BALANCED ENERGY HUBS

Development of a decentralized and future proof energy system

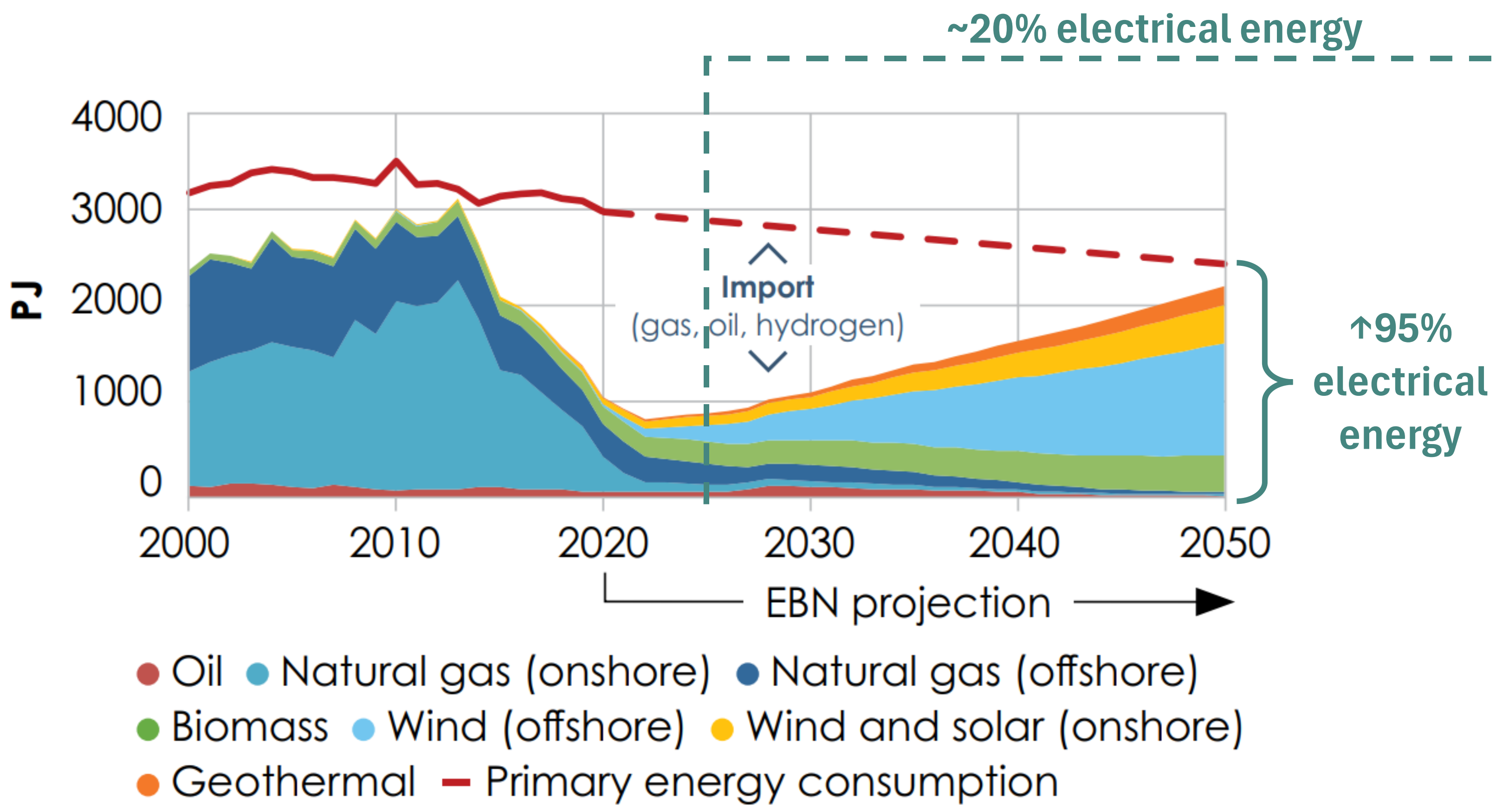
stijn.van.aken@metalot.nl

A sustainable energy mix

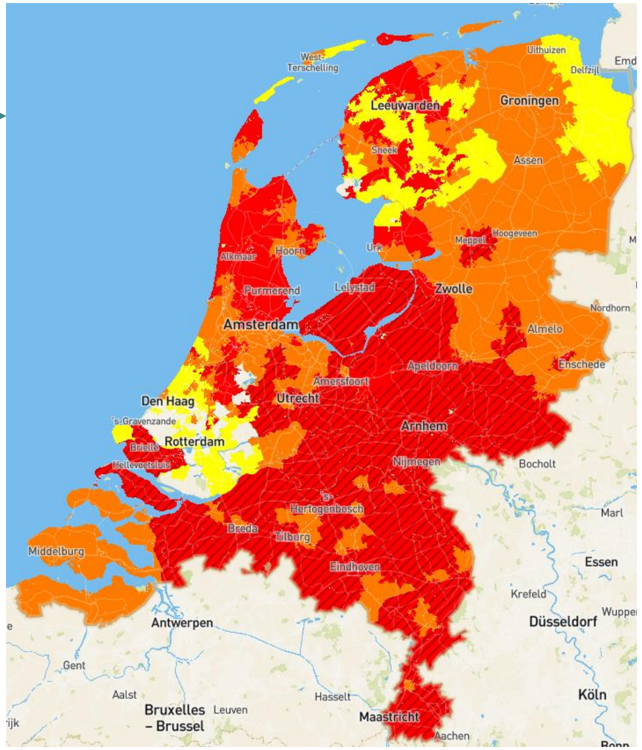
And challenges along the way

Dutch energy mix

Facing out fossil fuels and forecasted increase of green energy



Source: *EBN Infographic 2022*



Grid capacity: 600 PJ
Total demand: 3000 PJ

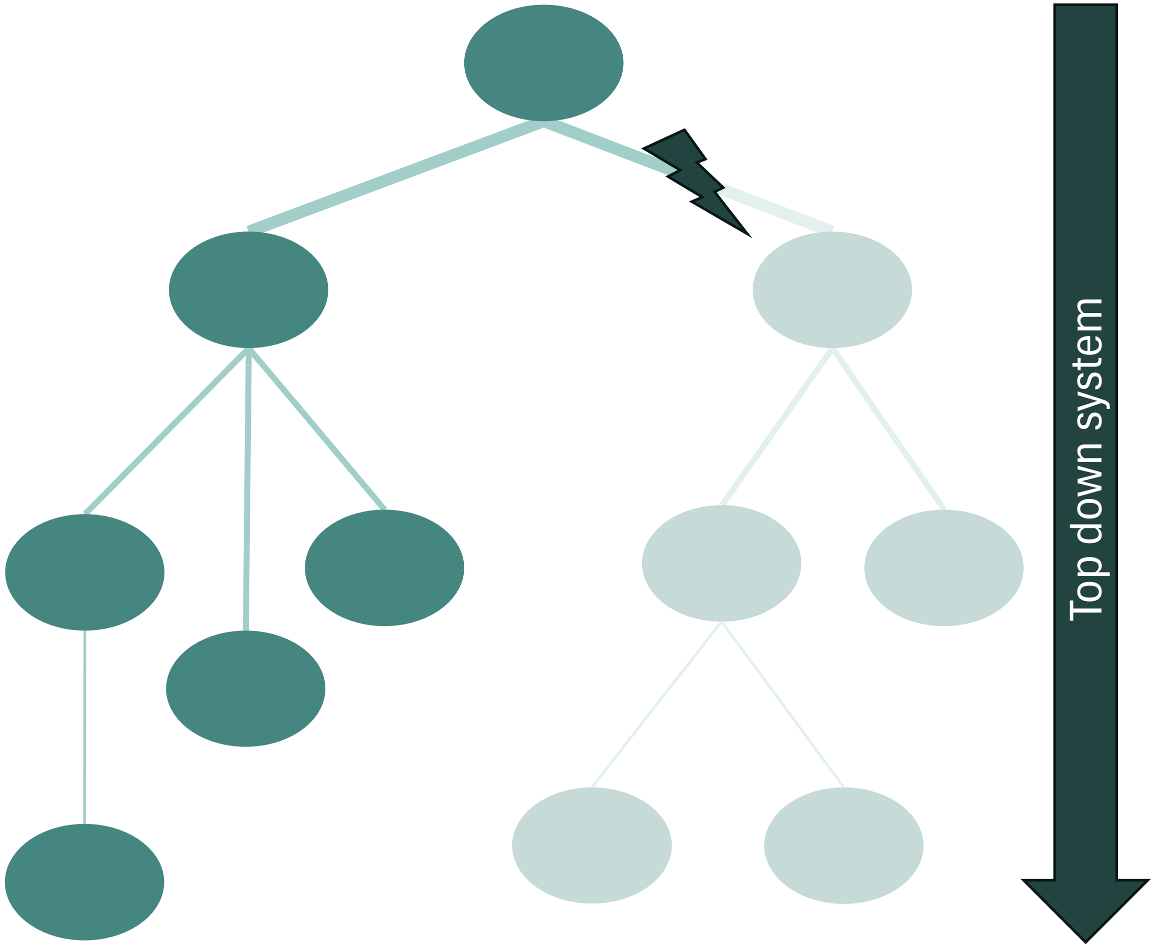
Source: *Netbeheer Nederland*

metalot

Top down system

The current electricity grid architecture is reaching its limitations of transport capacity

- Electricity grid designed as **top down system**
- Feed electricity from one **central grid** and divide
- A **problem** on the grid affects all subsequent links
- **Intensifying** the grid to meet the current demand requires approximately 10 years
- The grid is not suitable for absorbing strong **fluctuations** in the supply of green energy, which will only increase in the future



