THE MINIMUM COST OF TRANSPORTING HYDROGEN VIA TRUCKS BETWEEN FRANCE AND GERMANY

European Hydrogen Energy Conference – EHEC 2018

MARCH 15TH 2018 I <u>AMIN LAHNAOUI</u>, CHRISTINA WULF, HEIDI HEINRICHS, DIDIER DALMAZZONE

SYSTEMS ANALYSIS AND TECHNOLOGY EVALUATION (IEK-STE)
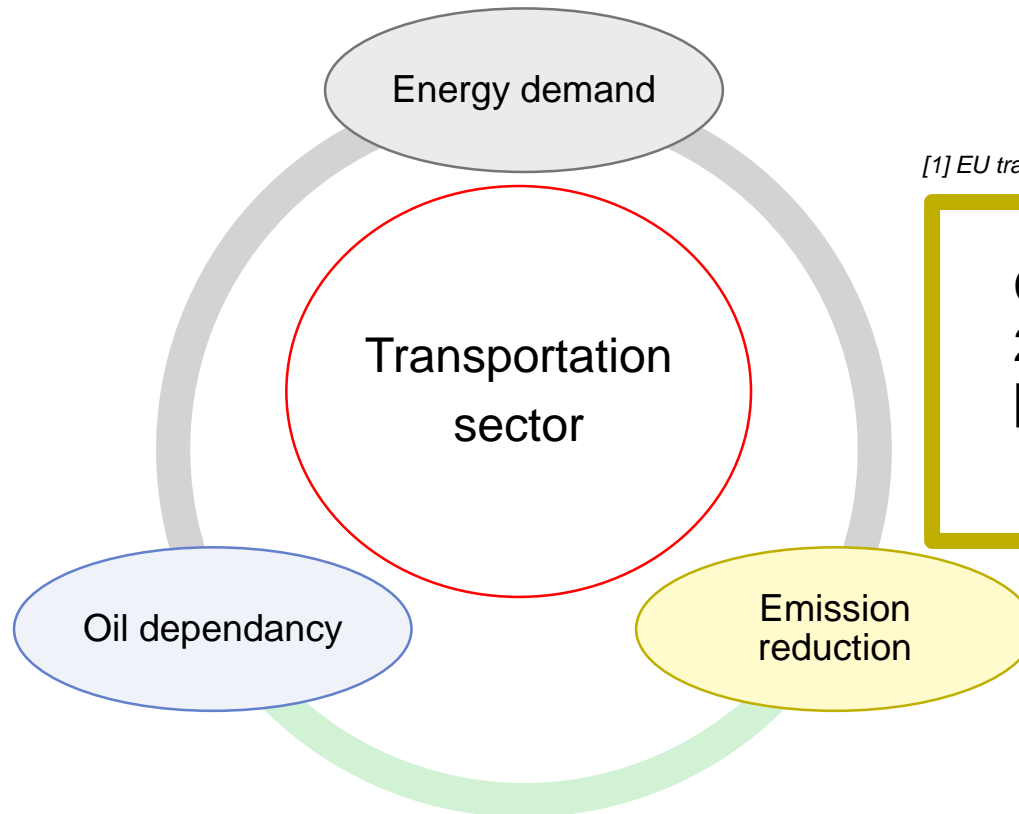
INTRODUCTION

European context

32 % of the EU final energy consumption in 2014 [1]

[1] EU transport in figures, EU commission 2015

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INTRODUCTION

European context

Energy demand

Transportation sector

Oil dependancy
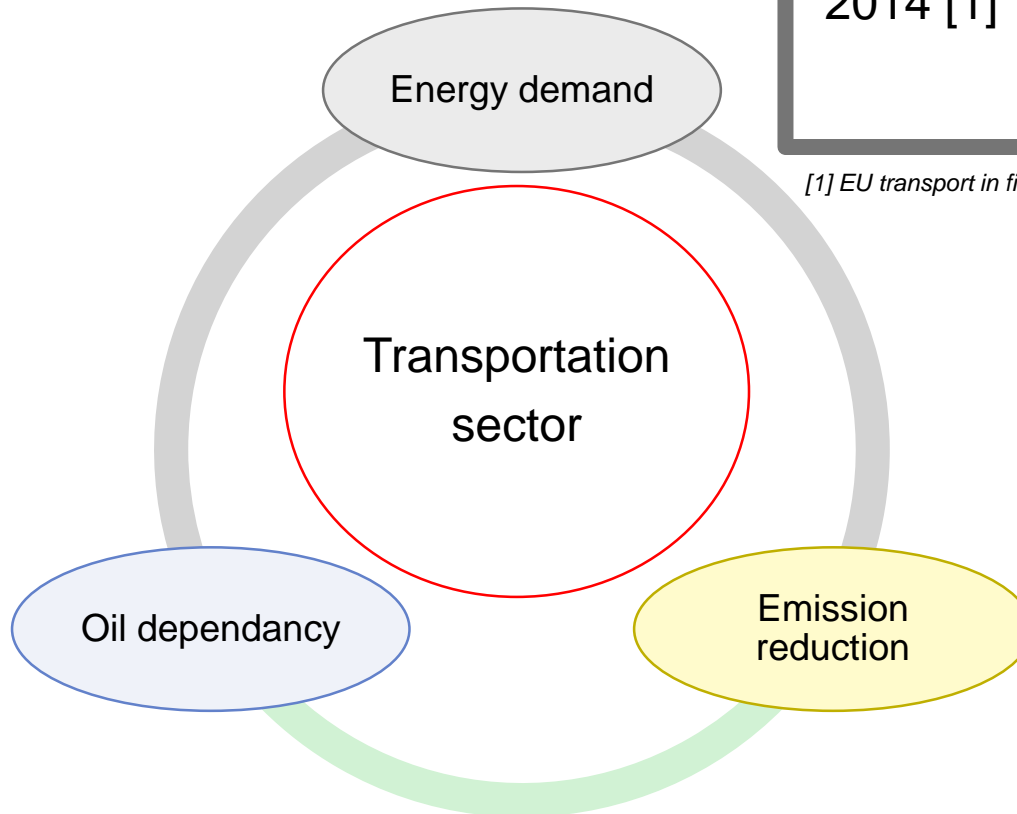
Emission reduction

[1] EU transport in figures, EU commission 2015

CO_2 emission increase by 22 % during the last 25 years [1]

