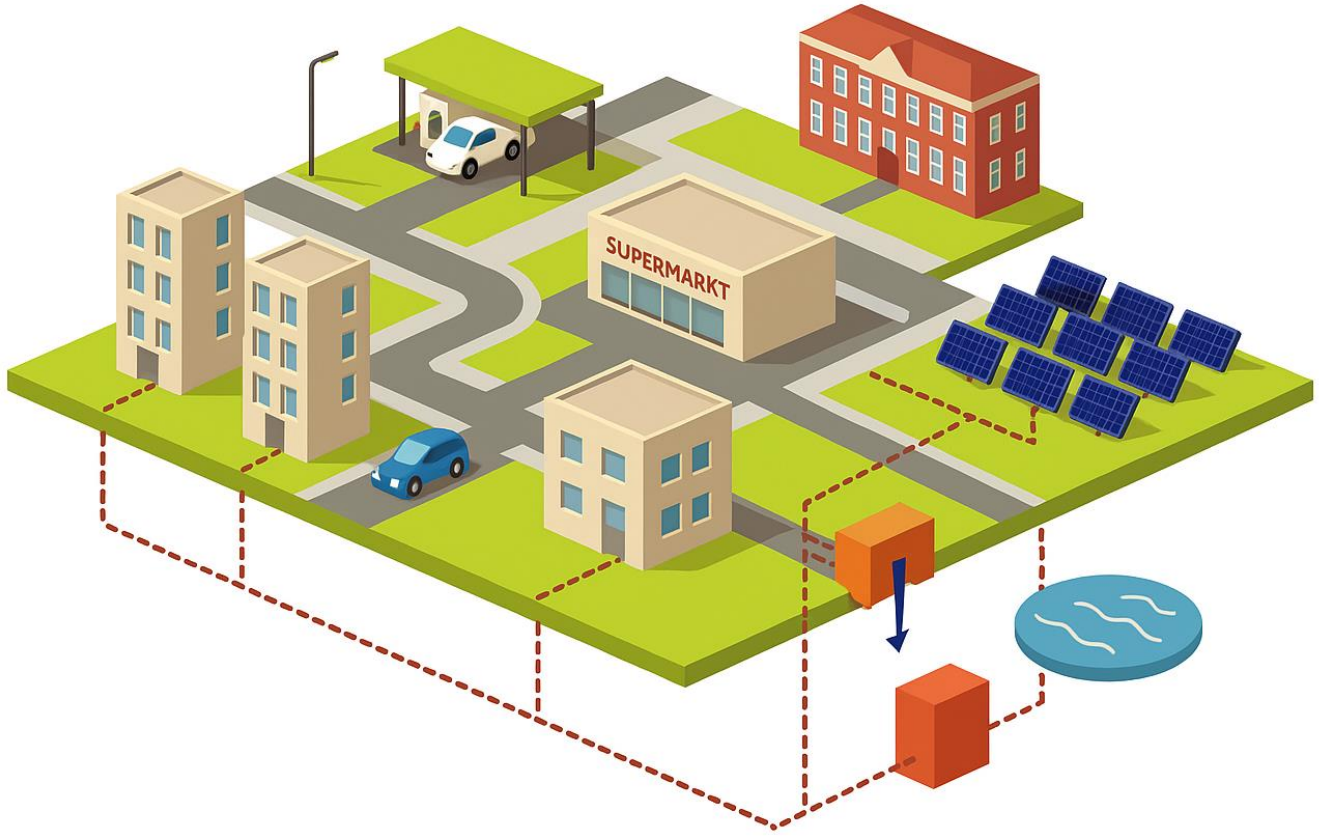
Energy Hubs in Area Development Projects

A Multi-Case Study of Implementation Barriers and Enablers under Grid Congestion in the Netherlands



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P5 Presentation
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June 24th, 2025

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MSc. Van den Bragt

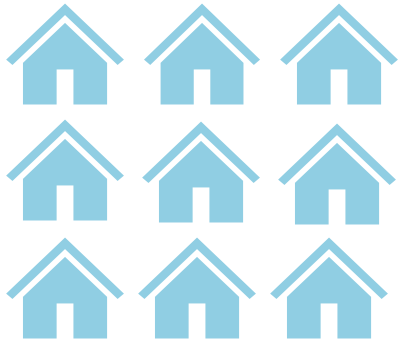
Content

1 Background & Problem Statement

Housing Crisis in the Netherlands

400.000

Current housing shortage in the Netherlands



900.000

New homes - Government target for 2030

€ 5 billion

Allocated to support this goal

Zondag 1 mei 2022, 15:53

Overbelast stroomnet raakt bedrijven en woningbouw

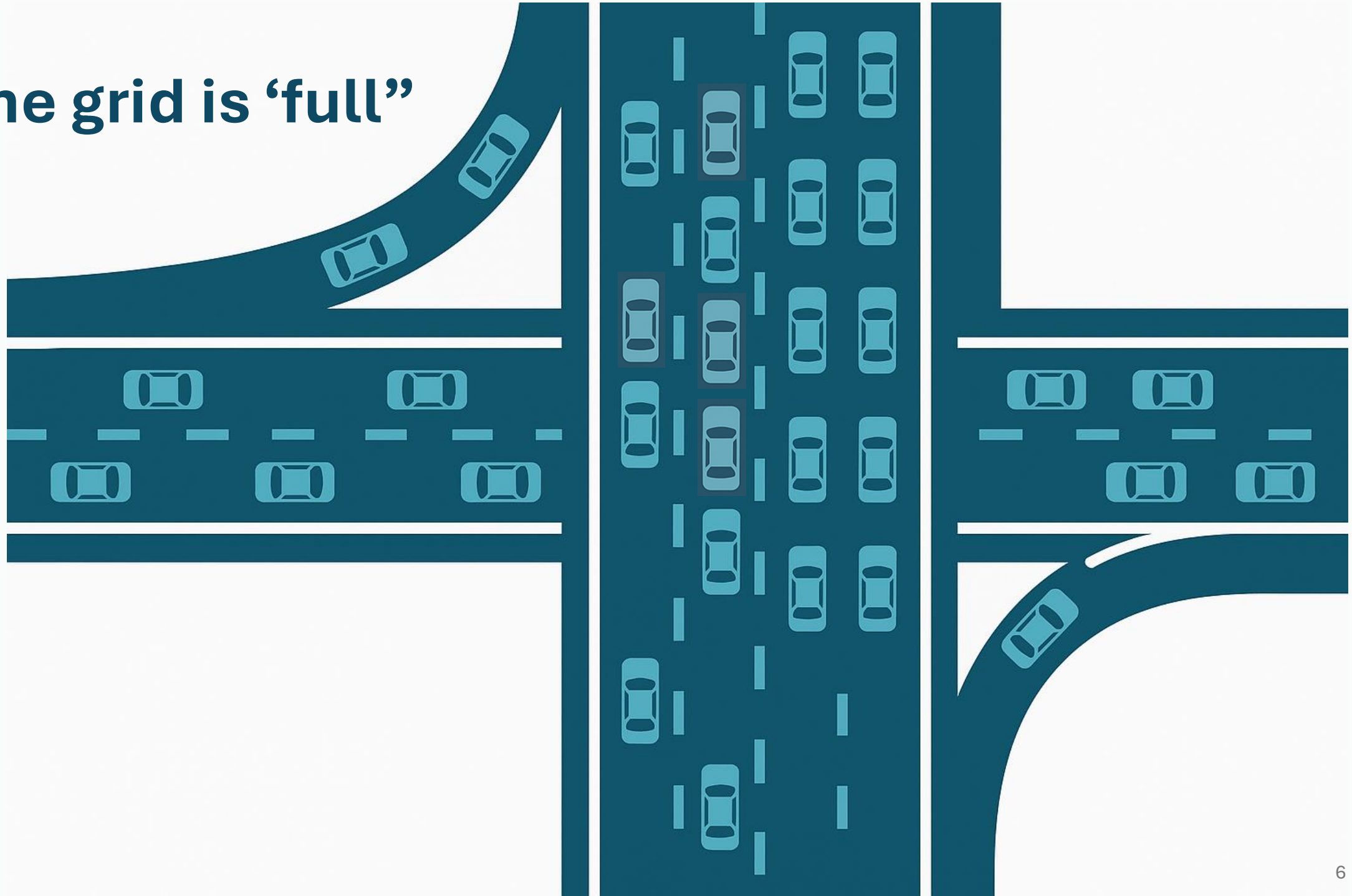
Elektriciteitsprobleem legt bouw in groot deel Almere per direct stil

