Multi-carrier energy systems

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Overview

Overview

- Who am I?
- What is the problem?
- How can we tackle this problem?
- Current research goal related to multi-carrier energy systems
- Possibilities

Who am I?

This is what I have done:

- Applied Mathematics BSc. and MSc.
- Failure probabilities related to dikes
- Improving computational time of a genetic evaluation model [1]

(a) NSK 2019

(b) Dike

(c) Cows

[1] B.-V. Nguyen (2021). "Two-level preconditioning applied on the ssSNPBLUP model". MA thesis. Delft University of Technology, Delft Institute of Applied Mathematics

Research

What I do currently:

Modelling and simulating integrated energy networks

Problem

Goal

- Reducing emission

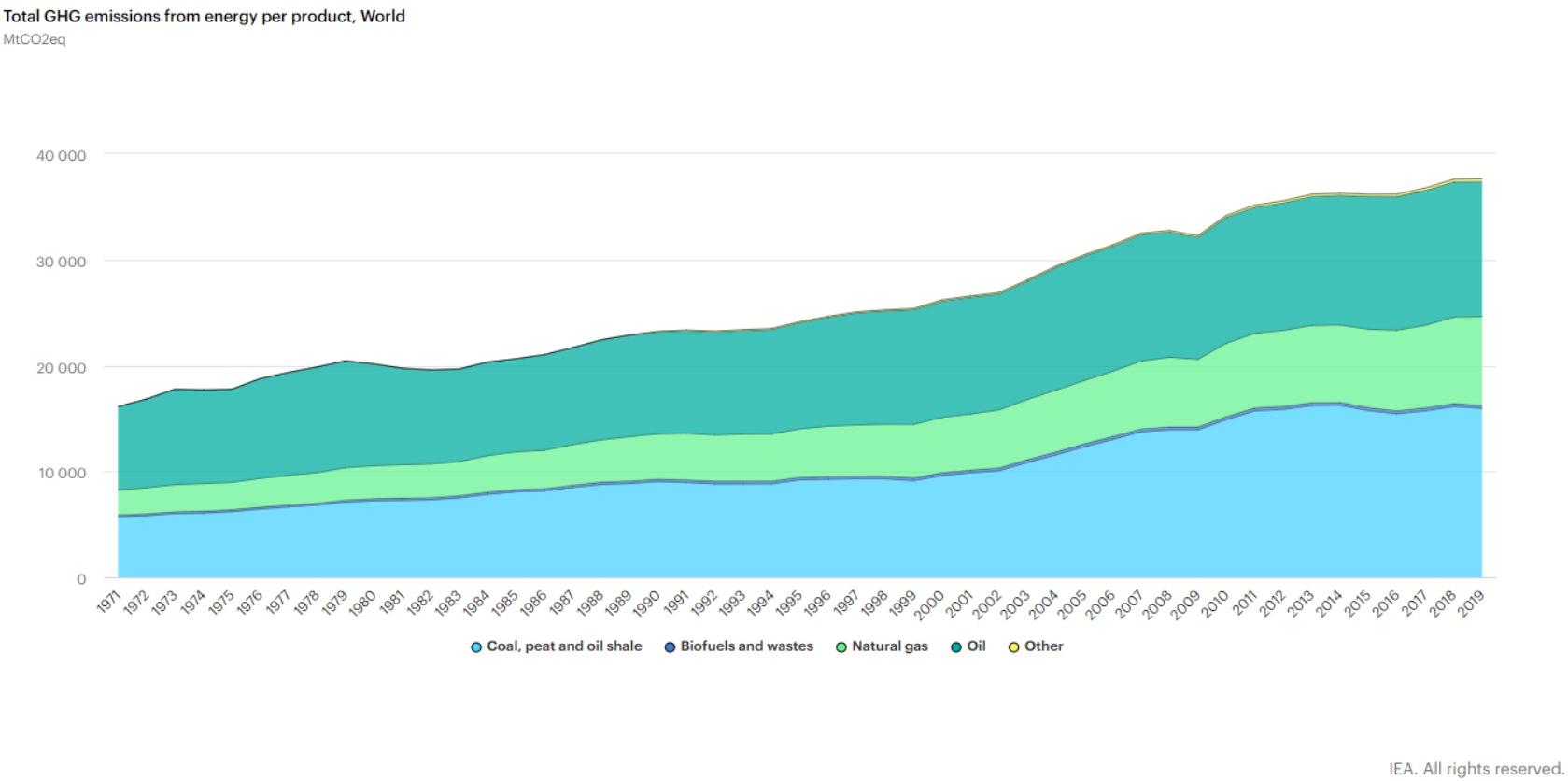


Figure: Green house gas emission from 1971 up to 2019.