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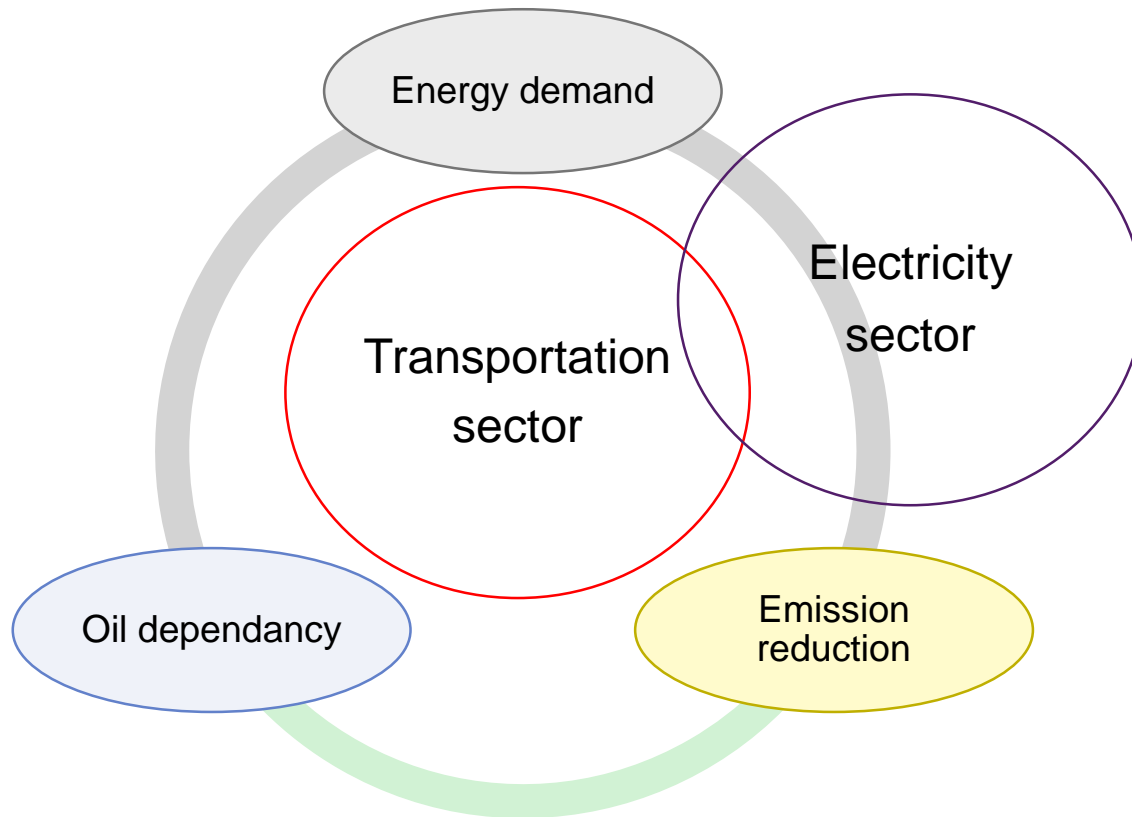Forschungszentrum

INTRODUCTION

European context

Share of alternative fuel vehicles among newly registered passenger cars in 2015 was < 2 % [2]

[2] Statistical pocketbook 2017 - EU transport in figures

Energy demand

Transportation sector

Oil dependancy

Emission reduction

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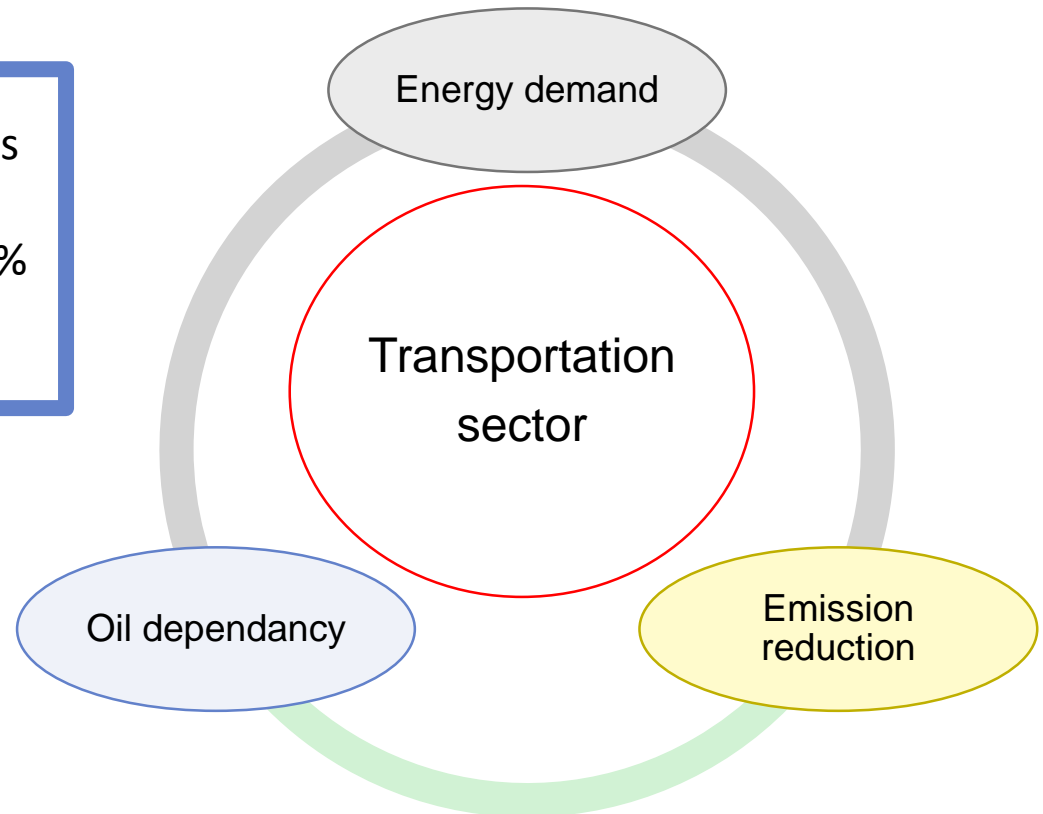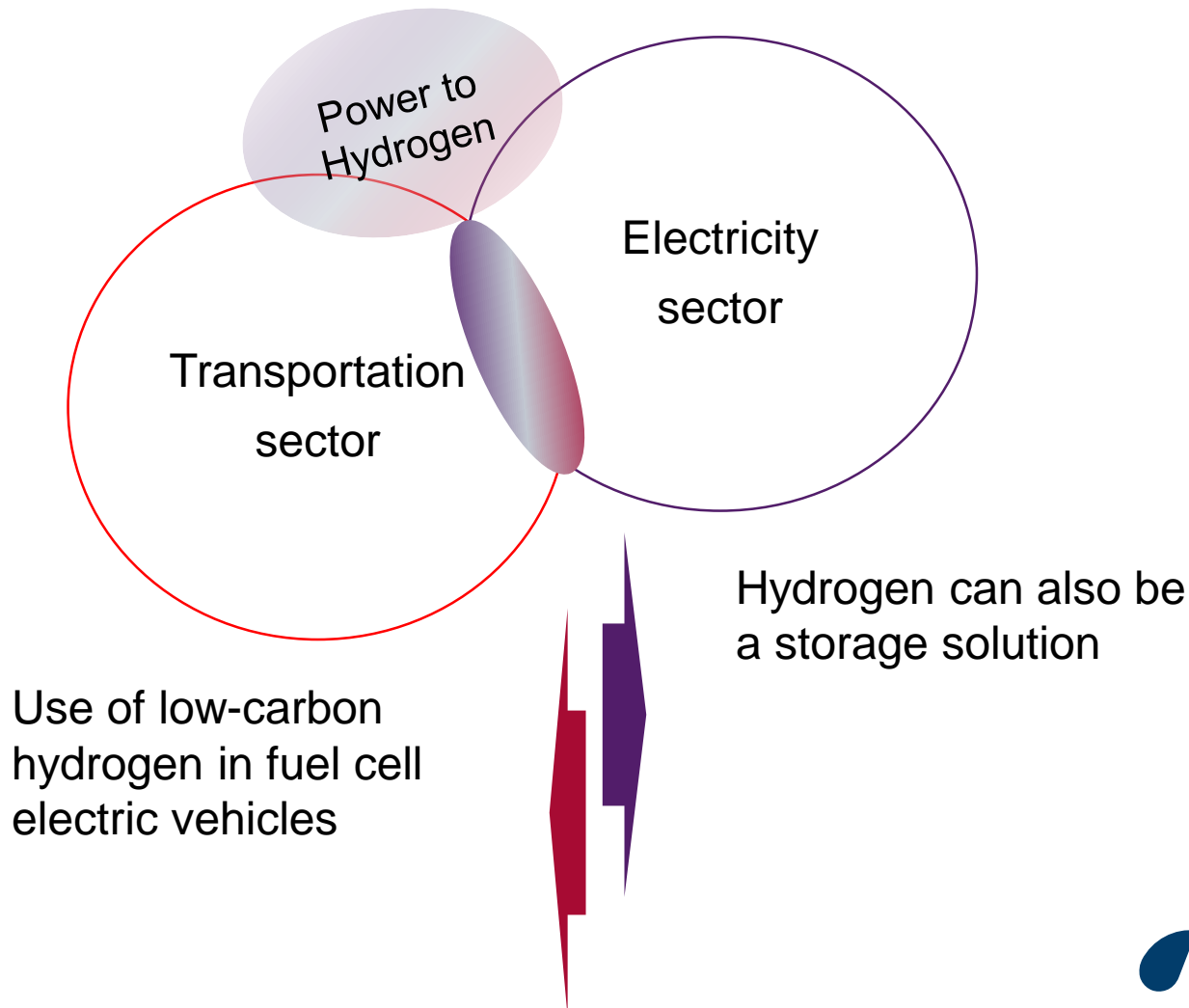
INTRODUCTION

