

The Hydrogen Value Chain

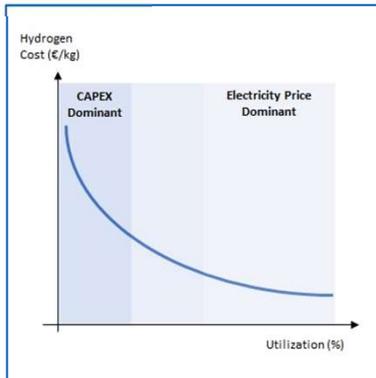
From production to applications

Fichtner is working in all areas of the hydrogen value chain and is actively contributing to the sector's development

Fichtner competencies



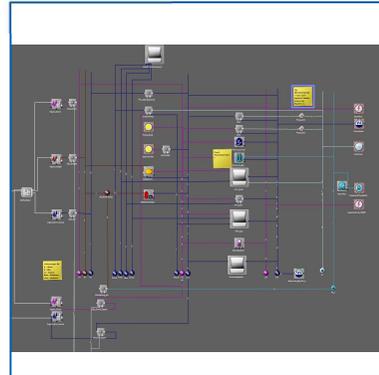
Business Models



Hydrogen business model development e.g. for a company in the natural gas industry



System Planning



System modelling to integrate power-to-x technologies (from plant to country level)



Hydrogen Plant Design



Three decades engineering experience for installations with hydrogen



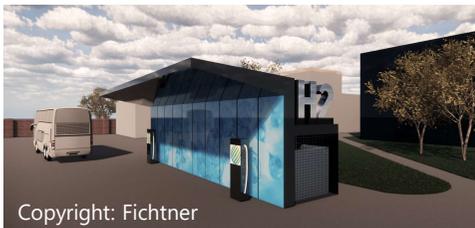
Hydrogen Infrastructure



Hydrogen-readiness of natural gas assets and grid calculation of networks



Hydrogen Mobility



Integrated concepts for hydrogen production and mobility infrastructure



Green Chemicals



Process engineering know-how and experience in the chemical and refinery sector



Sector Development



Fichtner Forum Hydrogen 2019 with over 60 participants from 16 countries

Why are people talking about hydrogen?

Current interest in hydrogen as an energy source and commodity is dominated by four main drivers