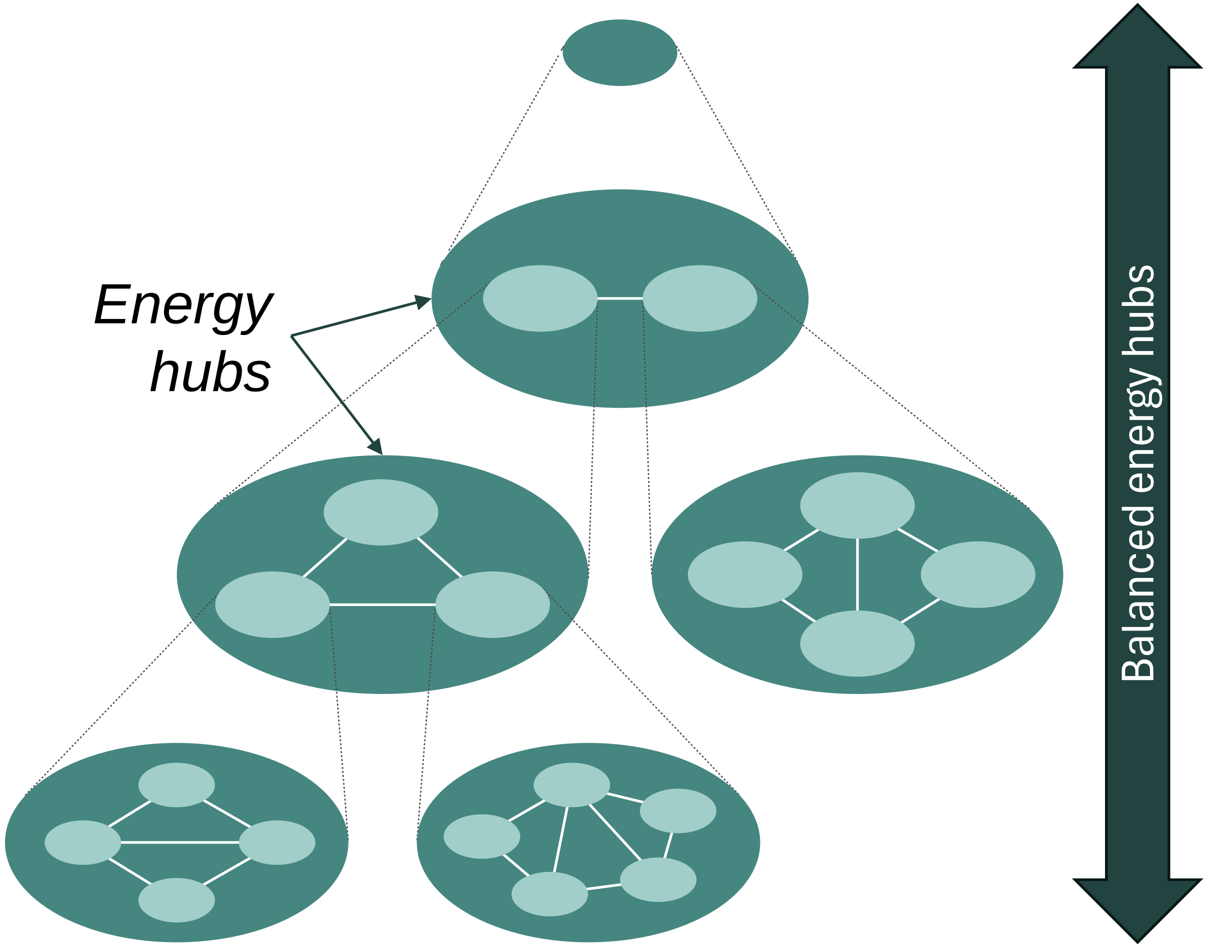
Balanced energy hubs

A future proof energy system

Future grid design

Development towards balanced energy hubs

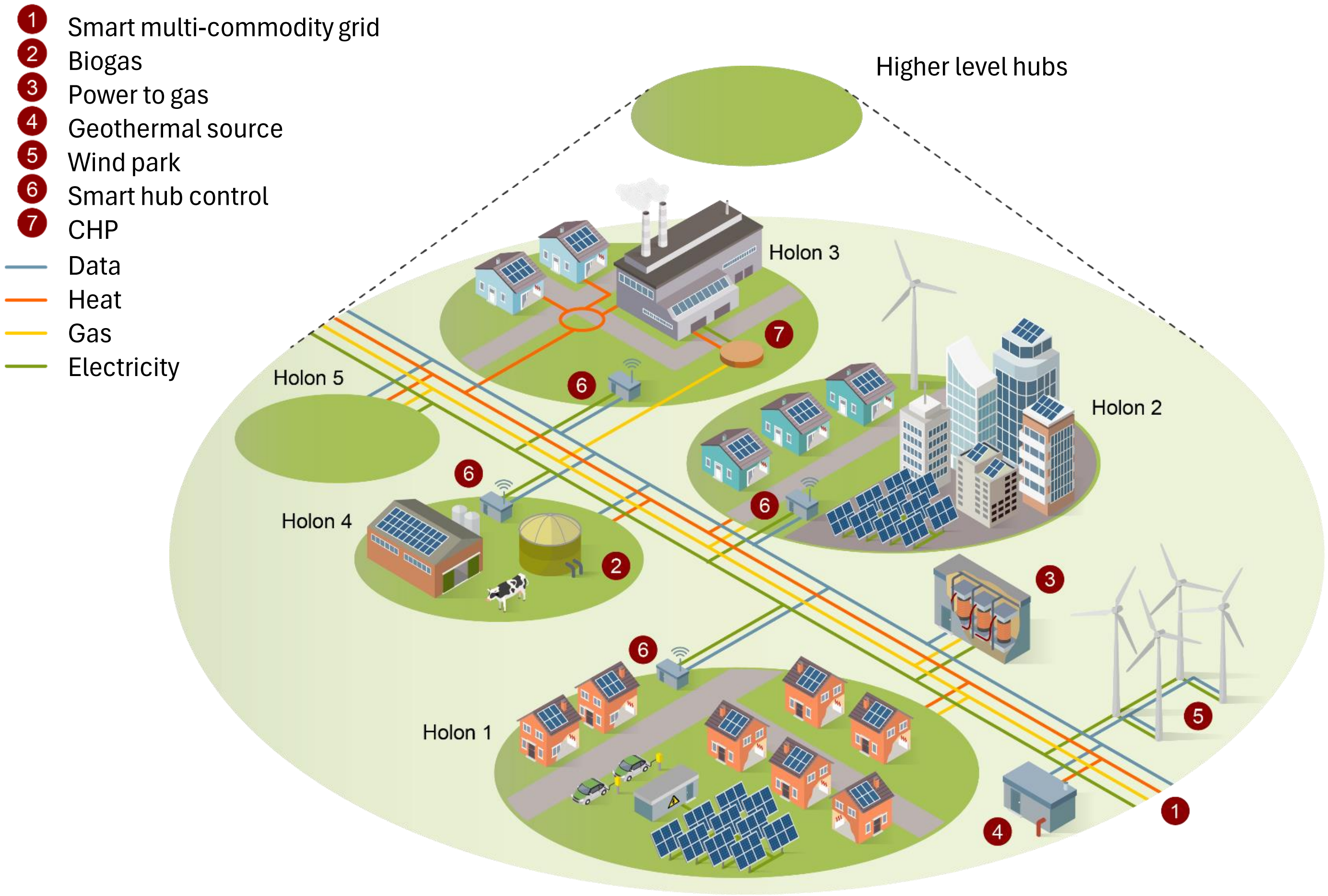
- Balanced energy hubs with **local** energy production, storage and consumption
- **Autonomous** operation
- Connection between hubs only for **balancing** purposes
- **Data driven** and self optimized and organized
- Many options for **customization** to meet specific needs of different users



