Natural gas vehicles and smart gas grids

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This article explores the applicability of smart grid concepts to the Dutch gas network, by reflecting on the experience of the electricity sector.

Why natural gas vehicles?

Natural gas vehicles (NGVs), like electric vehicles (EVs), are an alternative to oil-fuelled vehicles: combusting conventional methane generates about 25% less CO2 than oil derivatives. There are close to 15 million natural gas vehicles on global roads today, with the three greatest users being Iran, Pakistan and Argentina. NGVs may in some circumstances have advantages over EVs, such as range. The Dutch automobile industry expects an increase in NGV sales.

NGVs are usually charged at dedicated stations, but domestic charging facilities are now available. The pressure of the gas grid is much lower than that required for a compressed natural gas (CNG) vehicle, so electricity is required to compress mains gas before it is used in cars.

Why smart gas grids?

So called 'smart' electricity grids have been a familiar concept for a number of years. As more renewables come on to the grid, the flow of information and power is no longer in one direction, but becomes bi-directional.

Figure 1: location of Groningen

A similar phenomenon can occur in the gas network. Groningen is an interesting example of this. Located in the north of the Netherlands in a gas-rich region, high quality and well controlled natural gas is injected into the network from a small number of

points. The gas then transports itself through pressure differences to where it is drawn off the network.

However, this system looks set to change with the introduction of new gases such as biogas. Small producers of biogas, such as farmers, will be able to inject gas of variable quality at multiple decentralised points. As such, regional gas distribution companies will have to move from passive transit systems to active systems that dynamically control the quality and pressure of gas in bidirectional flows. Pressures have to be carefully maintained, and the volume of gas extracted from the network should not exceed the volume injected into the network.

Effect of integrating natural gas vehicles in smart gas grids

A modelling study was carried out to investigate the effect of NGVs on gas grid balancing in Groningen. This was compared to a similar study using EVs and the electricity network.

How do NGVs change seasonal demand profiles?

For context we consider householders' various energy demands in Groningen. Gas demand (for heating, as is the case in the UK) is highly seasonal, whereas electricity and energy use for mobility are relatively constant throughout the year. This is illustrated in Figure 2:

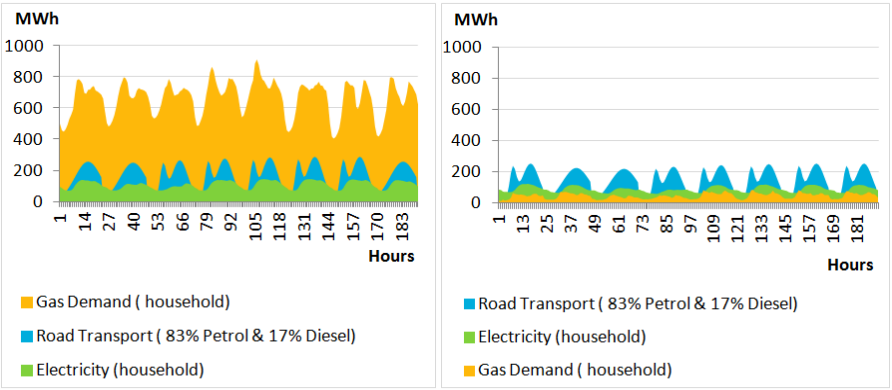

Figure 2: Current Groningen energy demand in winter (left) and summer (right)

The consequence of this difference is important when EVs and NGVs are added. If the Groningen vehicles fleet were 100% EVs, the impact on the electric grid would be an increase of 50% in electricity demand in a constant way throughout the year. However, for NGVs in the winter the impact is negligible, but in summertime NGVs would be almost the main end use of natural gas.

How do NGVs change hourly demand profiles?

One concept in electrical smart grids is the use of the batteries in EVs to discharge back to the grid if required and with the EV owners' consent. Can this concept transfer to NGVs in the gas network? This is modelled in Figure 3, in which vehicles are plugged in to charge during the night and discharge back to the grid during certain points during the day, to flatten the total city gas demand profile during winter… but not during summer!

For electric vehicles, in general the power levels during the charging process depends on the battery chemistry. In the future, there may be prospects for fast charging (having higher maximum power) which would enable charging of a battery pack in a few minutes. Similar to EVs, It is assumed that NGVs would recharge at night; however, current home refuelling technology is slow. This has the interesting consequence that there is little dispersion in users' recharging timings and therefore the load on the gas network.

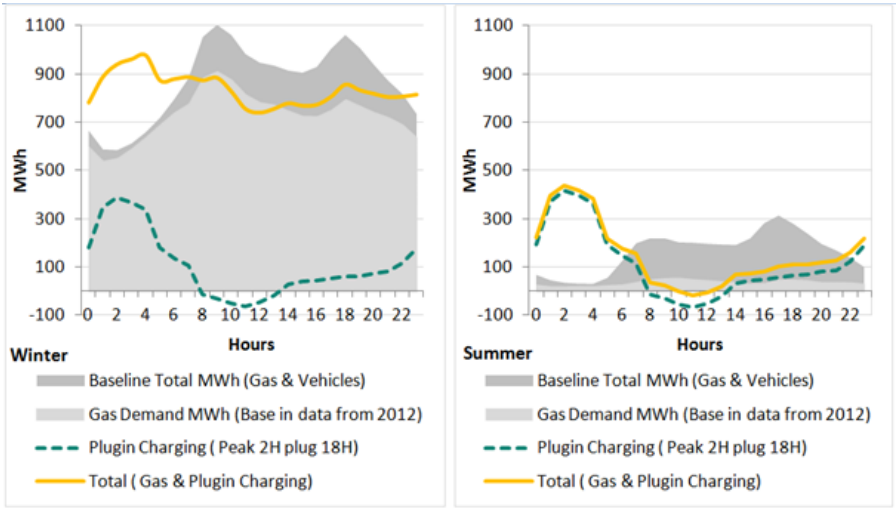

Figure 3: light-coloured line is the total gas demand over a winter day (left) and summer day (right) including the effect of NGVs. Note their flattening effect in winter but peak-creating effect in summer.

Using NGVs with EVs

In the long term, managed charging of NGV and EVs, coordinated among megawatts of charging load, could help provide additional services or emergency reliability services. In the Netherlands using the NGV and EV capability to charge and discharge the gas and electricity grids could be an important support for the integration of renewable power generation.

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