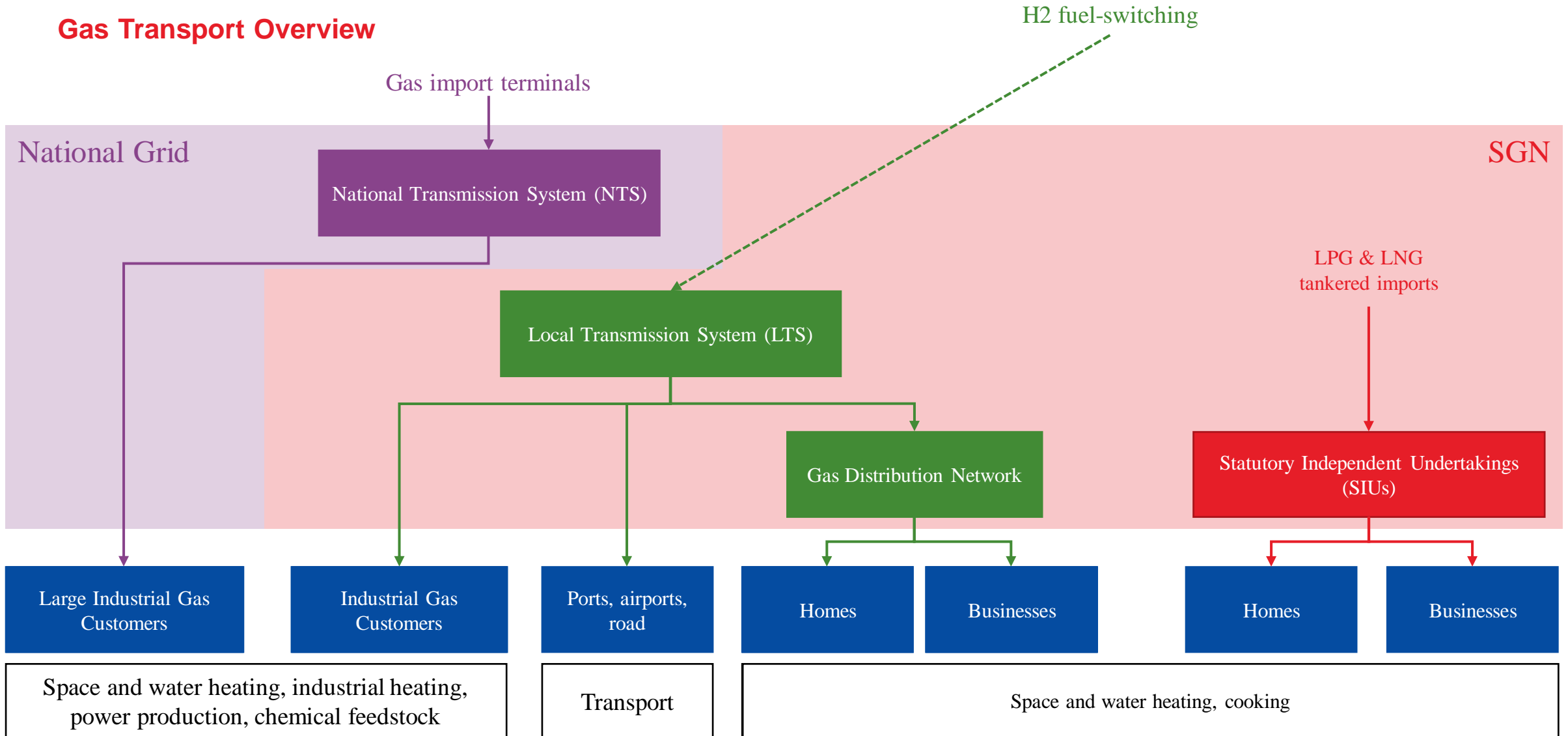
Gas Transport Overview

H₂ fuel-switching



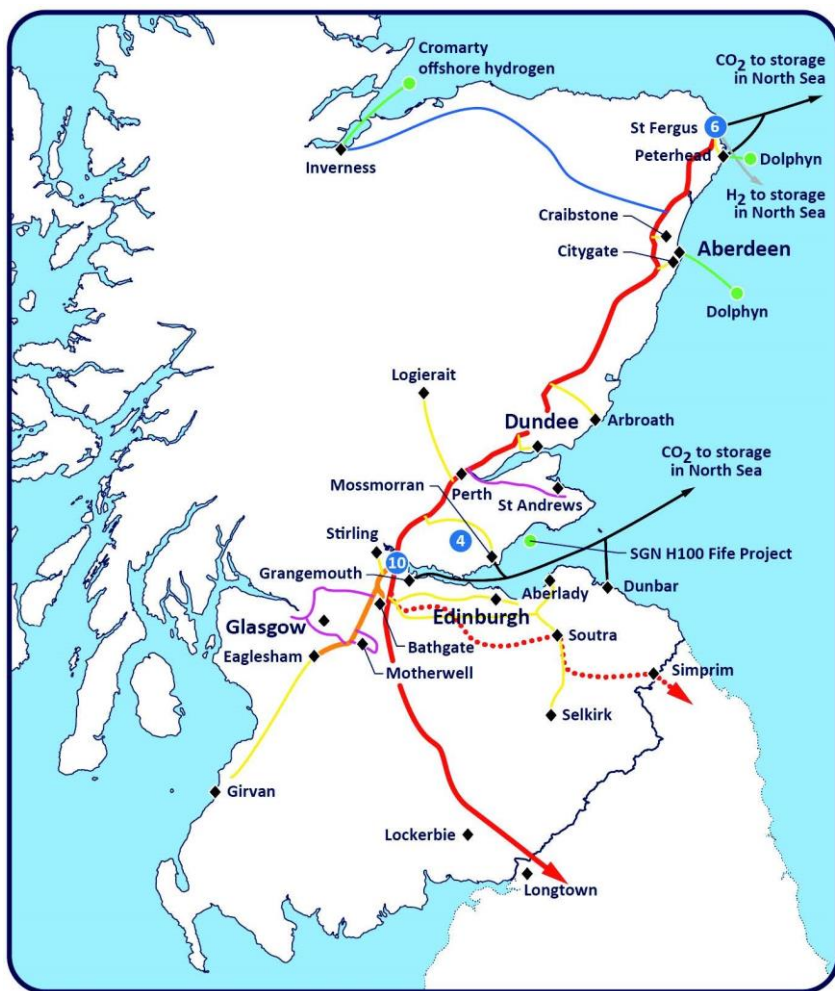
Scotland's Gas Network

Gas Transport Overview



Initiatives Underway

SGN North-East Network & Industrial Clusters Project



- Legend**
- New main hydrogen trunkline
 - Alternative main hydrogen trunkline
 - Main hydrogen spur line
 - Repurposed existing spur line
 - New hydrogen spur line
 - New or repurposed spur line
 - CO2 network
 - H2 network (offshore storage)
 - Proposed green hydrogen production
 - Proposed blue hydrogen production (No. = SMRs/ATRs to be constructed)
 - ◆ City/Town

Note: PRSs are located at the outlet end of each spur line.

1. Executive Summary

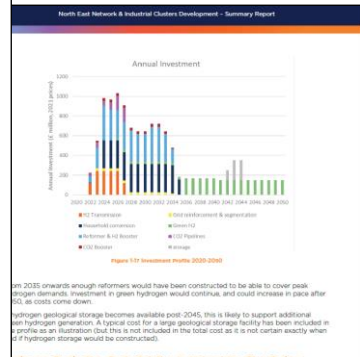
The Scottish Government's Climate Change Act 2019 commits Scotland to 'net-zero' emissions of all greenhouse gases (GHGs) by 2045, which means that any residual GHG will need to be balanced by activities that take CO₂ out of the atmosphere. This is likely to require carbon capture and storage (CCS) on all major emitters, and the conversion of fossil fuel systems to hydrogen is likely to play a major part in reducing emissions from sectors such as domestic heating and transport. The Scottish Government's Energy Strategy, published in 2017 sets a target of 50% of the energy for Scotland's heat, transport and electricity consumption to come from renewable sources by 2030. It recognises the important role that hydrogen could play in meeting this and future targets. Additionally, hydrogen can be deployed to reach the Scottish Government's target to decarbonise the heat demand of one million homes by 2030 as part of the government's Heat in Buildings Strategy, which outlines the steps required to reduce greenhouse gas emissions from Scotland's homes.