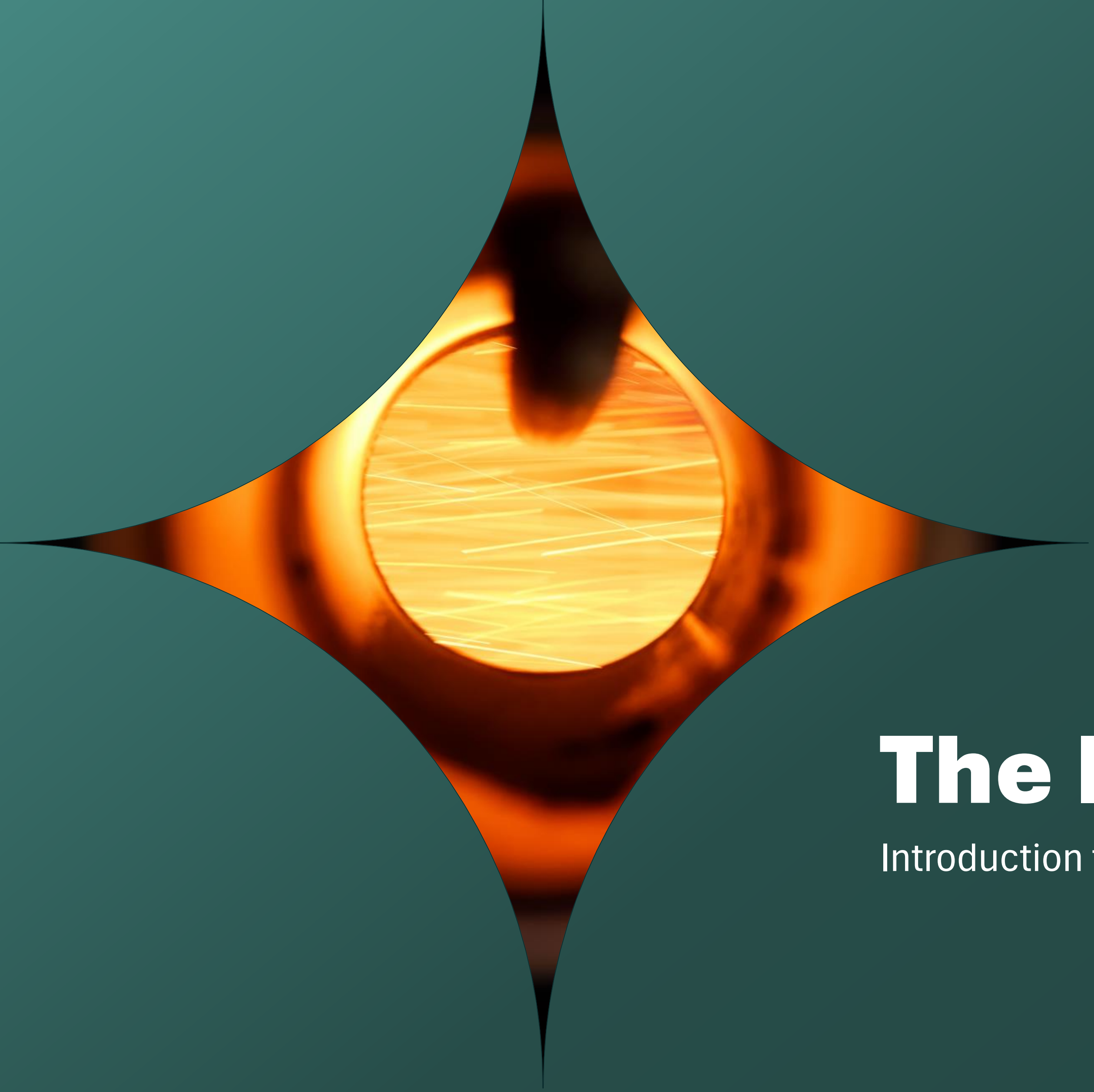
Balanced hubs in practice

Example of what a society with multiple balanced energy hubs could look like

- Connect energy producers and consumers on the **lowest level possible**
- **Local energy storage** for day/night, but also seasonal storage
- Exchange of energy only for **balancing** purposes



Source: *Top Sector Energie*

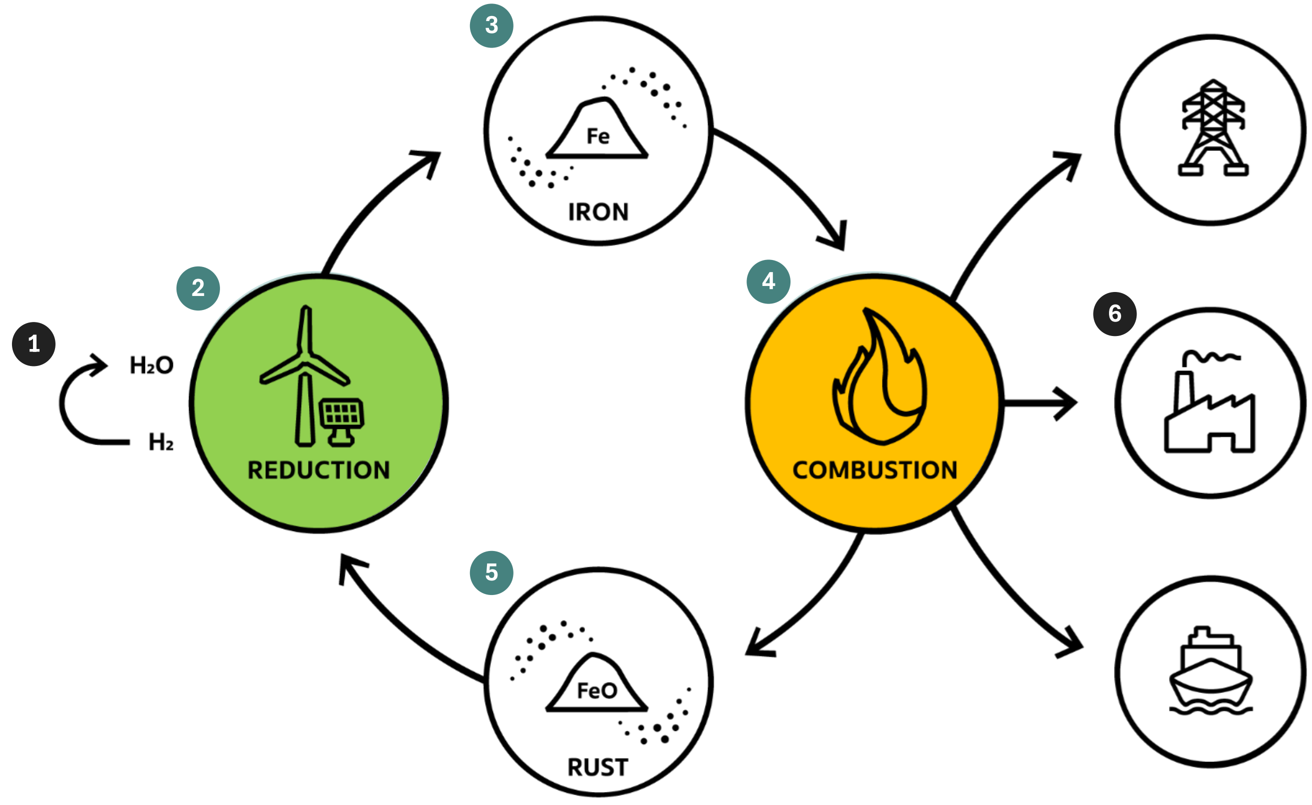


The Iron Power Cycle

Introduction to the Iron Power Cycle and its key benefits

Introduction to Iron Power

Renewable energy storage and transportation in a circular value chain



1 Energy production

- Energy production using **renewable energy sources**
- Energy (electricity) is converted into hydrogen in order to prepare for reduction