European context

An increase of 22 % of the global generation from RE in 2015 [3], increases excess electricty

[3] Tracking clean energy progress 2015 – International Energy Agency, IEA

INTRODUCTION

Power to Hydrogen as a coupling vector

Power to Hydrogen

Electricity sector

Transportation sector

Use of low-carbon hydrogen in fuel cell electric vehicles

Hydrogen can also be a storage solution

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INTRODUCTION

Power to Hydrogen as a coupling vector

Electricity sector

Transportation sector

Defining an infrustructure

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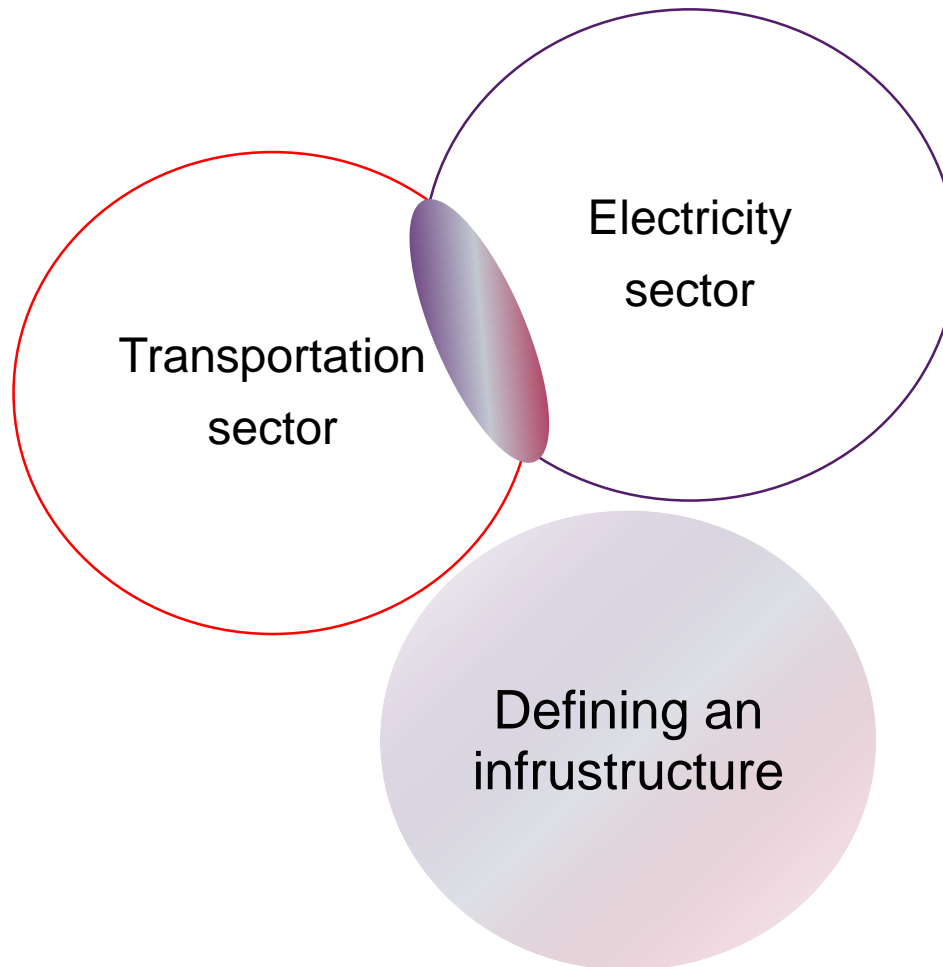
MODEL FRAMEWORK