17 november 2023, 09:32 Algemeen Netcongestie

NOS Nieuws • Woensdag 21 februari 2024, 08:56

Bijna tienduizend ondernemingen op wachtlijst voor stroomaansluiting

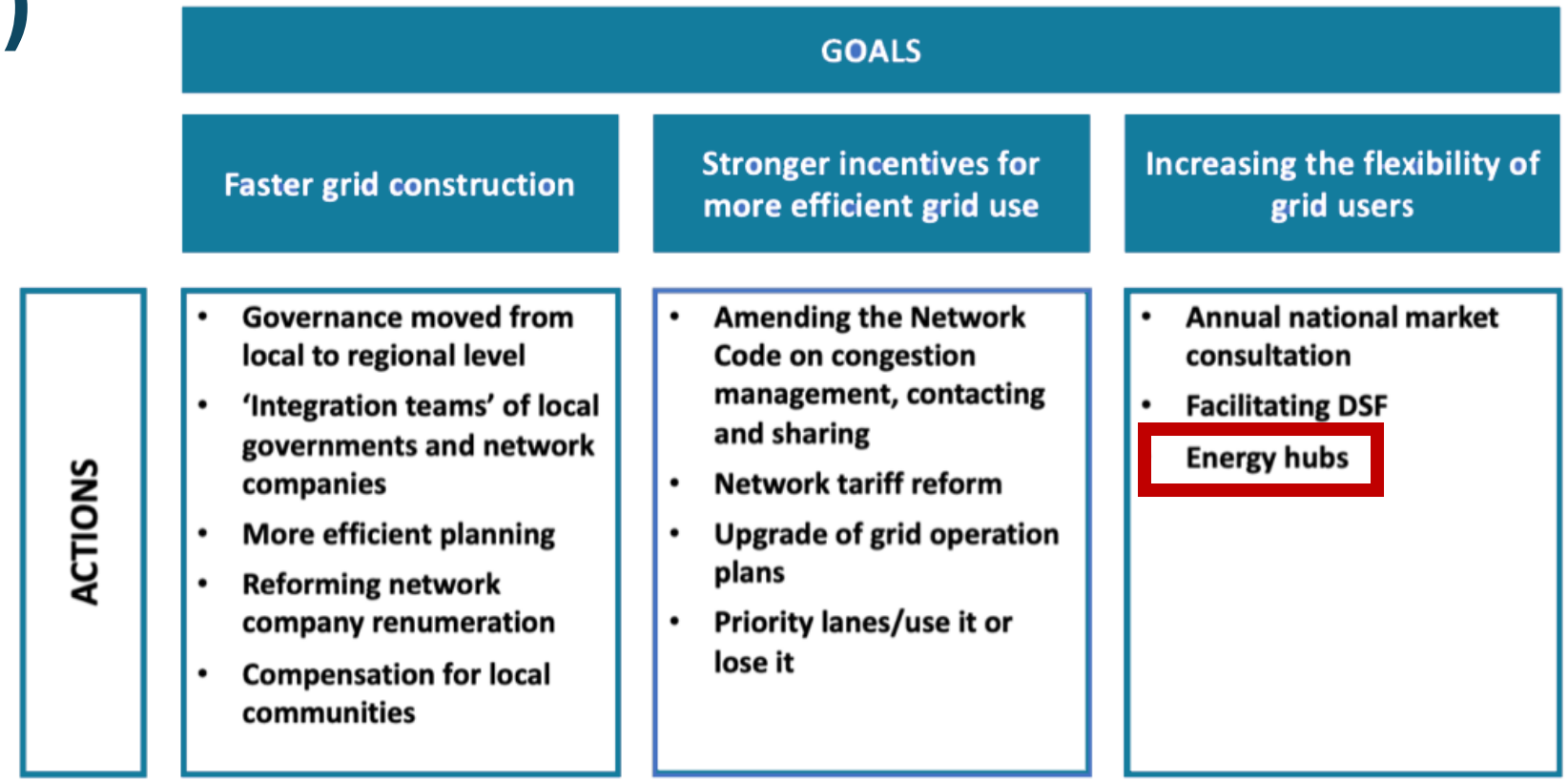
The grid is ‘full”



Grid congestion - *Netcongestie*

"Refers to a situation where the electricity grid has reached its maximum capacity and can no longer accommodate additional energy supply or demand." - *RVO, 2022*

National Grid Congestion Action Programme (LAN)



Source: (Pato,2024; adapted from LAN)

The Big Problem

Little to no documentation exists on EHubs in area development projects

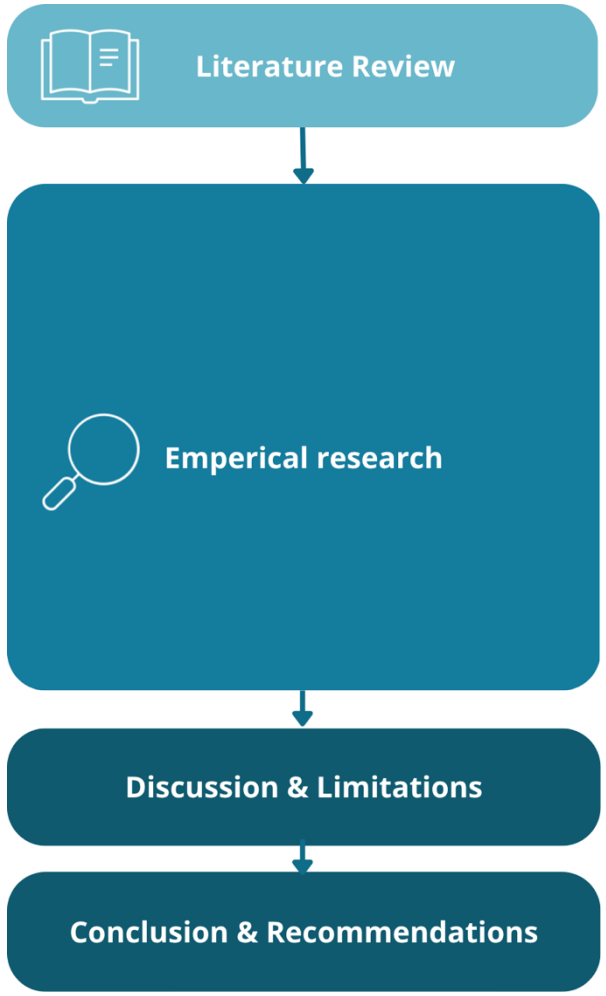
How are Energy Hubs defined and configured in area development projects facing grid congestion in the Netherlands,
and what lessons can be learned from the technical, organisational, legal and financial barriers and enablers identified in current pilot projects to inform future practice?

How are Energy Hubs defined and configured in area development projects facing gird congestion in the Netherlands,
and what lessons can be learned from the technical, organisational, legal and financial barriers and enablers identified in current pilot projects to inform future practice?

1
2
3
4
5

Sub Research questions

1. "How can an Energy Hub be **defined**?"
2. "How are Energy Hubs **configured** in existing literature in terms of technical, organisational, and legal dimensions?
3. "How are Energy Hubs **configured** in current pilot projects interms of **technical**, **organisational**, and **legal** aspects?"
4. "What **technical**, **organisational**, **legal**, and **financial barriers** and **enablers** affect the implementation of Energy Hubs in these pilot projects?
5. "What cross-case lessons can be drawn from these barriers and enablers to **inform** the **future practise** of Energy Hubs in area development projects under grid congestion?"