2 Reduction

- a • Reduction of iron oxide powder to **store energy**
- Reduction creates iron powder from iron oxide powder
- To start reduction-oxidation cycle, material is brought in upfront, after which it can be used for 10-100 cycles
- b • Future potential to use direct electrolysis for reduction, skipping the need for hydrogen production

3 Transport and storage of iron powder

- Transport and storage of iron powder to **transfer energy**

4 Oxidation

- **Release of (heat) energy** by oxidation of iron powder
- Produces high output temperature (>1500°C)

5 Return transport and storage of iron oxide powder

- **Return flow** of iron oxide powder to complete cycle

6 End-usage

- Potential for high-grade heat industry usage, centralized energy generation, district heating and hydrogen production

Why Iron Power

Key advantages of Iron Power

Carbon free

No CO_2 emissions

Low NO_x

Up to 90% less NO_x emissions compared to fossil fuels

Safe and compact

Not explosive nor toxic and a high volumetric energy density

Circular

Iron powder is used in a circular way

Cost competitive

Compared to alternative green energy carriers

From theory to practice

Current status of technology and future roadmap

From theory to practice

Current status of technology and future roadmap

2017

First iron flame

5 kW

2020

First industrial combustion pilot at Swinkels Brewery

100 kW

2022

Combustion research by Iron+ at

Energy Lab, *200 kW*

metalot

From theory to practice

Current status of technology and future roadmap

2022

Combustion research by Iron+ at Metalot Future Energy Lab, *200 kW*

1st gen. combustion system for district heating by start-up RIFT, *500 kW*

2023

2nd gen.
Swinkels

metalot

From theory to practice

Current status of technology and future roadmap

2023

2nd gen. combustion equipment pilot by Iron+ at Swinkels Brewery, *500 kW*

1st gen. reduction system by start-up RIFT, *80 kW*

2024

2nd gen. com
Ennatuurlijk

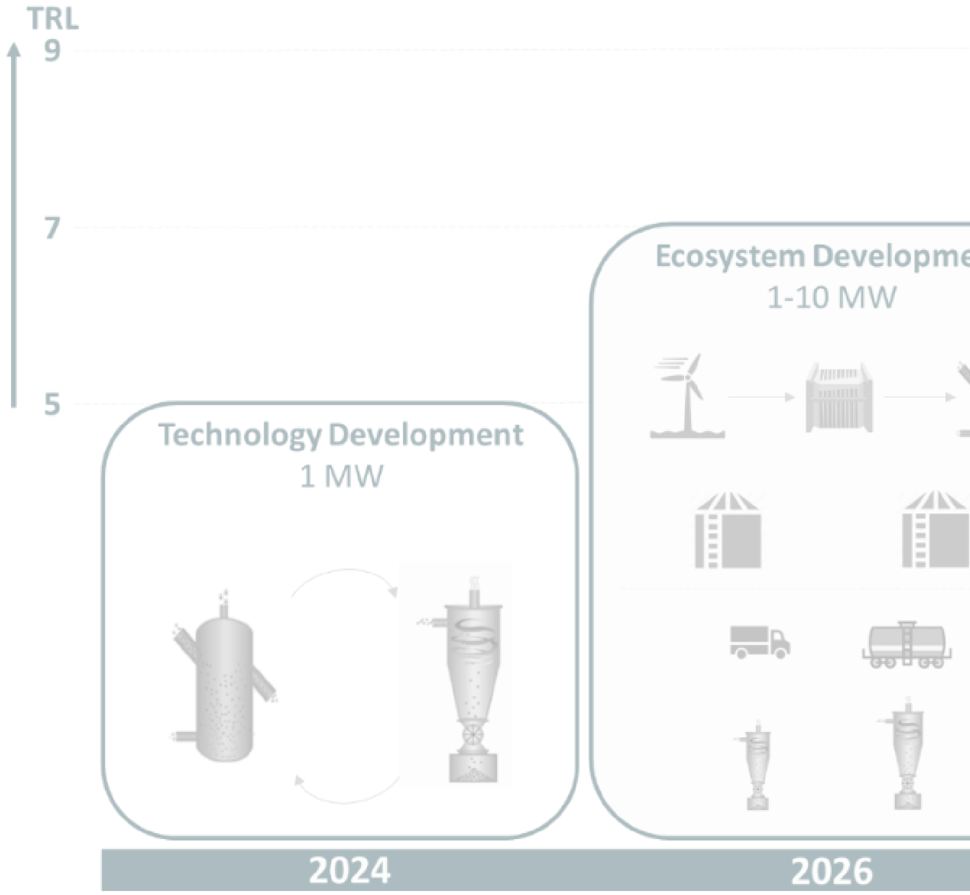
metalot

From theory to practice

Current status of technology and future roadmap

2024

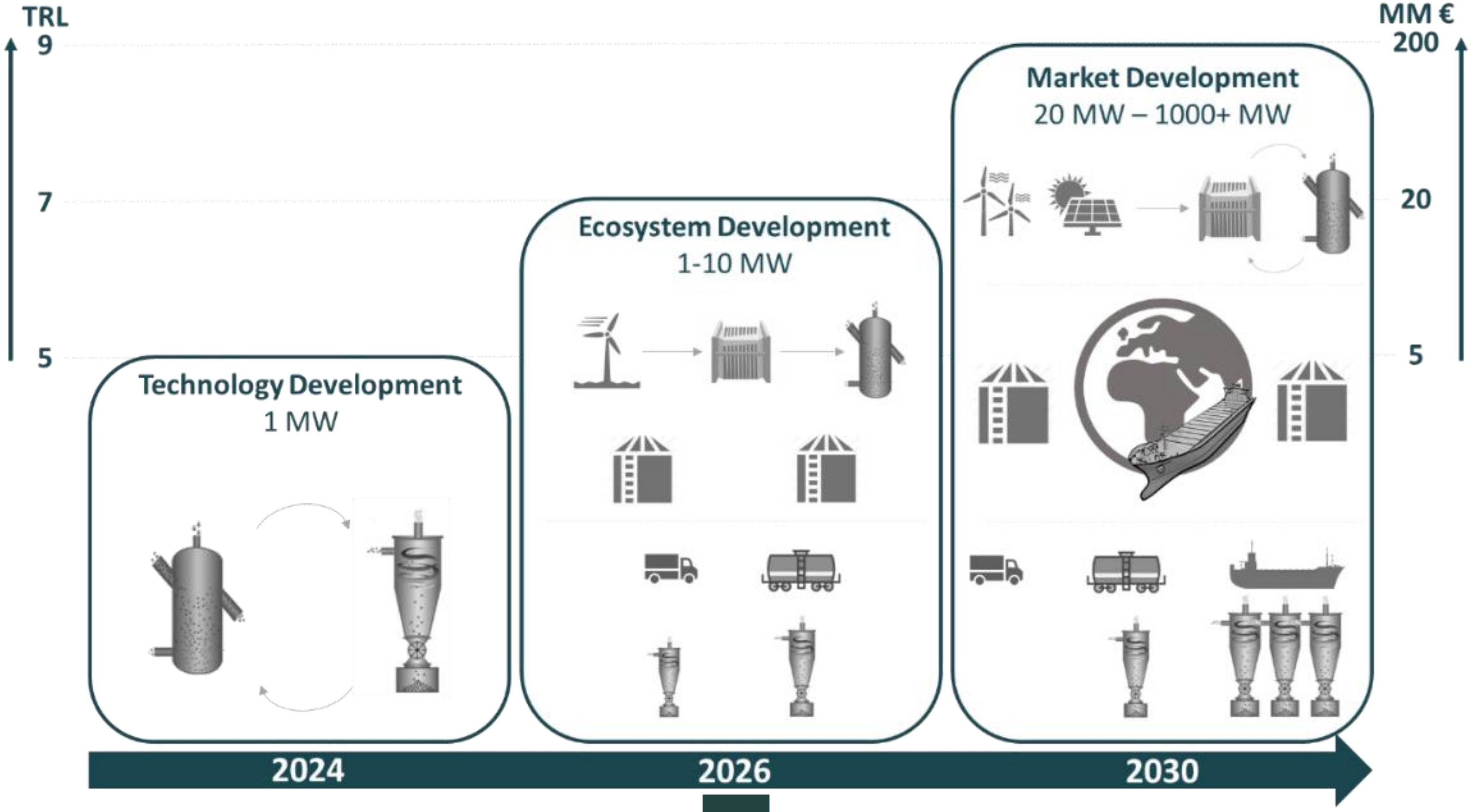
2[nd] gen. combustion equipment test by RIFT at Ennatuurlijk district heating, *1 MW*



From theory to practice

Current status of technology and future roadmap

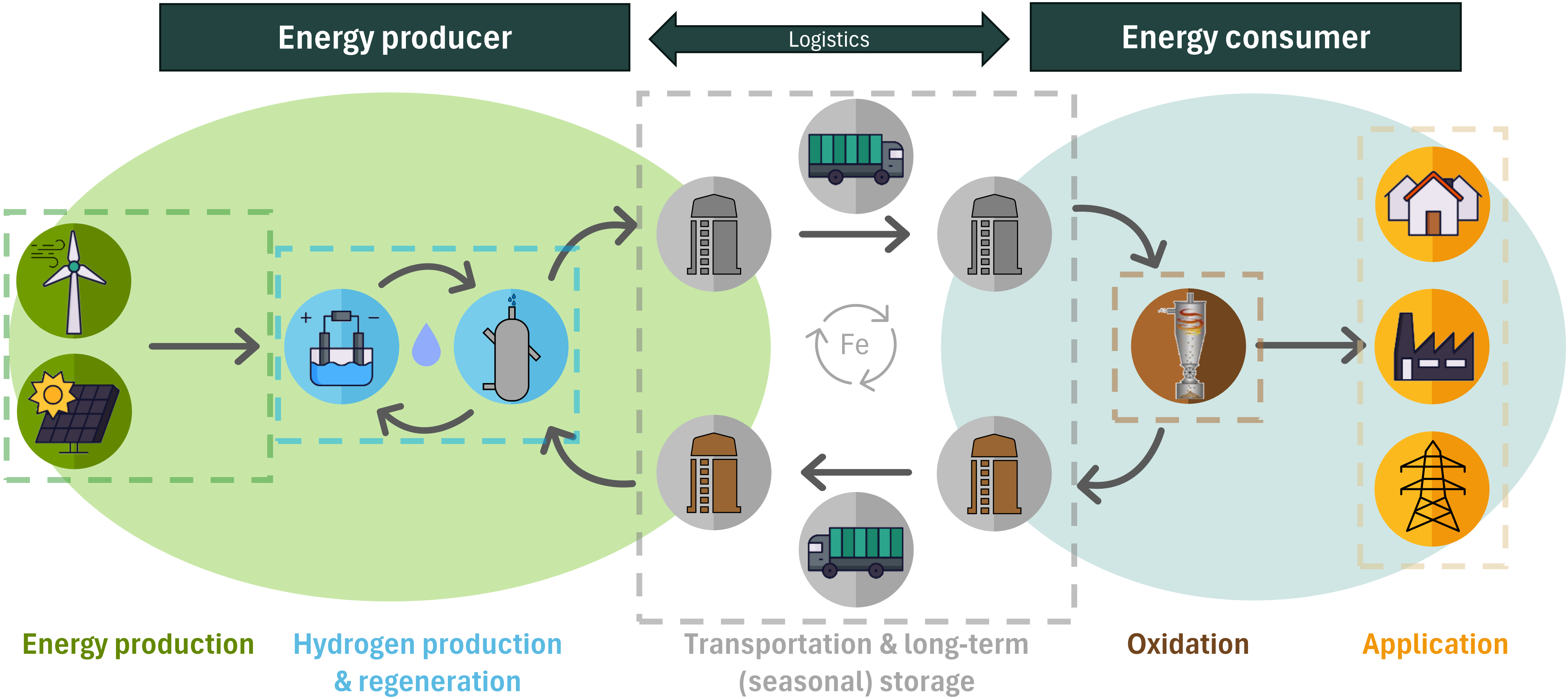
py RIFT at



metalot

Identifying early adopter cases

Implementing Iron Power in a decentralized energy hub at readily demonstrated scale (~1 MW)