Hydrogen supply chain

Time frame: 2030
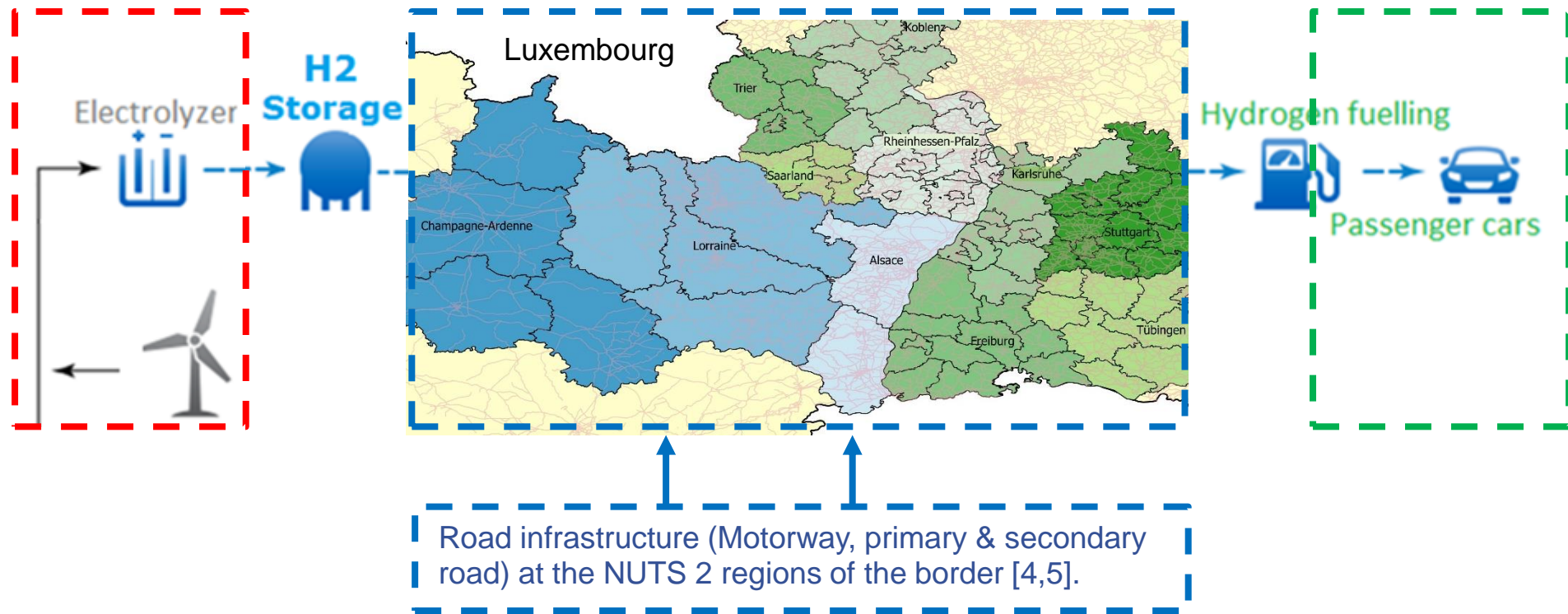
Electrolyzer

H2 Storage

Luxembourg

Koblenz
Trier
Rheinhessen-Pfalz
Saarland
Karlsruhe
Champagne-Ardenne
Lorraine
Alsace
Stuttgart
Freiburg
Tübingen

Hydrogen fuelling

Passenger cars

Road infrastructure (Motorway, primary & secondary road) at the NUTS 2 regions of the border [4,5].

NUTS regions in France [4] and in Germany [5]. EUROSTAT, European statistics

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MODEL FRAMEWORK

Input parameters

- Current share of regional installed capacity to the national one [6,7]
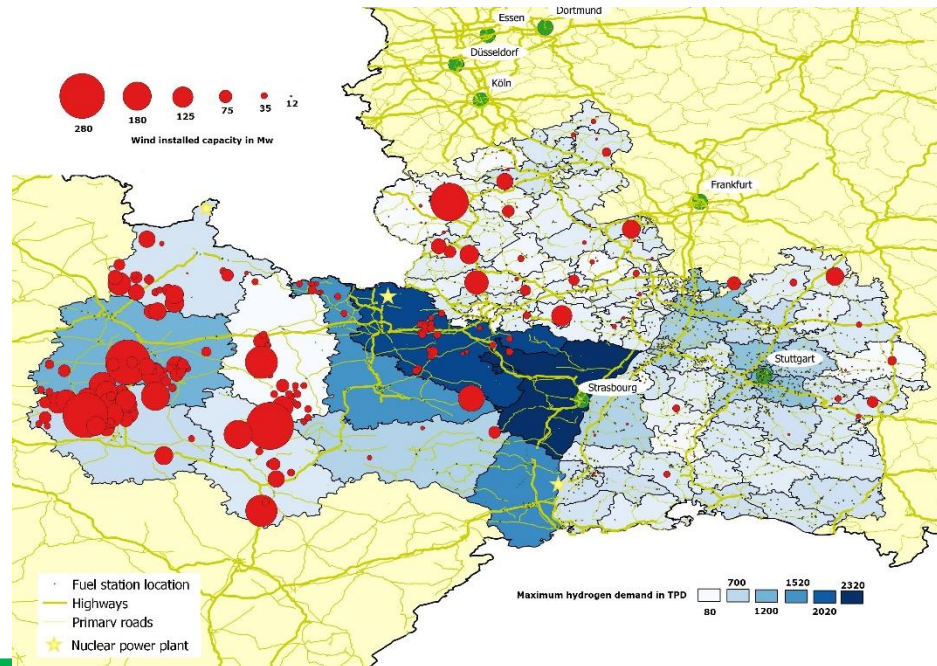- Projection of installed capacity [8]
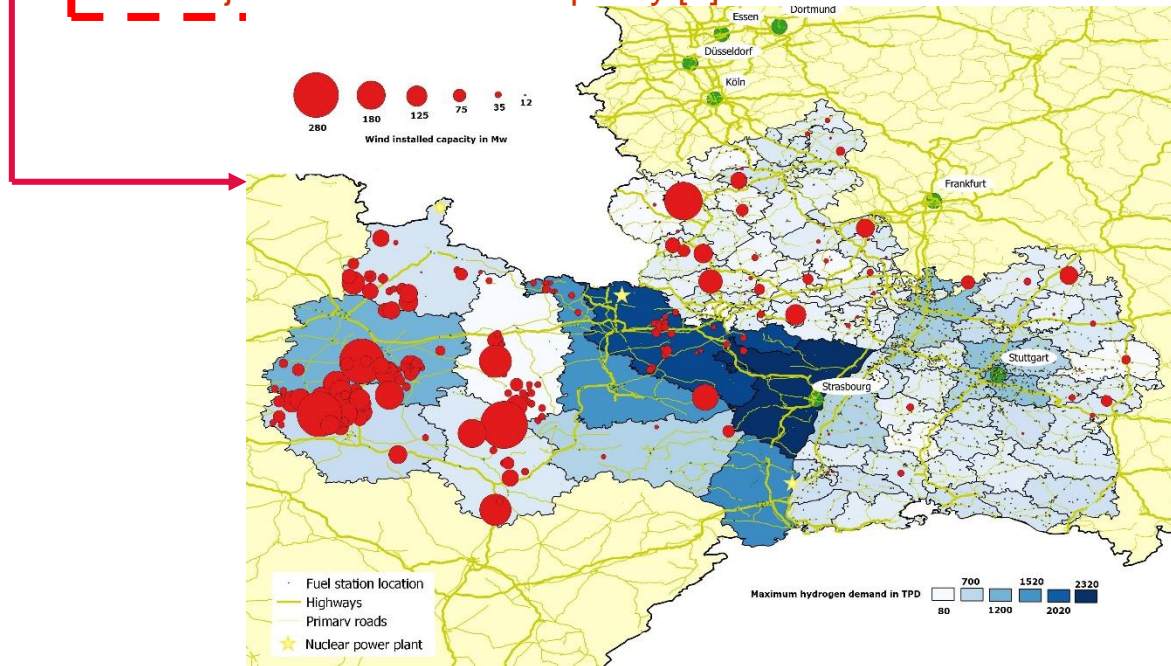
Installed capacity, zones Baden-Württemberg, Saarland and Rheinland-Pfalz *[6] and* zones 08, 10, 51, 52, 54, 55, 57, 67, 68 and 88 *[7].* The Wind Power.
[8] Wind energy scenarios for 2030. European Wind Energy Association