The Research Scope

Subject

Energy Hubs in Area Development Projects

Geographical

The Netherlands

Spatial

Residential and Mixed-use area developments

Temporal

Focus on early 2025

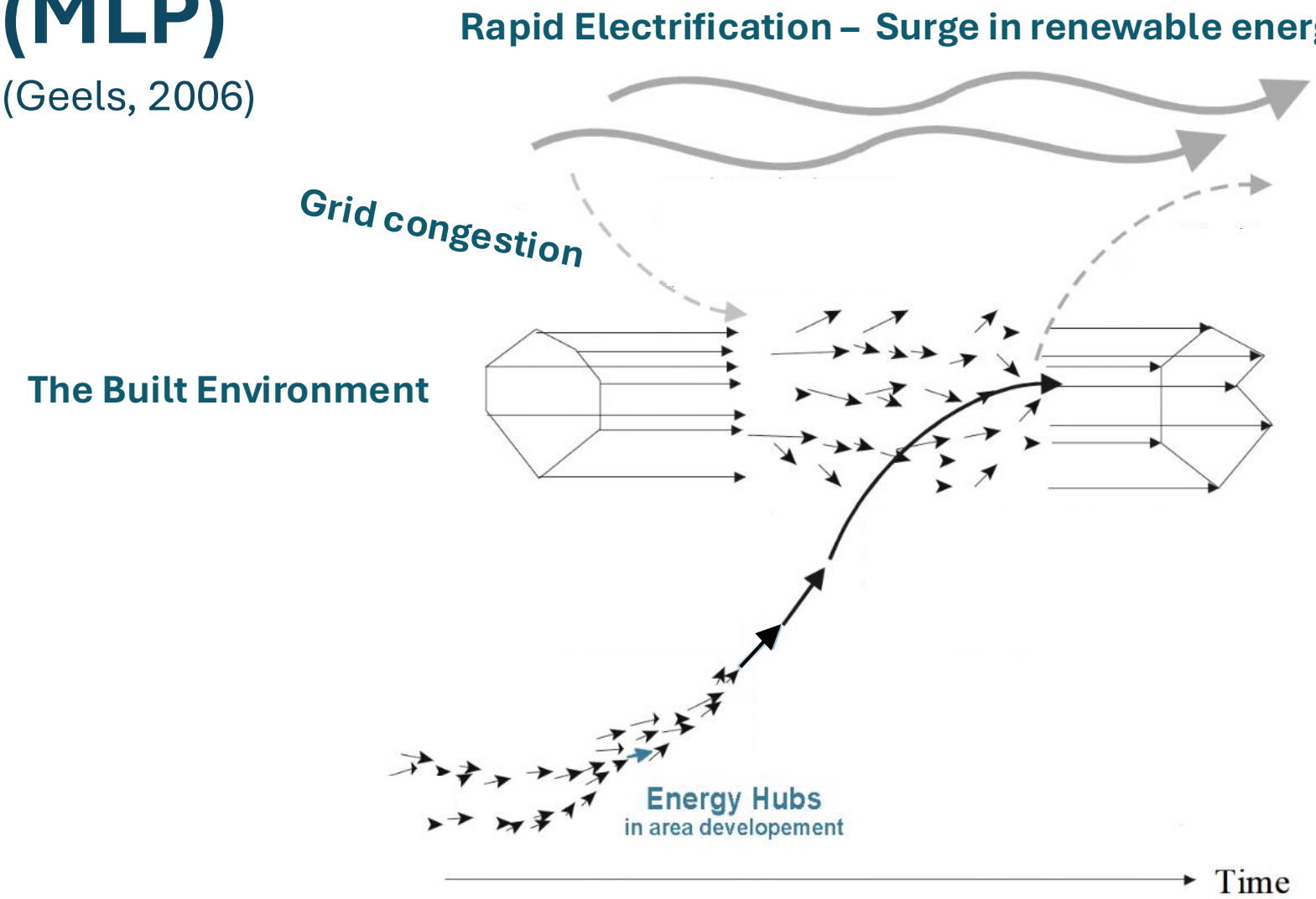
Legal

Laws and Regulations in Effect before May 2025

2 Theoretical Lens

Multi Level Perspective – Framework (MLP)

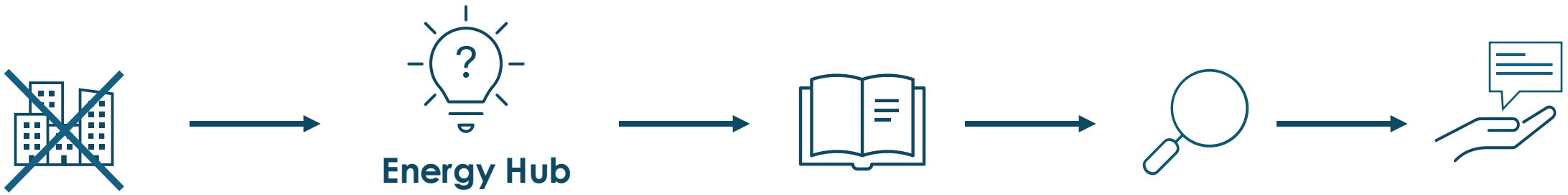
(Geels, 2006)



1. Dominant design
2. Internal momentum
3. Strategic interaction with regime

3 Methodology

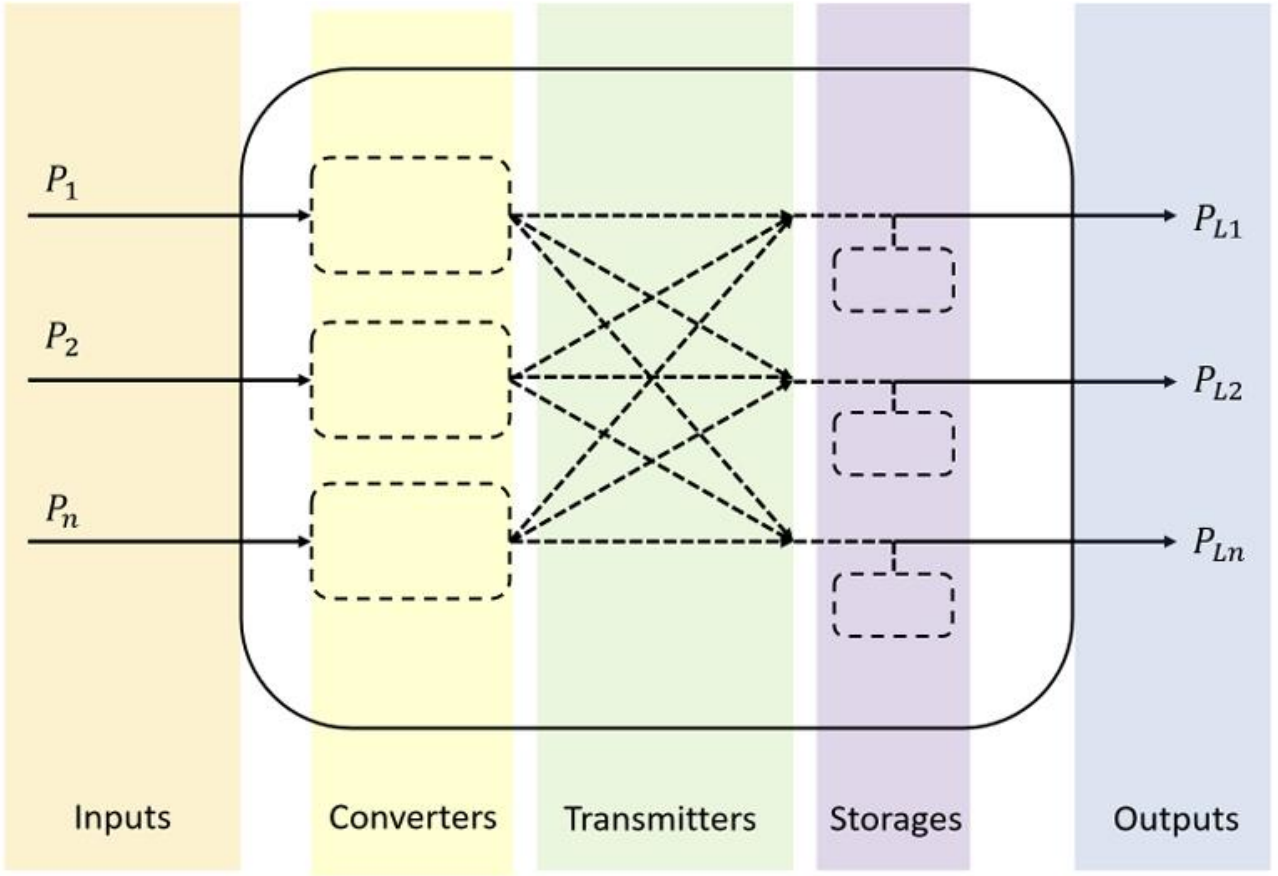
The Research Flow



4 Literature Review

1 “How can an Energy Hub be **defined**?”

EHub Concept



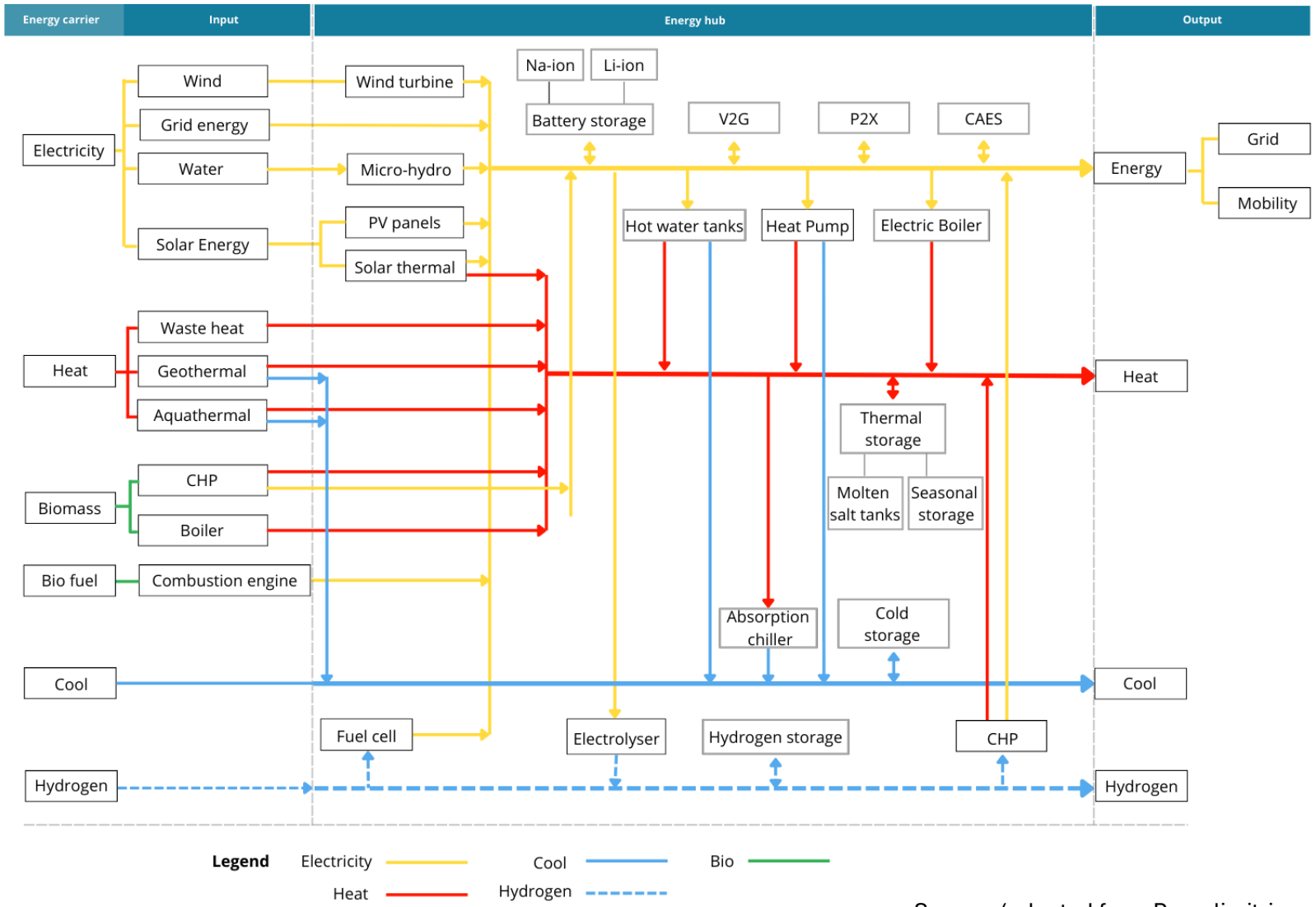
Source: (Ines,2024 adapted from Thang et al., 2018)