Problem

Figure: 1953, flood disaster Zeeland in the Netherlands.

Problem

(a) Combined heat and power plant

(b) Gas-fired power plant

(c) Gas-fired boiler plant

Research

What I do currently:

Modelling and simulating integrated energy networks

Model

We want to have:

- A model that can do load flow analysis
- A model that incorporates interaction between different energy carriers
- A model that can clearly show how different networks can be combined into one network

Multi-carrier energy systems

Research based on multi-carrier energy systems

- Anne Markensteijn's research on multi-carrier energy systems [2]
- Graph-based model
- Steady-state load flow analysis

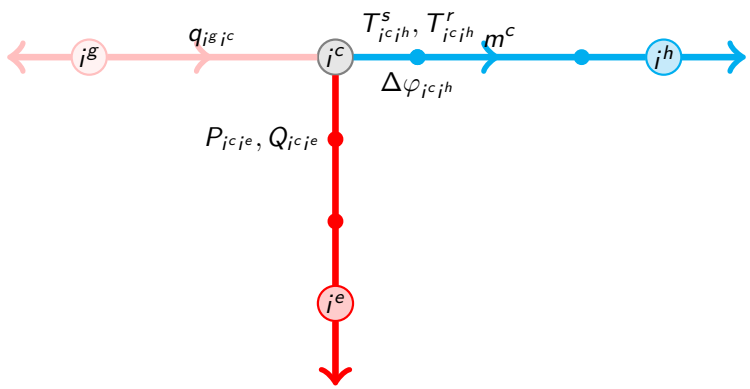


Figure: A coupling node connecting gas, electricity and heat with dummy links is shown in this figure. Additionally, the associated dummy link variables are depicted here.

[2] A. S. Markensteijn (2021). "Mathematical models for simulation and optimization of multi-carrier energy systems". PhD thesis. Delft University of Technology, Delft Institute of Applied Mathematics

Single-carrier energy systems

Electricity

- Load flow model based on conservation law
- Equations and variables associated with nodes and links

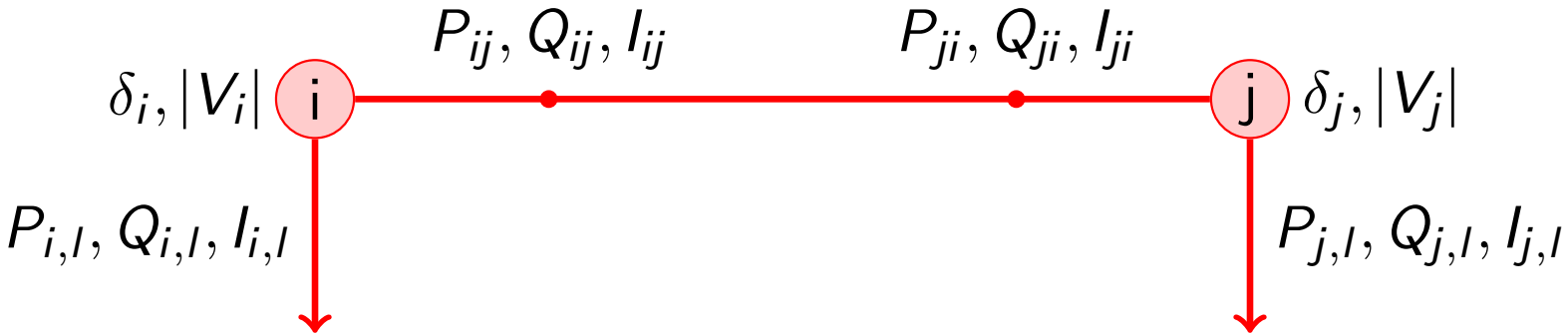


Figure: An electrical network with defined directions of a link between two nodes that have one terminal link each.

