Research proposal

Company: Gasunie Transport Services, Infrastructure Planning Department

Problem description and research questions

The energy transition motivated by the 2015 Paris Climate Agreement will have profound effects on the use of gas and power transmission systems in the Netherlands, both locally and on a national scale. In a situation of oversupply, surplus power has to be transported and stored (e.g. as hydrogen produced by electrolysis), while in periods of power shortage (e.g. on cloudy, windless winter days) additional electricity has to be produced by power plants running on hydrogen or green gas. The gas and power transmission systems will become more and more connected and may gradually evolve into an integrated system for transport, conversion and storage of energy.

The Dutch national transmission system operators Gasunie Transport Services and TenneT are currently exploring the outlook of an integrated energy system on a national scale in 2050. As a first step in modelling such an integrated system, a linear energy transmission model of the combined Dutch electricity and gas grids was developed. So far, the model has been used to check the feasibility of hourly demand and supply “snapshots”, based on energy scenarios for 2050 proposed by CE Delft in their widely acknowledged report “Net voor de Toekomst” (2017).



**Figure 1:** *Flow patterns in a particular snapshot*

Considering the urgency of the energy transition in the Netherlands, Gasunie and TenneT wish to substantiate their model and its results by further developing the underlying methods and techniques. The purpose is to solidly found the linear model on hydraulic and electric transport equations, to extend the model to handle e.g. annual time series based on market behaviour and to include optimisation of conversion capacities and locations.

The two most important challenges are:

* *Validation of the linear approach to gas and electricity transport modelling*  
  Do gas and electricity transport differ fundamentally or are equivalent descriptions possible? Can energy transport be described sufficiently accurate by a set of linear equations? Can flow route optimization be applied in the same way for gas and electricity?   
    
  **Figure 2:** *Linear modelling of transmission flows*
* *Modelling of conversion efficiencies*  
  Conversion (power-to-gas or gas-to-power) provides a useful bridge between different energy flows, but it comes at a cost: energy loss due to limited process efficiency. These losses depend on actual conversion flow and as such introduce a new dimension to the system. A flow-related modelling of energy losses would make it possible to introduce variable conversion elements and find the optimal distribution of conversion capacity in the system.

Work on these issues will lead to a better defined model for the future integrated energy system in the Netherlands. There may be applications for energy systems abroad as well.

Internship / master thesis

This research work is a team effort. During the research you act as a member of a multidisciplinary team of mathematicians, physicists and other scientists at the planning department of Gasunie Transport Services in Groningen. There will be ample opportunity to build and maintain contacts with other institutions, e.g. TenneT in Arnhem.