Definition of an EHub

A **collaboration** involving **multiple stakeholders** that coordinate the **generation, storage, conversion, and consumption** of energy **locally,** through a **formal agreement** and represented by a **legal entity** or a designated natural person.

2 "How are Energy Hubs **configured** in existing literature in terms of technical, organisational, and legal dimensions?

Technical



Source: (adapted from Papadimitriou et al., 2023)

Organisational: Key Stakeholders

DSO
Project developers
Energy Service Providers
Thermal and Mobility Operators
Large Consumers
Residents

Legal

Legislation

- Experimentation Decree
  - 2015-2018
- Groeps Transport Overeenkomst (GTO)

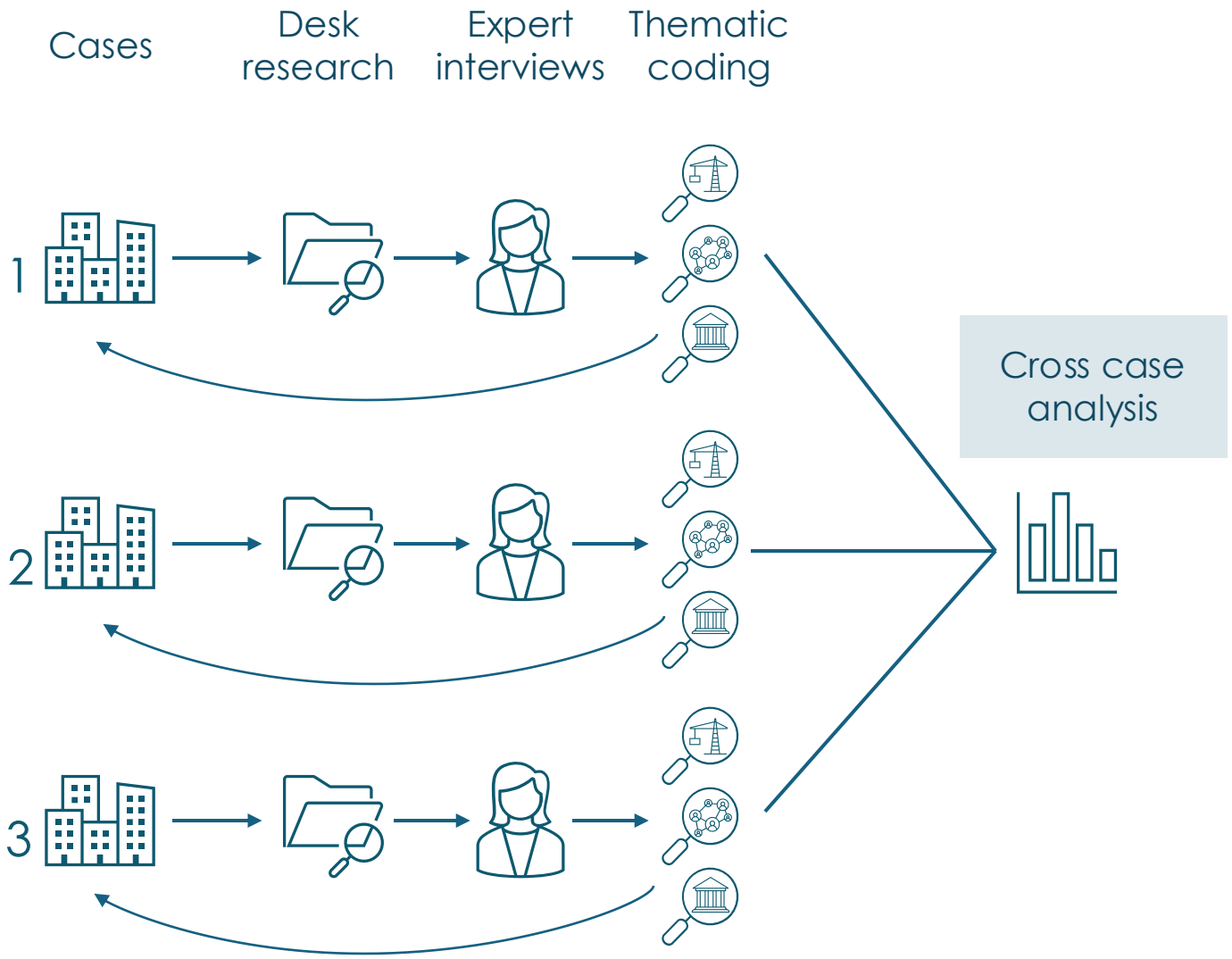
Contract forms

- Coöperation
- B.V.

4 Empirical Research

3 "How are Energy Hubs **configured** in current pilot projects in terms of **technical**, **organisational**, and **legal** aspects?"

Case study


Cases
Desk research
Expert interviews
Thematic coding
1
2
3
Cross case analysis

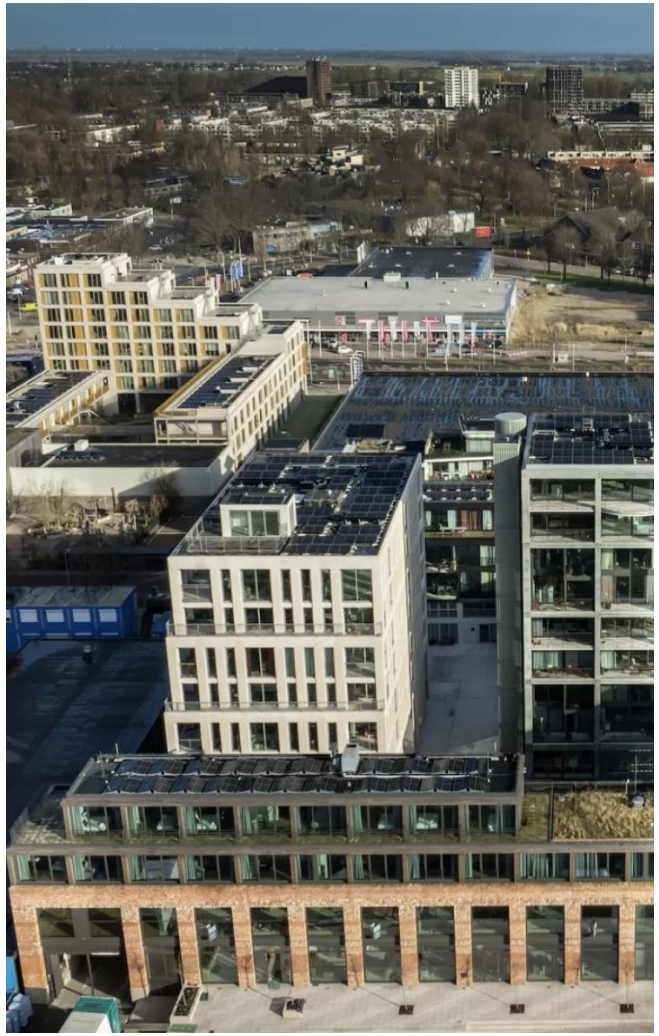
Interviewees for Case Study

Actor	Merwede	Schoonschip	Republica
Technical Advisor	✓	✓	✓
DSO	✓	–	-
Legal Advisor	-	✓	✓

Merwede

Schoonschip

Republica



	Merwede	Schoonschip	Republica
	Utrecht	Amsterdam	Amsterdam
	Expected to finish 2027	Finished 2020	Finished 2023
	4250 homes	47 homes	74 homes
	65.000 m2	-	20.000 m2
	5.2 MW	130 kW	1.5 MW