Single-carrier energy systems

Gas

- Load flow model based on conservation law
- Equations and variables associated with nodes and links

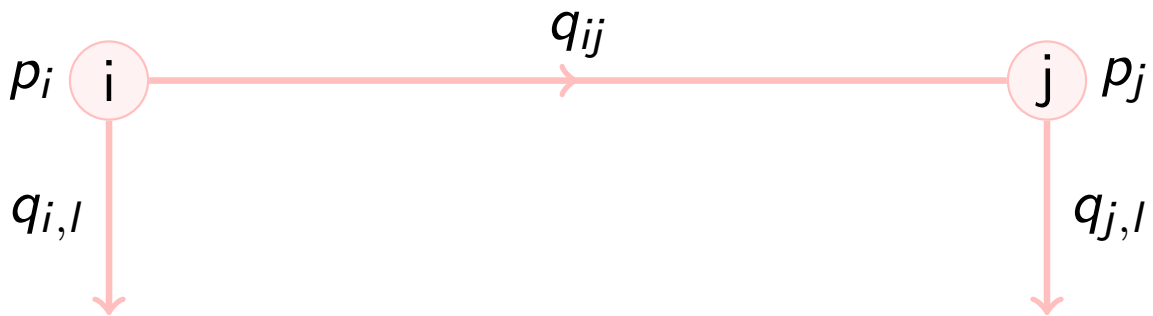


Figure: A gas network with defined directions of a link between two nodes that have one terminal link each.

Single-carrier energy systems

Heat

- Load flow model based on conservation law
- Equations and variables associated with nodes and links

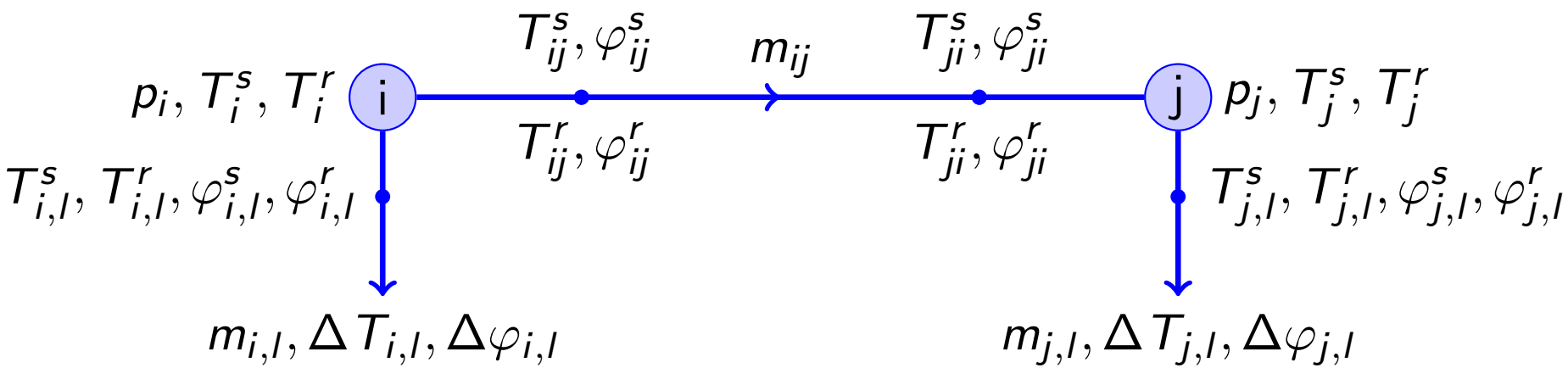
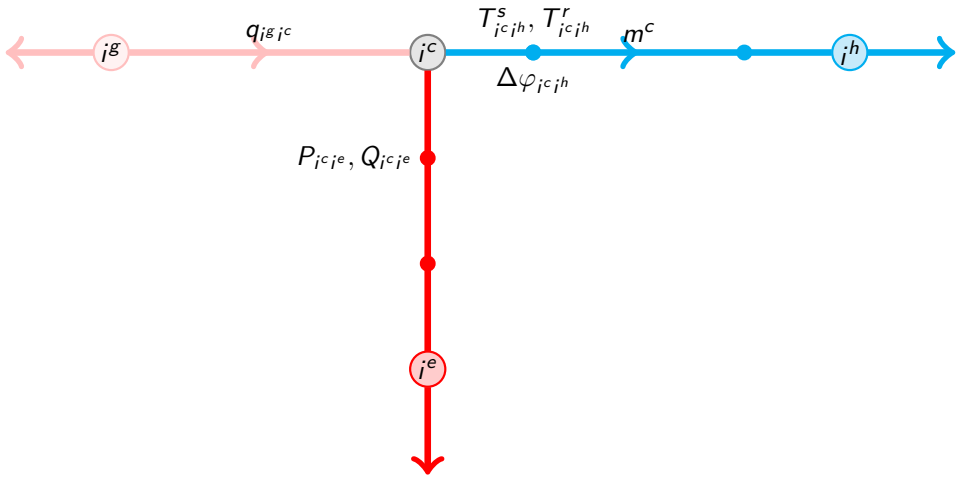