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MODEL FRAMEWORK

Input parmeters

- Projection of population and average distance travelled per capita [9,10]
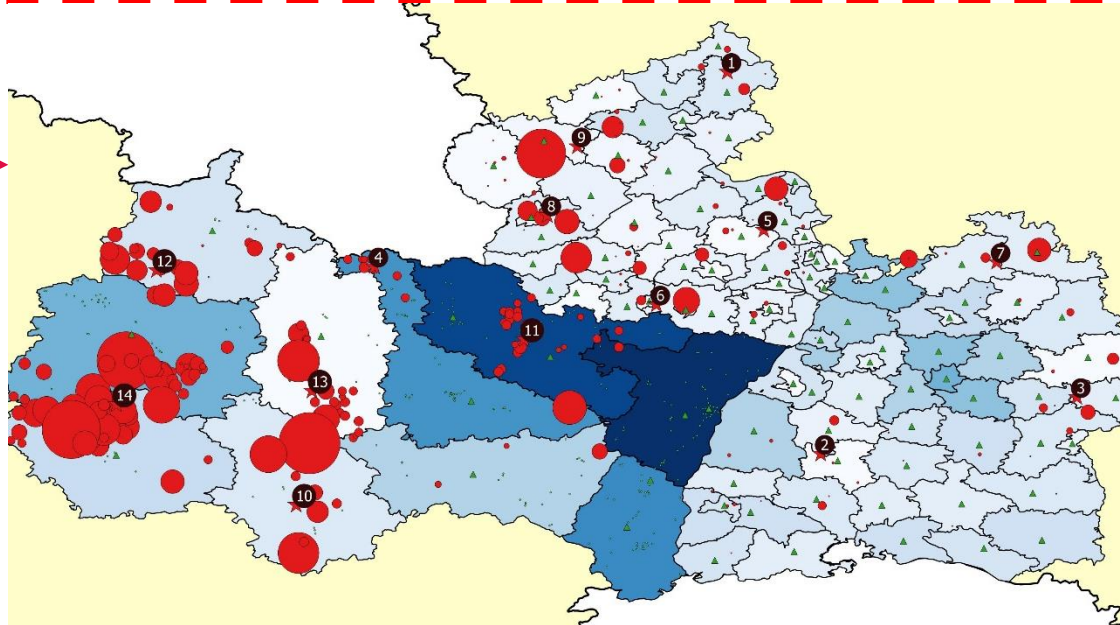- Scenario for the share of FCEV in new fuel [11]

Population projections data *[9] and* Passenger road transport on national territory, by type of vehicles registered in the reporting country [10]. EUROSTAT, European statistics
[11] Technology Roadmap, Hydrogen and Fuel Cells. International Energy Agency, IEA

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MODEL FRAMEWORK

Input parmeters

- Maximum distance between production locations as an input parameter
- Center of mass of hydrogen production

MODEL FRAMEWORK

Input parmeters

- Distribution as a center of NUTS 3 regions [4,5]
- Center of mass of the distribution of the refueling stations (FR)

NUTS regions in France [4] and in Germany [5]. EUROSTAT, European statistics

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MODEL

LCOCH : Levelized cost of compressing hydrogen in € / kg
P_i & P_j : pressure levels