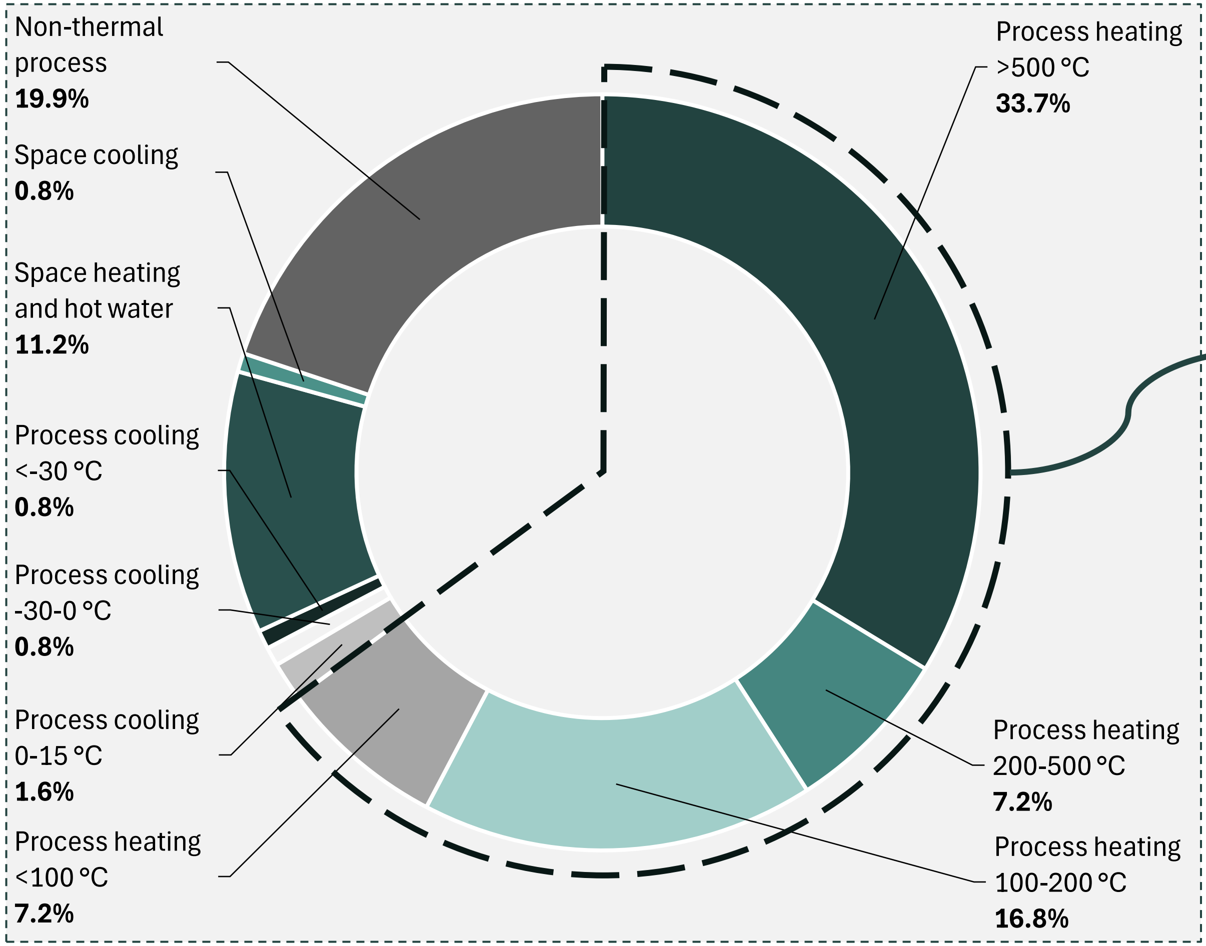


Potential impact

Long-term vision on the role of Iron Power in the energy transition

Energy consumption by industry

Breakdown of energy consumption for industrial processes



Source: *European Energy Research Alliance, IEA 2023*

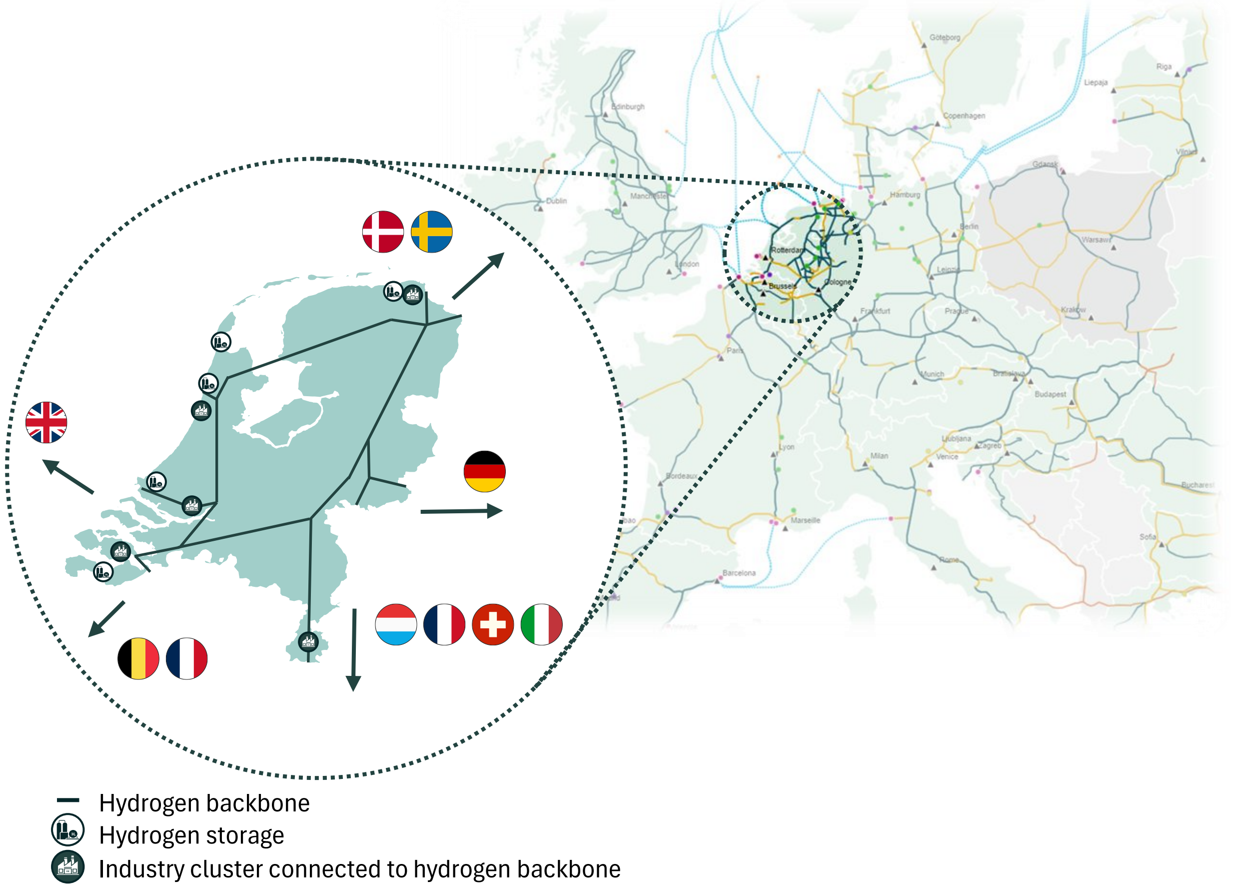
- Thermal energy demands combined account for **around 80%**
- **Process heating consumes 64.9%** of the industrial energy
- **Electrification** not always the best solution
- Need for an alternative energy source that can produce **high temperatures**