Scotland is excellently placed to pursue an energy transition programme which would see existing hydrocarbon infrastructure repurposed to facilitate a change to low and zero carbon energy. Scotland's abundant renewable energy resources (which include 25% of Europe's offshore wind and tidal resources) along with well-developed onshore and offshore oil and gas infrastructure, and presence of offshore geological spaces for carbon sequestration, and themselves well to SGN's proposed gas network reconfiguration project.

The concept proposed by SGN would allow existing natural gas infrastructure to be repurposed to provide customers with new utility services that would result in SGN playing a major role in achieving the Scottish Government's 2045 net-zero target. Switching a large proportion of all gas and users to low carbon hydrogen would provide a substantial contribution to meeting Scotland's ambitious 2030 and 2045 climate targets.

Work was appointed by SGN to provide consultancy services for the North East Network & Industrial Clusters Development project (the Project). This constitutes a feasibility study of the Project Area as delineated in Figure 1-1 and investigating the potential to reconfigure SGN's gas distribution network in the north east and east coast of Scotland, to separately transport hydrogen to end users and captured carbon dioxide (CO₂) to geological stores.

The extent of the Project Area offers a significant opportunity for substantial decarbonisation of Scottish industry and commercial and domestic heat demand. The proposed reconfiguration solution offers for expansion of hydrogen into new markets in transport and exports.



Hydrogen Production Costs Relative to Natural Gas Plus Carbon

Figure 1-8 below illustrates the data compiled from a number of sources to compare the projected cost of blue and green hydrogen production with a fully loaded carbon cost from the unabated burning of natural gas.

As governments have galvanised their commitments to a net-zero greenhouse gas emissions by 2050, the cost of natural gas from the energy mix will be required to be lower than electrical heating. It is typically been lower cost than electrical heating as of low and zero carbon hydrogen for spatial heating on a distributed basis will require conversion to a net hydrogen. It is probable that blue hydrogen will also be able to reach scale quickly compared with gas for storage systems.

Respective cost of greenhouse gas emissions is expected to be less uneconomic relative to blue and green hydrogen. It is likely to play an important and affordable form of the 2045.

Hydrogen Demand

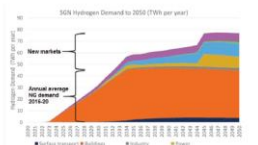
Hydrogen can be a key vector for the decarbonisation of power and heating systems that are currently fuelled by natural gas. Where the requisite hydrogen is produced from low carbon sources (e.g. blue hydrogen with 90% of the carbon captured and stored) this can be considered a near carbon sink as the reduction in natural gas use. This Project also considers wider applications for hydrogen in sectors such as transport, power and agriculture.

The following chart summarises the estimated demand profile, by sector for the Project Area, including a 5% allowance for the export of hydrogen in addition to the sum of all other sectors. This demand profile has been modelled in conjunction with input from local stakeholders who engage with the Project.

The Project has identified opportunities in the Project Area to supply hydrogen to SGN's existing customer base and also new markets in the transport, industrial, power generation and export sectors.

The selected Project system reconfiguration option allows for early adopters and producers of hydrogen to be connected, thus integrating the various complementary hydrogen initiatives already underway in Scotland such as the Dolphyn and Acorn projects.

The Project has the potential to provide a route to market for green hydrogen producers operating in the Project Area with network infrastructure in place to supply into:



Network: Blending and Conversion

Industry consensus suggests gas appliances can operate safely and efficiently on blends of up to 20% hydrogen by volume, but they require modifications to operate beyond this level up to 100% hydrogen. A conversion programme would be required with a transition to SGN hydrogen networks.

Implementation

Things to Consider

- Should we pursue hydrogen blending or jump to 100% conversion?
- Does separate ownership and operation of the NTS and GDNs help or hinder implementation?
- How does a GB energy system spanning different jurisdictions convert?
- How far, if at all, should we rely on 'blue' hydrogen?
- What is the opportunity for CO₂ disposal as a service?
- How do we ensure future hydrogen producers and consumers can rely on gas networks to facilitate transport?

ARUP