MODEL

Ideal 5 stage compressor

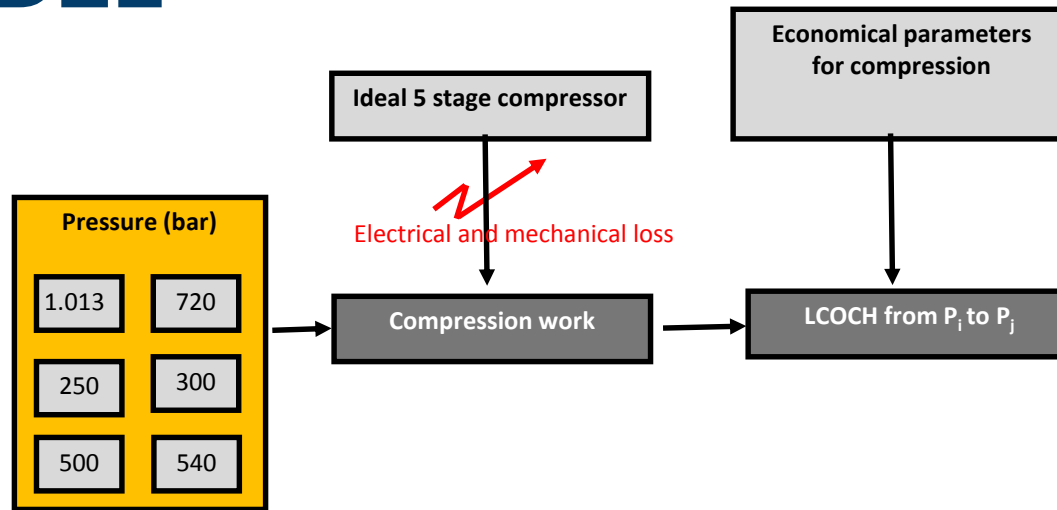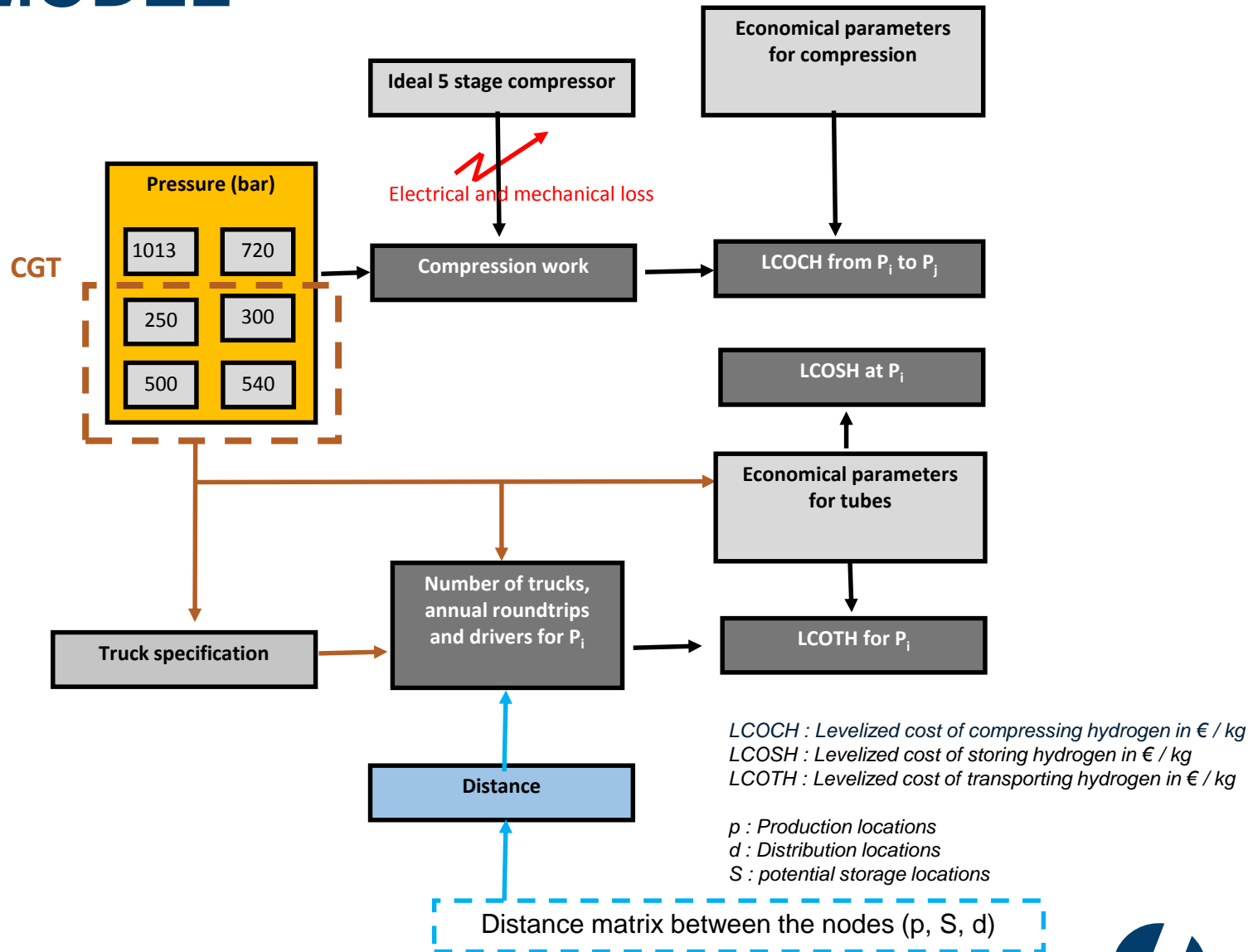Economical parameters for compression

Electrical and mechanical loss

Pressure (bar)

CGT

1013	720
250	300
500	540

Compression work

LCOCH from P_i to P_j

LCOSH at P_i

Economical parameters for tubes

Number of trucks, annual roundtrips and drivers for P_i

Truck specification

LCOTH for P_i

Distance

Distance matrix between the nodes (p, S, d)

LCOCH : Levelized cost of compressing hydrogen in € / kg
LCOSH : Levelized cost of storing hydrogen in € / kg
LCOTH : Levelized cost of transporting hydrogen in € / kg

p : Production locations
d : Distribution locations
S : potential storage locations

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MODEL

Economical parameters for compression

Ideal 5 stage compressor

Electrical and mechanical loss

Sum minimum

CGT

Pressure (bar)

1013	720
250	300
500	540

Compression work

LCOCH from P_i to P_j

COCH

+

COSH

LCOSH at P_i

Economical parameters for tubes

Hydrogen Flow

+

Truck specification

Number of trucks, annual roundtrips and drivers for P_i
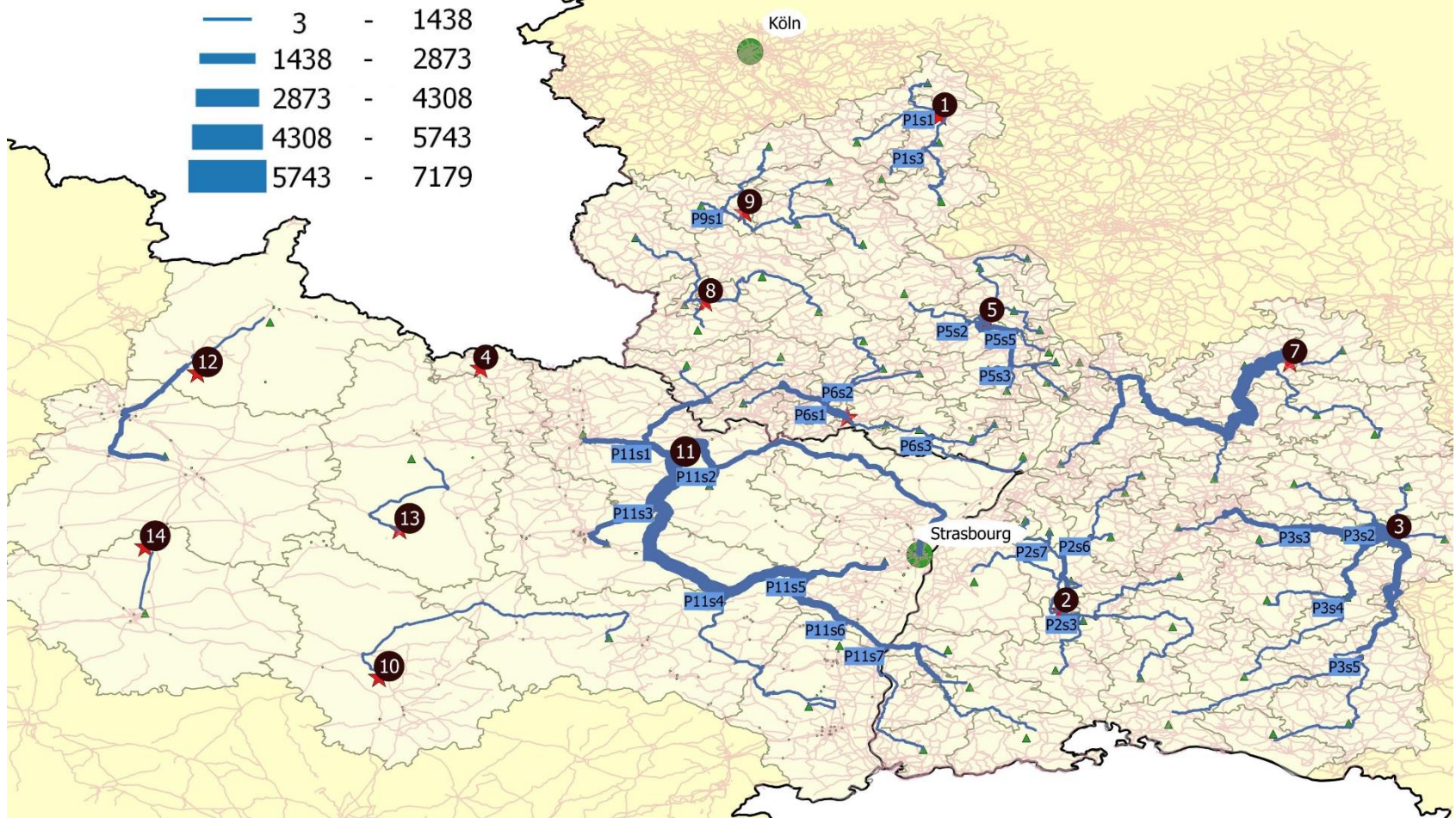
LCOTH for P_i