Merwede

Solar PV

Battery Storage

AETS

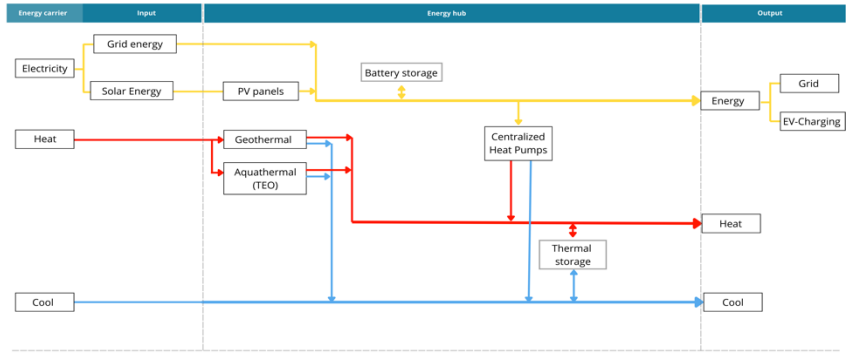
Ectogrid

(Central) Heat pumps

EMS

Smart EV Charging

Shared Mobility



Schoonschip

Solar PV

Battery Storage

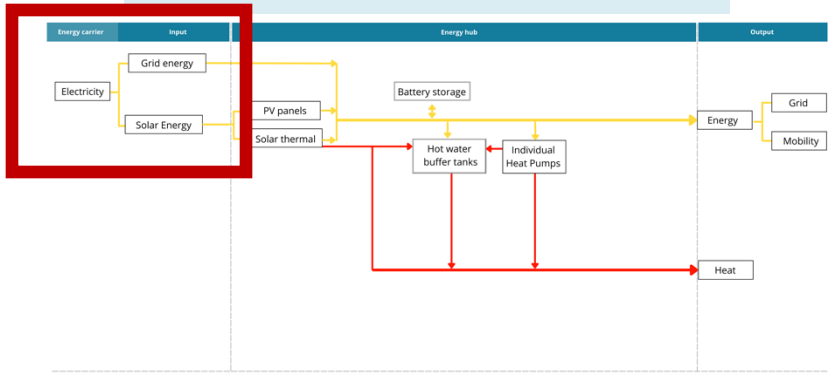
Heat pumps

EMS

VPP

Smart EV Charging

Shared Mobility



Republica

Solar PV

Battery Storage

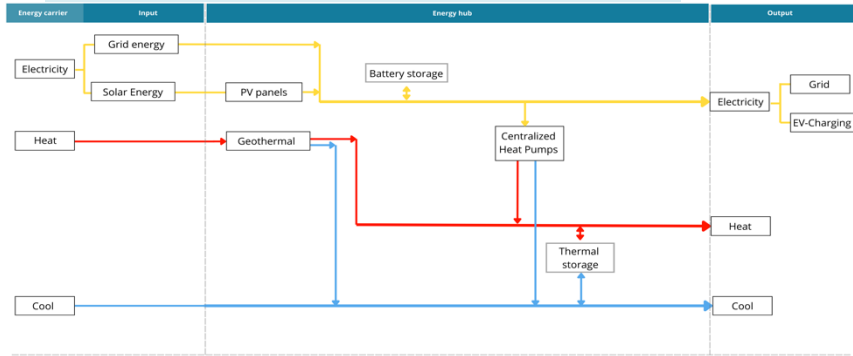
AETS

Ectogrid

(Central) Heat pumps

EMS

Shared Mobility

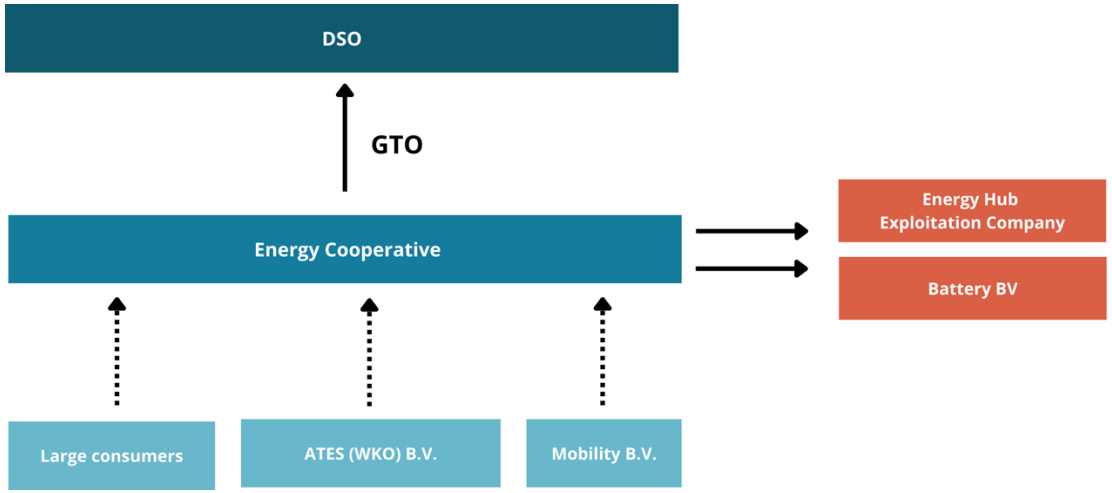


Cross-case Analysis

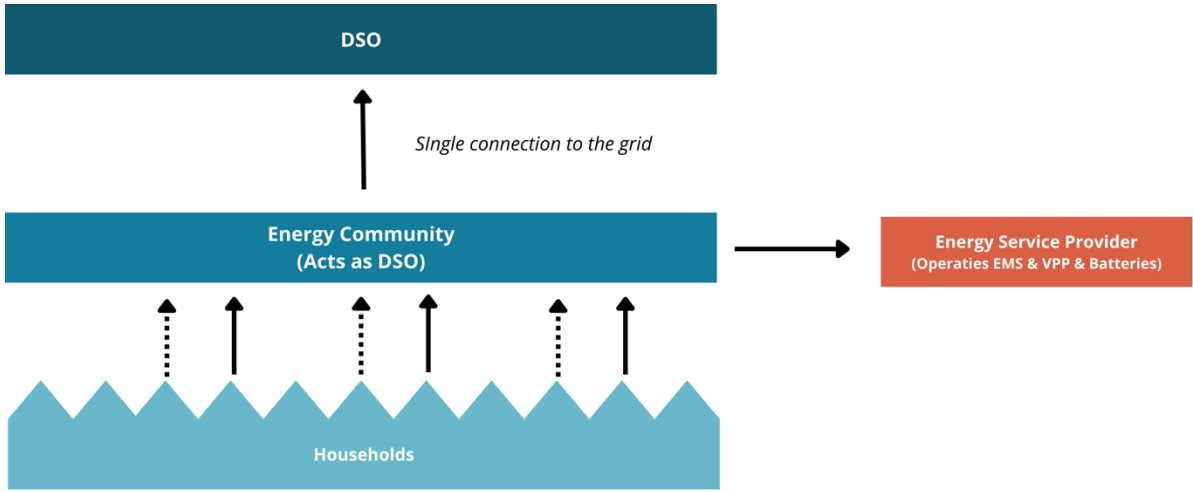
Technical Configuration

Technology Category	Merwede	Schoonschip	Republica
Solar PV	✓	✓	✓
Battery Storage	✓	✓	✓
ATES	✓	x	✓
Ectogrid	✓	x	✓
Heat Pumps	✓	✓	✓
EMS	✓	✓	✓
VPP	x	✓	x
Smart EV Charging	✓	x	x
Shared Mobility	✓	✓	✓

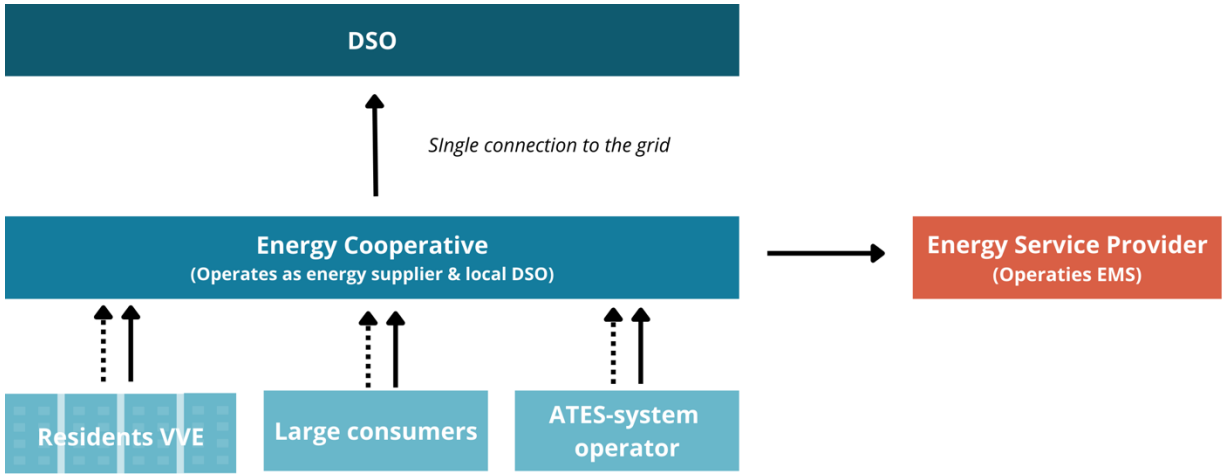
Merwede

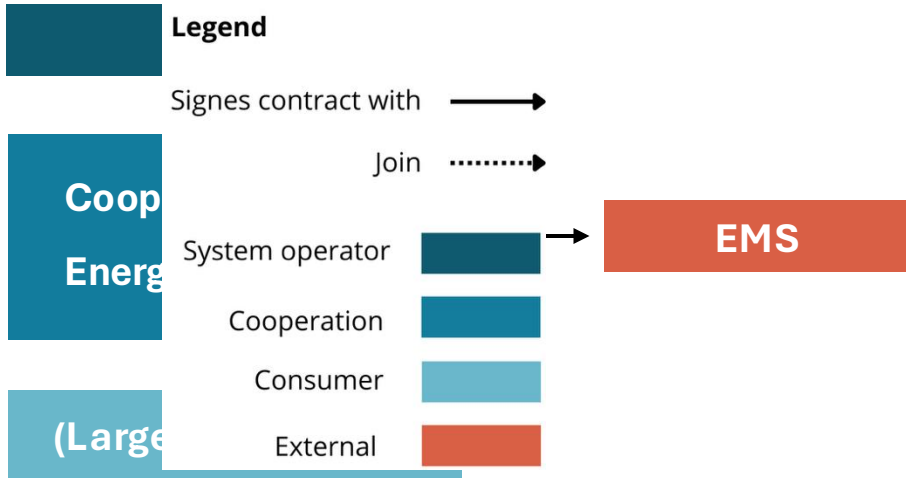


Schoonschip



Republica





4 "What **technical**, **organisational**, **legal**, and **financial barriers** and **enablers** affect the implementation of Energy Hubs in these pilot projects?