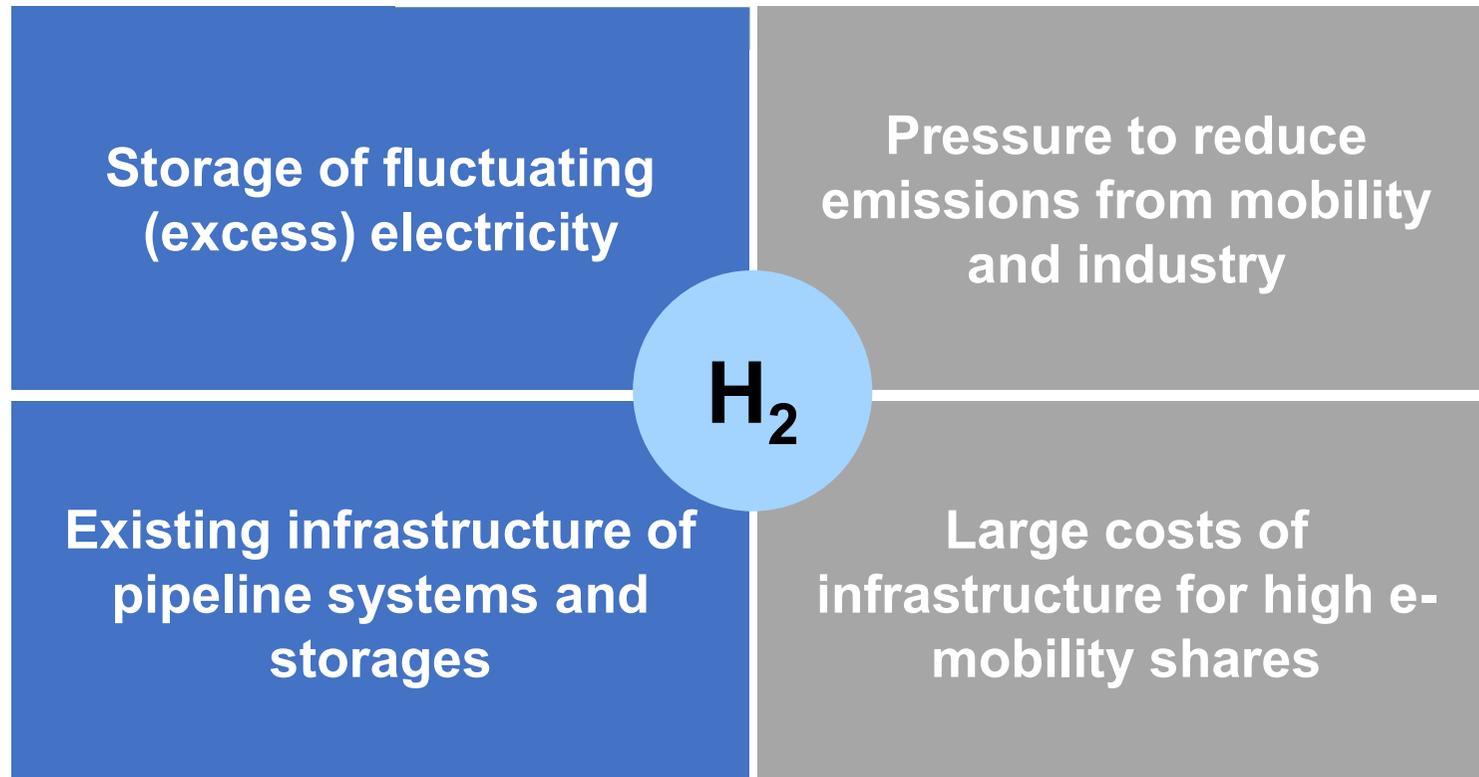
Background



Electricity
& Gas



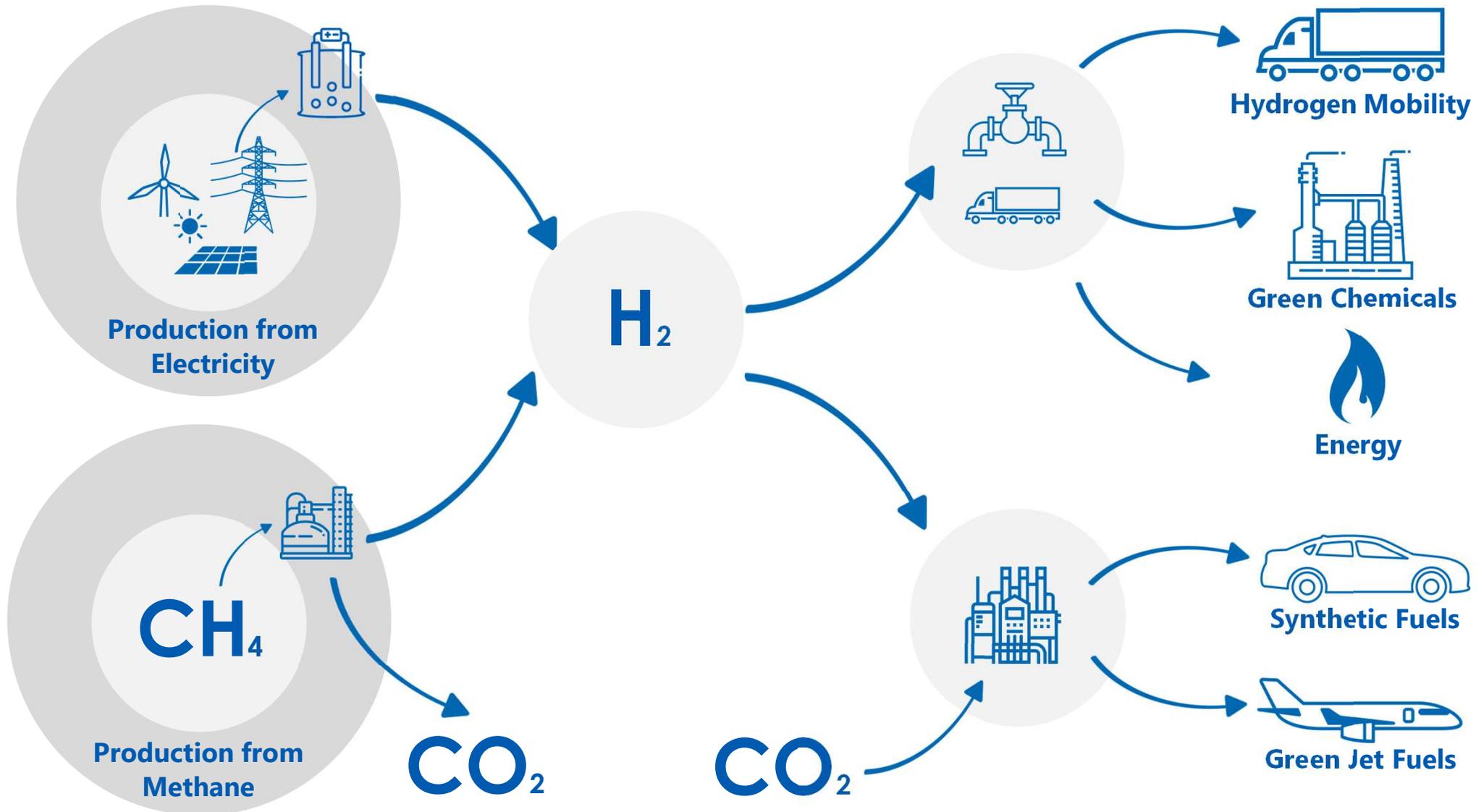
Mobility &
Industry



What will a hydrogen
value chain look like?