COTH

Distance

Demand

COCH : Total cost of compressing hydrogen in €
COSH : Total cost of storing hydrogen in €
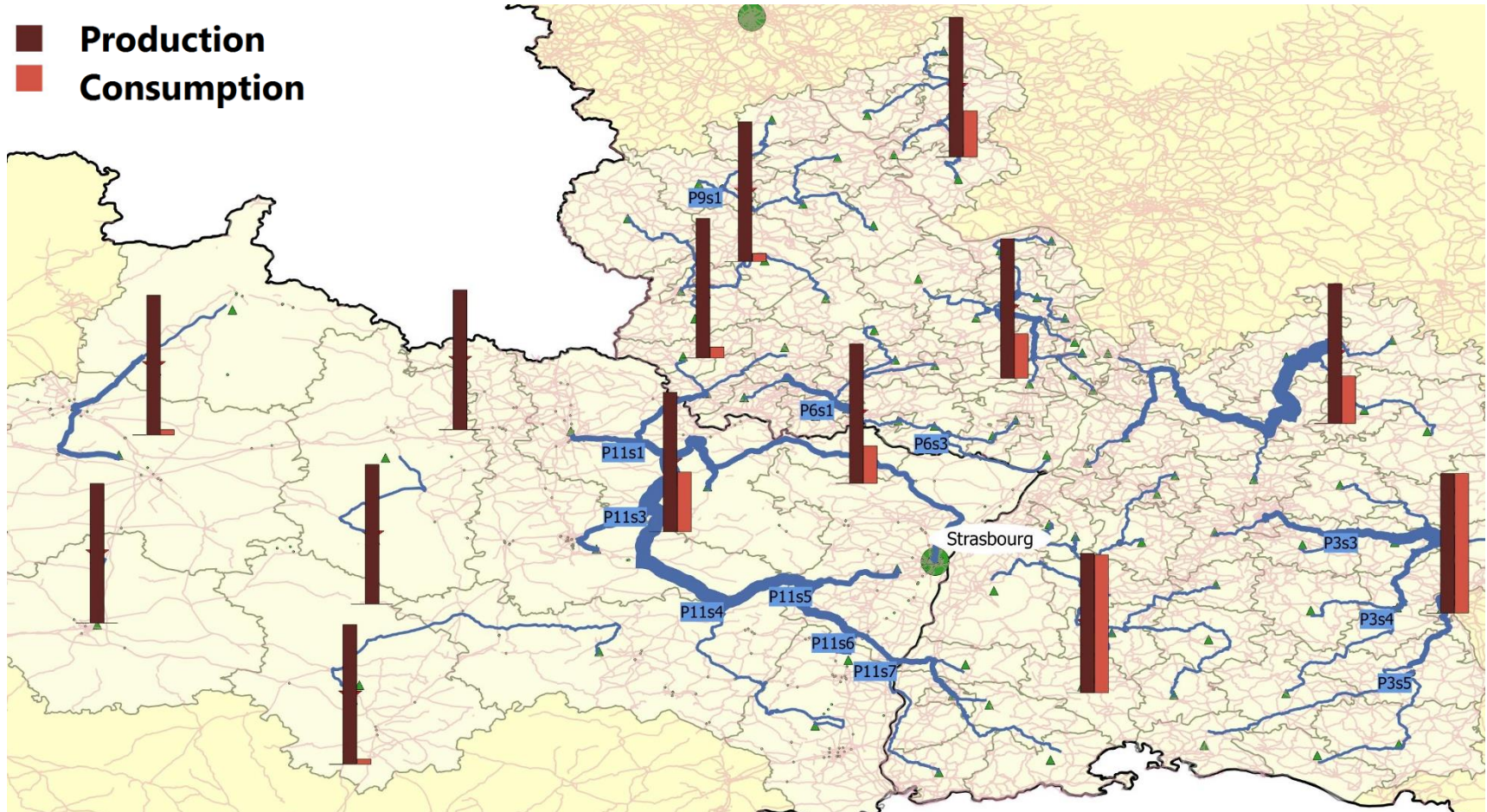*COTH : Total cost of transporting hydrogen in €*

Distance matrix between the nodes (p, S, d)