5 "What cross-case lessons can be drawn from these barriers and enablers to **inform** the **future practise** of Energy Hubs in area development projects under grid congestion?"

Cross Case Lessons of Barriers & Enablers

Enablers

- Early technical consultation
- Public subsidies
- Strong collaboration among stakeholders
- Pilot; Exemption from regulations
- EMS integration
- Economies of scale

Barriers

- Lack of standardization
- Initial design restrictions
- Diffuse project responsibilities
- Uncertainty about long-term legal status

Discussion

People

Need for an energy program manager
Skilled technical advisors
Early-stage collaboration
Exclude residents from the process

Planet

Support decentralised renewable energy systems
Use energy simulation tools

Profit

Need for new risk sharing models

Project

Design should minimise user intervention
Leverage economies of scale in larger projects

Process

Energy management is often a retrofit, not yet embedded

Limitations

- Early-Stage Projects
- Stakeholder Bias
- Context-Specific Findings
- Restricted Document Access

Future Research

- Longitudinal Study
- Quantitative Evaluation of System Impact
- Comparative International Research
- Legal and Regulatory Framework Development

Recommendations

- Evolve exemption into norm
- Provide templates for contracts and cooperations
- Reconsider future role of suppliers choice in DES
- Improve grid data access

- Early involvement Energy Project Manager
- EMS & Storage
- Adapt construction phasing to grid constraints
- Formalise legal cooperation

How are Energy Hubs defined and configured in area development projects facing gird congestion in the Netherlands,
and what lessons can be learned from the technical, organisational, legal and financial barriers and enablers identified in current pilot projects to inform future practice?

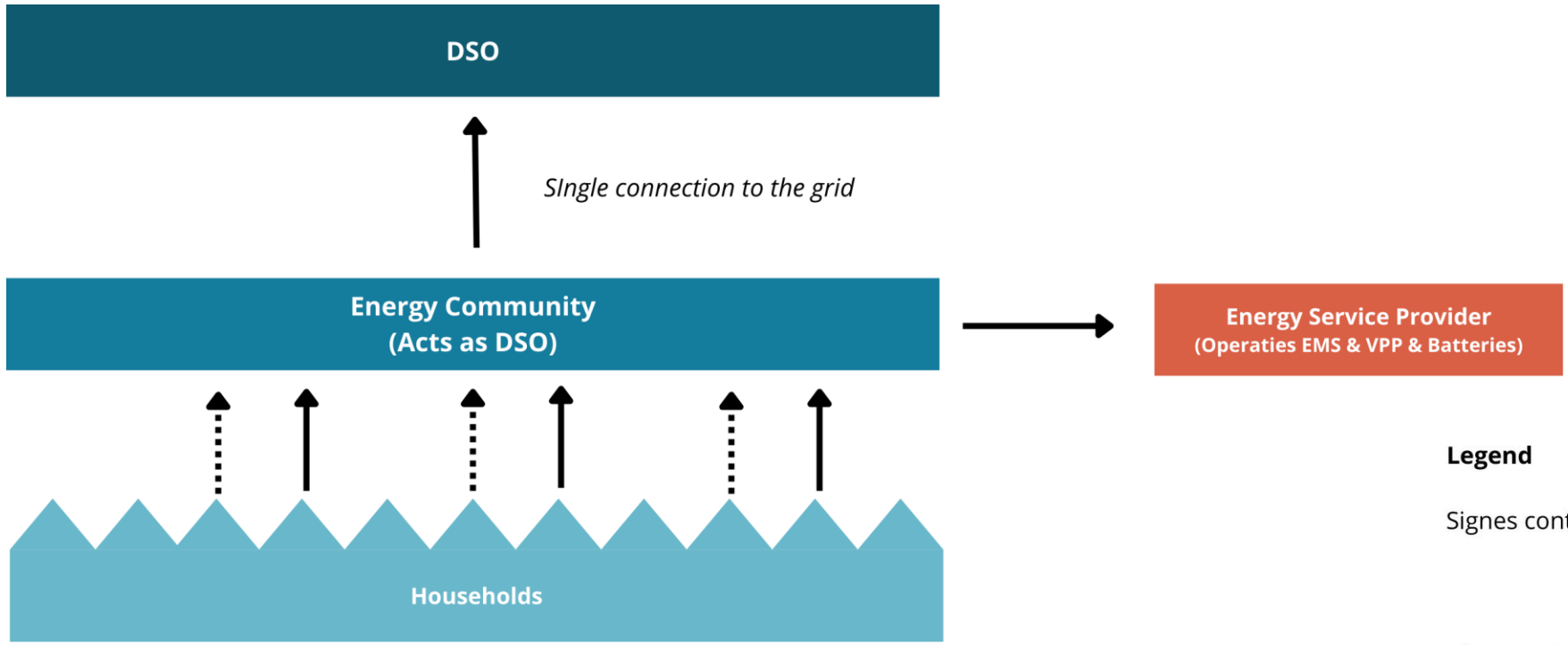
Questions?

Cross-case Analysis Configuration

Attribute	Merwede	Schoonschip	Republica
Scale	Large distric-scale 4250 households, 65.000m² commercial/social)	Small-scale 47 households	Medium-scale 74 households, 20.000m² commercial/social
Governance Model	Hybrid public-private, Energy cooperative with GVBs	Bottom-up energy cooperative initiated by residents	Developer-led cooperation with VvE & utility partnerships
Legal Framework	Group Transport Agreement (GTO), municipal co-ownership in DHC	Experimentation Decree (private grid ownership)	Experimentation Decree (private microgrid and internal supplier)
Grid Constraint Strategy	Load budgeting per dwelling; 5,2 MW cap; EMS that coordinates heating, mobility, battery systems to stay within contracred capacity; Load shifting V2G	Strict 130 kW cap; High local self-generation (solar PV), distributed home batteries, and a smart EMS that enables real-time load balancing, demand response, and participation in energy markets via a Virtual Power Plant (VPP).	1.5 MW cap; Managed by combining a local microgrid, centralized battery storage, thermal energy exchange (ATES), and building-level EMS control to balance loads, maximize on-site consumption, and reduce peak demand.
Market Participation	Limited/planned	Active (day-ahead, imbalance)	Limited; Underutilized potential
Replicability	Moderate (scalable under similar conditions)	Low (unique governance/legal setup)	Moderate (scalable under similar conditions)