metalot

The hydrogen backbone

Hydrogen from the planned backbone will not be a solution for all industries

- Approximately 350 production locations in NL that are not part of the 5 geographical industry clusters
- Not connected to the hydrogen backbone and therefore need **alternative distribution methods**
- Responsible for c. **30% of industrial CO_2 emissions** in the Netherlands
- Chemical-, ceramic-, food-, metallurgical-, paper-, glass-, waste and recycling-, ICT- and oil and gas industries
- Large part of 6th cluster companies is difficult to decarbonize as they need **high-grade heat** for their operations, which **excludes electrification** as solution method
- Due to decentral location, 6th cluster companies also have a demand for **decentral energy storage capacity**



Source: *Dutch Ministry of Economic Affairs (EZK), Koploperprogramma Het Zesde Cluster, Smart Energy hubs Kracht van Oost, VNO-NCW, Metalot, Roland Berger*

Business case

Analysis of possible business cases in the Dutch entrepreneurial landscape

In collaboration with the Deloitte Impact Foundation

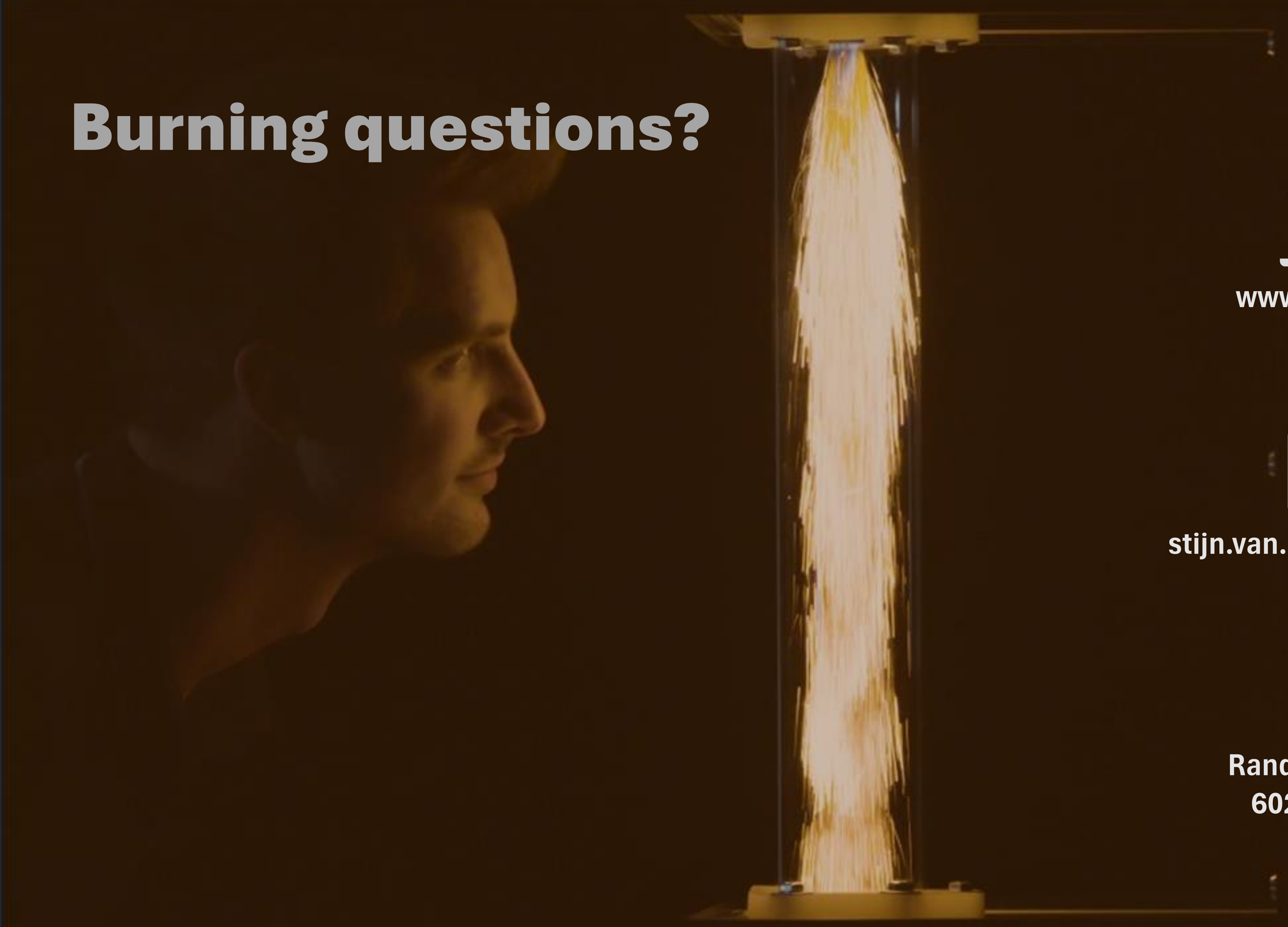
Example use cases

Practical applications of Iron Power

- Example use cases
- Small to medium energy needs
- No direct alternative
- Market sweet spot

metalot

Burning questions?



www.metalot.nl

stijn.van.aken@metalot.nl

Randweg-Zuid 34
6021PT Budel