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RESULTS

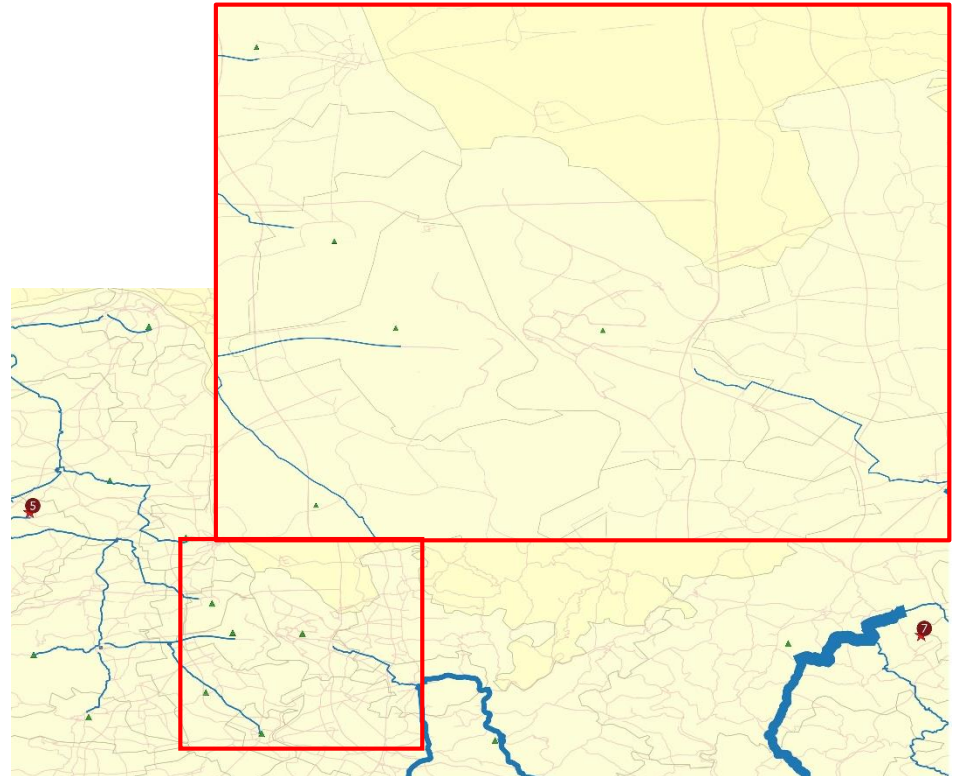## Flow distribution in TPD

RESULTS

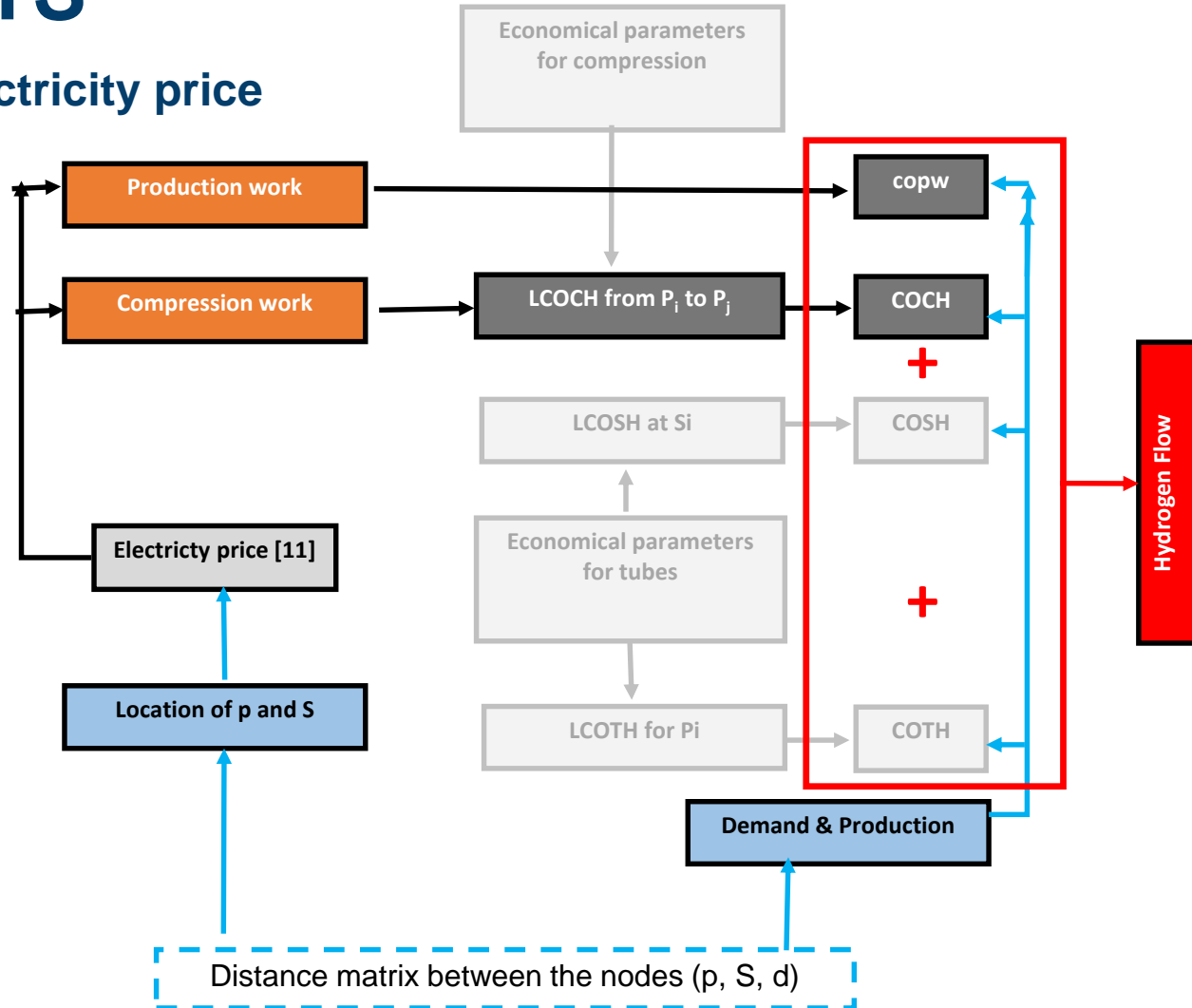## Hydrogen production in thousand TPD

RESULTS

Discussion

RESULTS

Impact of electricity price

[11] *Electricity price statistics.* EUROSTAT, European statistics

copw: cost associated to production work

RESULTS

Production in thousand TPD

	Production in TPD	Consumption in TPD	
		= electricity price	# electricity price
11 (F)	32900	-14000	-17200
8 (G)	15090	-1200	-1200
6 (G)	13407	-3600	<u>-1300</u>
5 (G)	12640	-4000	-4000
2 (G)	5230	-5200	<u>-4400</u>

(F) 0.07 € / kWh [11]* **(G)** 0.13 € / kWh [11]*

[11] *Electricity price statistics.* EUROSTAT, European statistics

*: cost including all taxes and levies

CONCLUSION

- The short term scenario of 2030 is not impacted by the locations of hydrogen production
    - The main distribution is covered by local production
    - 95 % of production in France is not locally consumed
    - The surplus is exported to surrounding regions

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- Including different electricity prices, reduces costs associated to production and compression in France
- In this scenario, more hydrogen is exported from France

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- Less local production in Germany will be covered

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