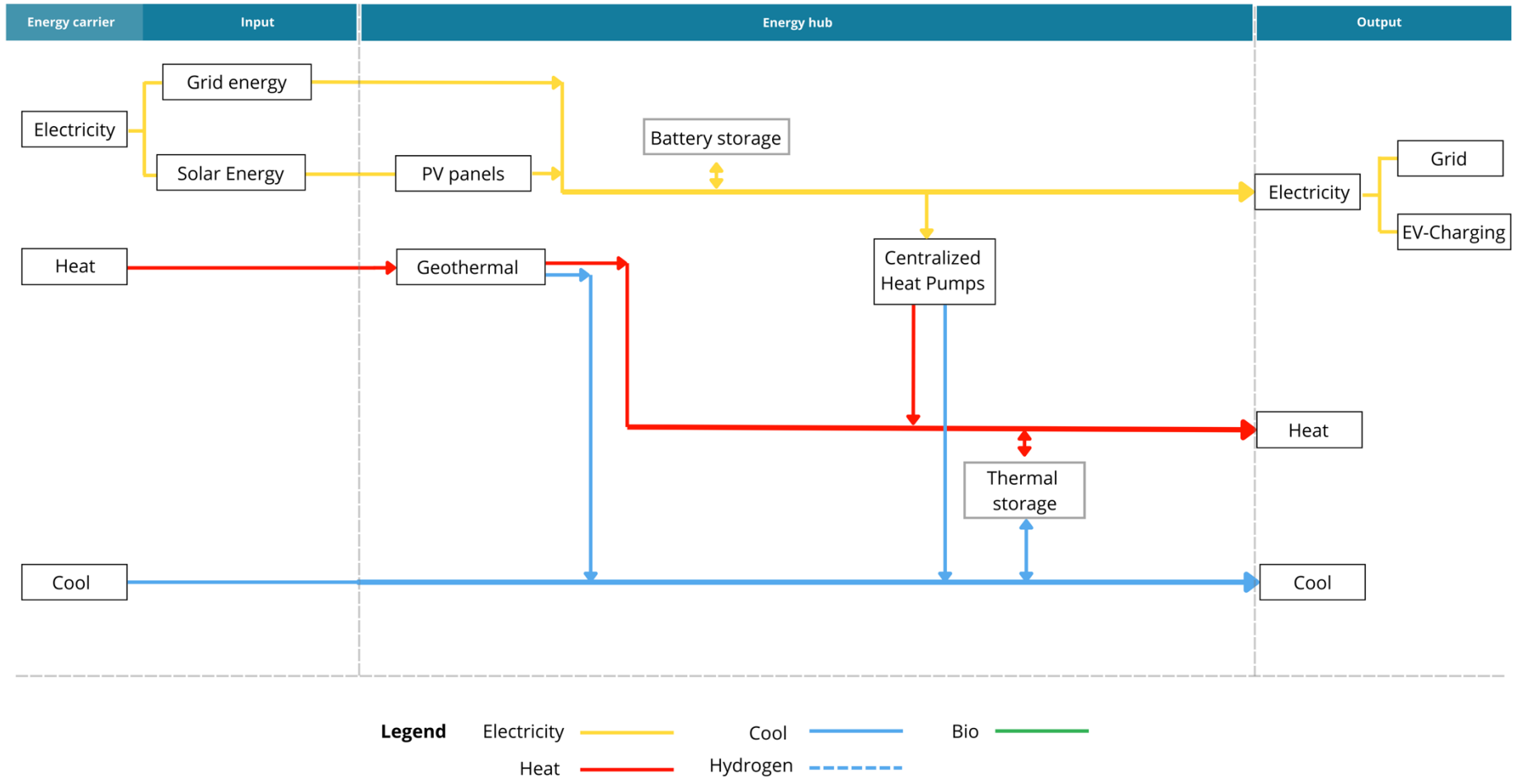
Legal Configuration

Schoonschip



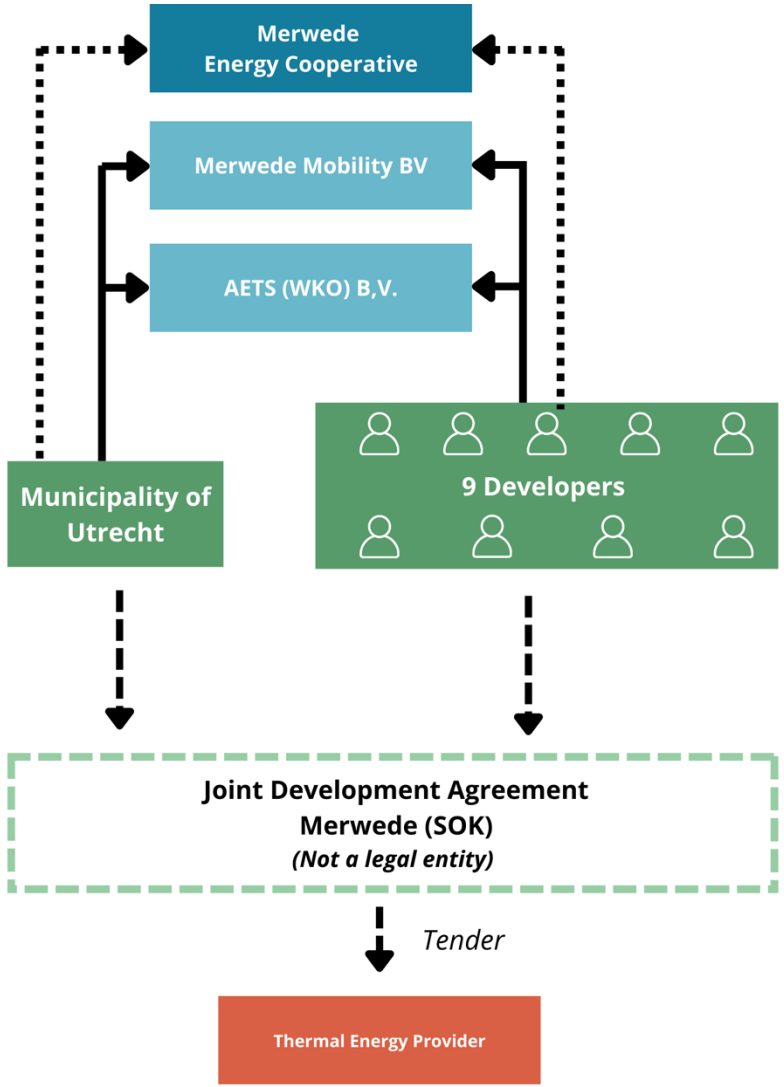
Technical Configuration

Republica



Organizational Configuration

Merwede

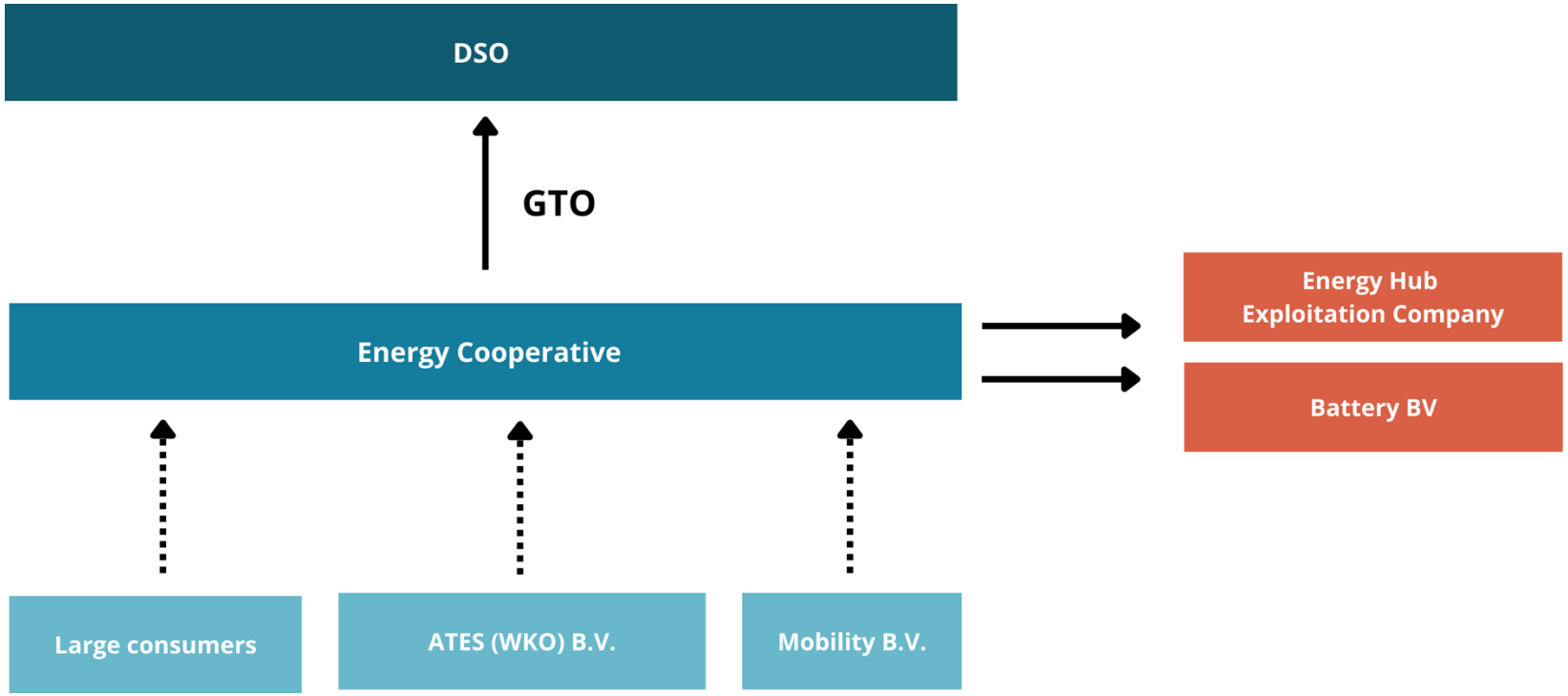


Legend

- Ownership
- Membership
- Sign
- Public/private parrties
- Agreement
- Cooperation
- Company
- External Company