Figure: A heat network with defined directions of a link between two nodes that have one terminal link each.

Multi-carrier energy systems

Heat

- Coupling link
- Node merging
- Coupling node and dummy link



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System of equations

Constructing and solving

- Collect equations from each carrier and coupling
- Equations can be nonlinear
- Solve with Newton-Raphson

Graph-based Model

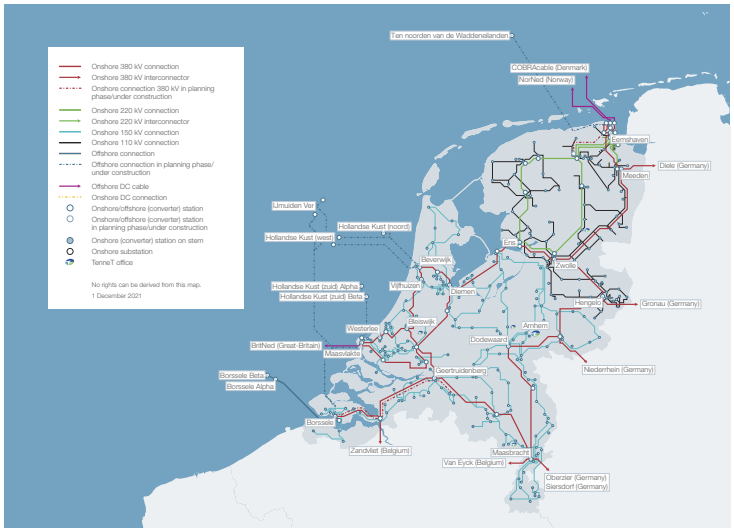
Issues

- Certain combinations of coupling nodes and single-carrier nodes can lead to an ill-posed problem.

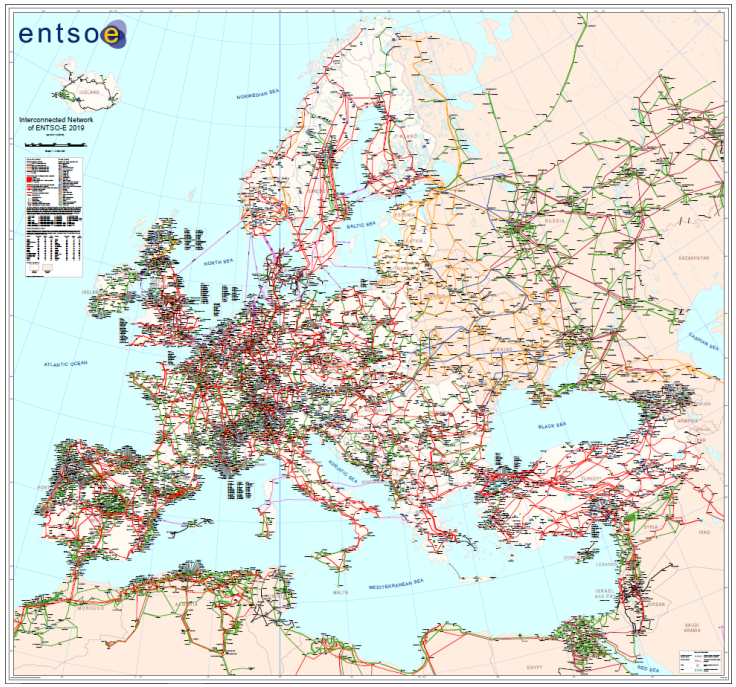
Research goals

Goals

- Scalability
- Solvability



(a) Dutch energy network



(b) European energy network

Research goals

Alternatives

- Transient models (storage)
- Reformulating single-carrier energy models to similar formulation
- Decoupled approach

Questions

Figure: Deadlift 3rd attempt at NSK 2019