Legal Configuration

Merwede



Legend

Contractual relationship

Membership

System operatior

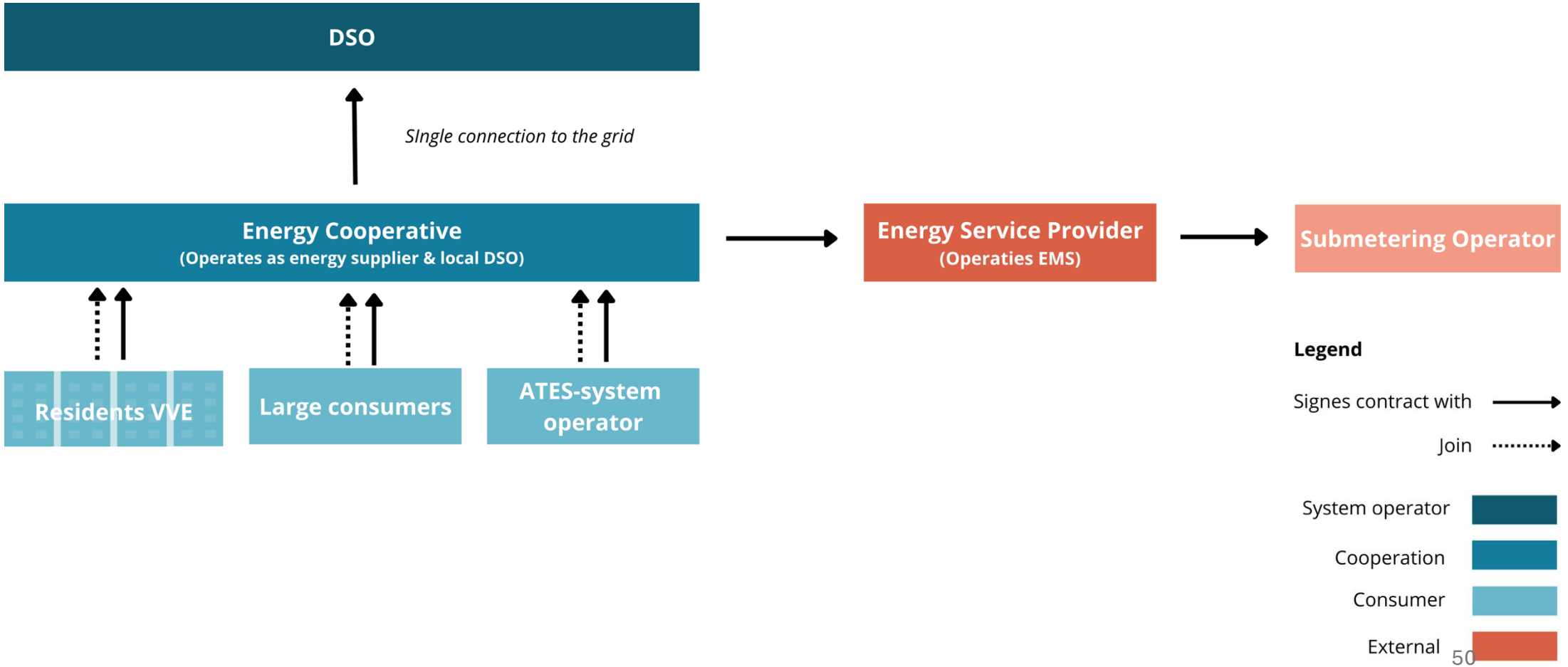
Cooperation

Consumer

External Company

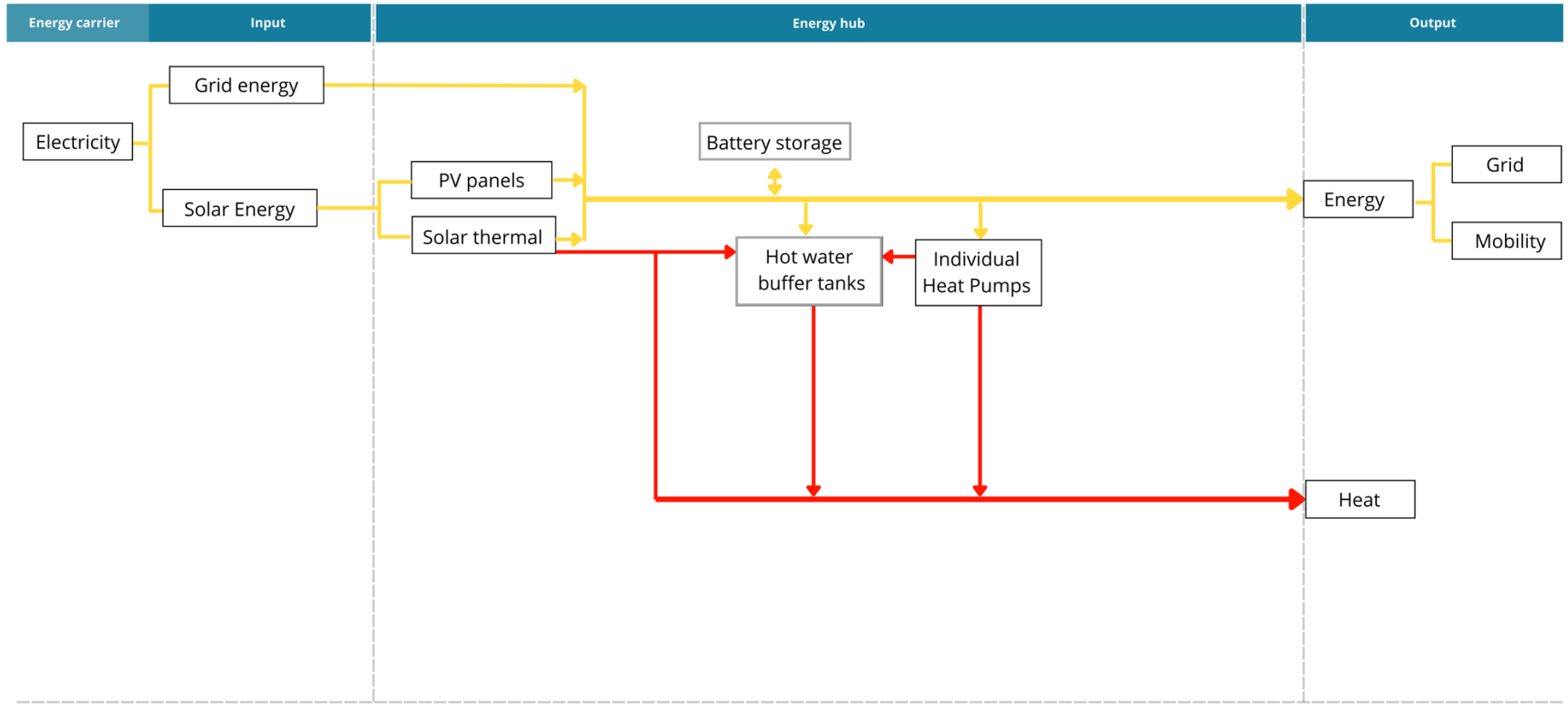
Legal Configuration

Republica



Technical Configuration

Schoonschip



Barriers and Enablers

Merwede

Themes	Type	Label
Technical	Barrier	Forecasting_uncertainty
	Barrier	Inflexible_large_consumers
	Barrier	No_grid_data_acces
	Barrier	Grid_capacity_limit
	Enabler	Centralised_solution
	Enabler	Predictable_profiles
	Enabler	EMS
	Enabler	Regulatory_support
Organisational	Barrier	Complex_stakeholder_coordination
	Barrier	Late_involvement_technocal_adviso
	Barrier	Stakeholder_dependency
	Barrier	Slow_Development
	Enabler	Stakeholder_collaboration
	Enabler	Cooperation
	Enabler	Joined_procurement
	Enabler	Win_win_framing
	Enabler	Technical_advisor
	Enabler	DSO_recignition_nonresidential
	Enabler	Willingness_DSO
Legal	Barrier	Legal_liability_risk_DSO
	Barrier	Legal_liability_risk_Developer
	Barrier	Lack_of_legal_instrument
	Enabler	Cooperation
	Enabler	Obligation_connecting_dwellings
	Enabler	Pre_contracted_load
	Enabler	Pilot
Financial	Barrier	High_upfront_investment
	Barrier	Stakeholder_dependency
	Barrier	Stakeholder_dependency
	Enabler	Pre_contracted_load
	Enabler	Commitment_stakholders
	Enabler	Flexibility

Barriers and Enablers

Schoonschip

Themes	Type	Label
Technical	Barrier	Lack_of_standardization
	Barrier	Small_scale_implimentation
	Barrier	Decentralize_solutions
	Enabler	EMS_integration
	Enabler	EMS_refinemens
Organisational	Barrier	Unclear_Roles
	Barrier	User_autonomy_design
	Barrier	Time_intensive_support
	Enabler	Stakeholder_collaboration
	Enabler	Early_enagement_technical_advisor
	Enabler	Residents_ technical_knowledge
	Enabler	Close_collaboration
Legal	Barrier	Future_legal_uncertainty
	Barrier	Permitting_constrain
	Enabler	Cooperation
	Enabler	VPP
Financial	Barrier	Decentralized_solutions
	Barrier	Limited_scalability
	Enabler	Subsidies
	Enabler	Innovation_added_value

Barriers and Enablers

Republica

Themes	Type	Label
Technical	Barrier	No_local_balancing
	Enabler	Standardized_design
	Enabler	Centralised_solutions
	Enabler	EMS_integration
Organisational	Barrier	EMS_refinemens
	Barrier	Lack_of_expertise
	Enabler	Developer_innovation_motive
	Enabler	Early_involvement
	Enabler	Single_developer
Legal	Enabler	Pilot
	Enabler	Cooperation
Financial	Barrier	No_local_balancing
	Enabler	Subsidies
	Enabler	Innovation_added_value