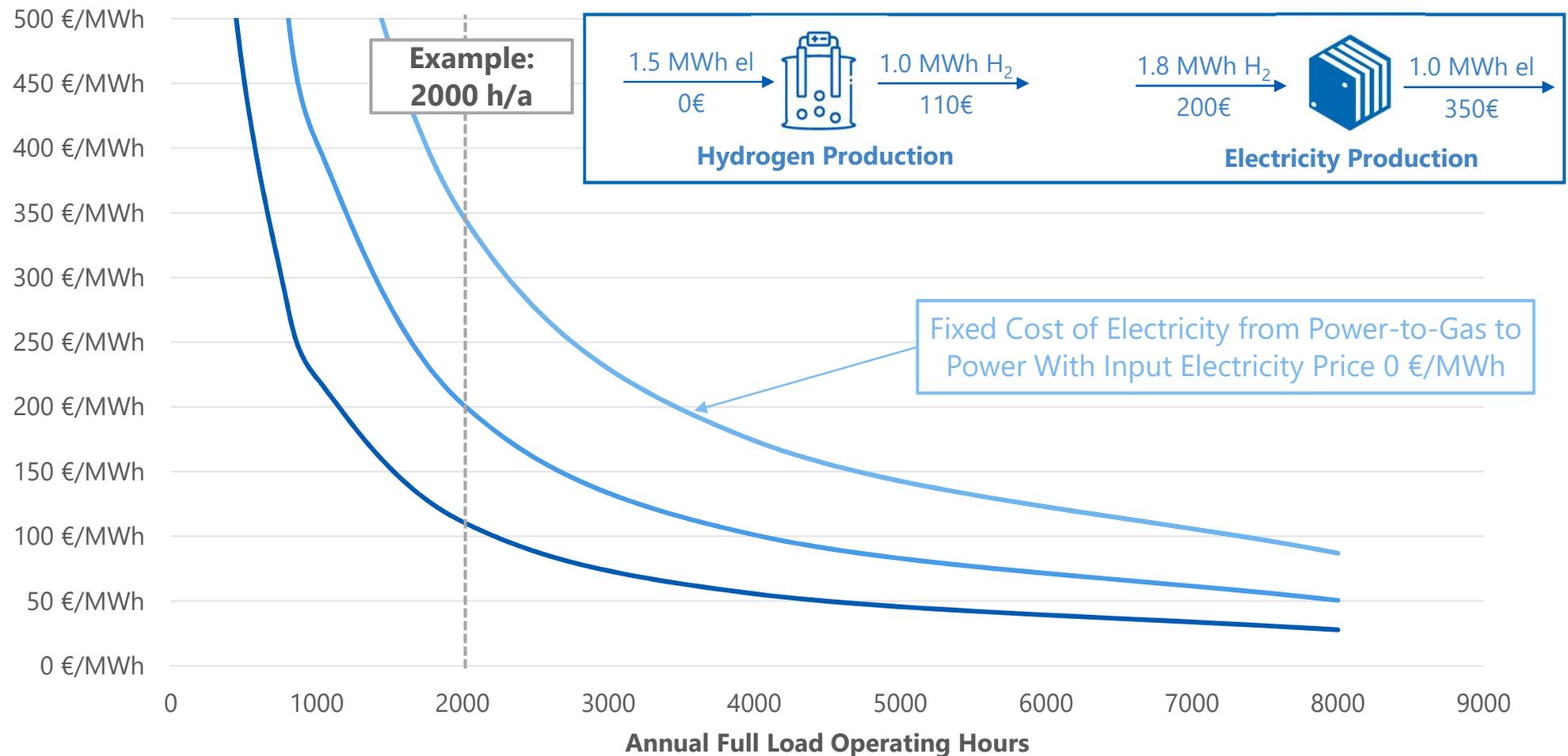
Hydrogen can be produced using different energy sources. It has a variety of applications in mobility, industry and energy

Hydrogen value chains - overview



Hydrogen as electricity storage is very expensive. Therefore, it can only be considered as an option in the far future or under special circumstances

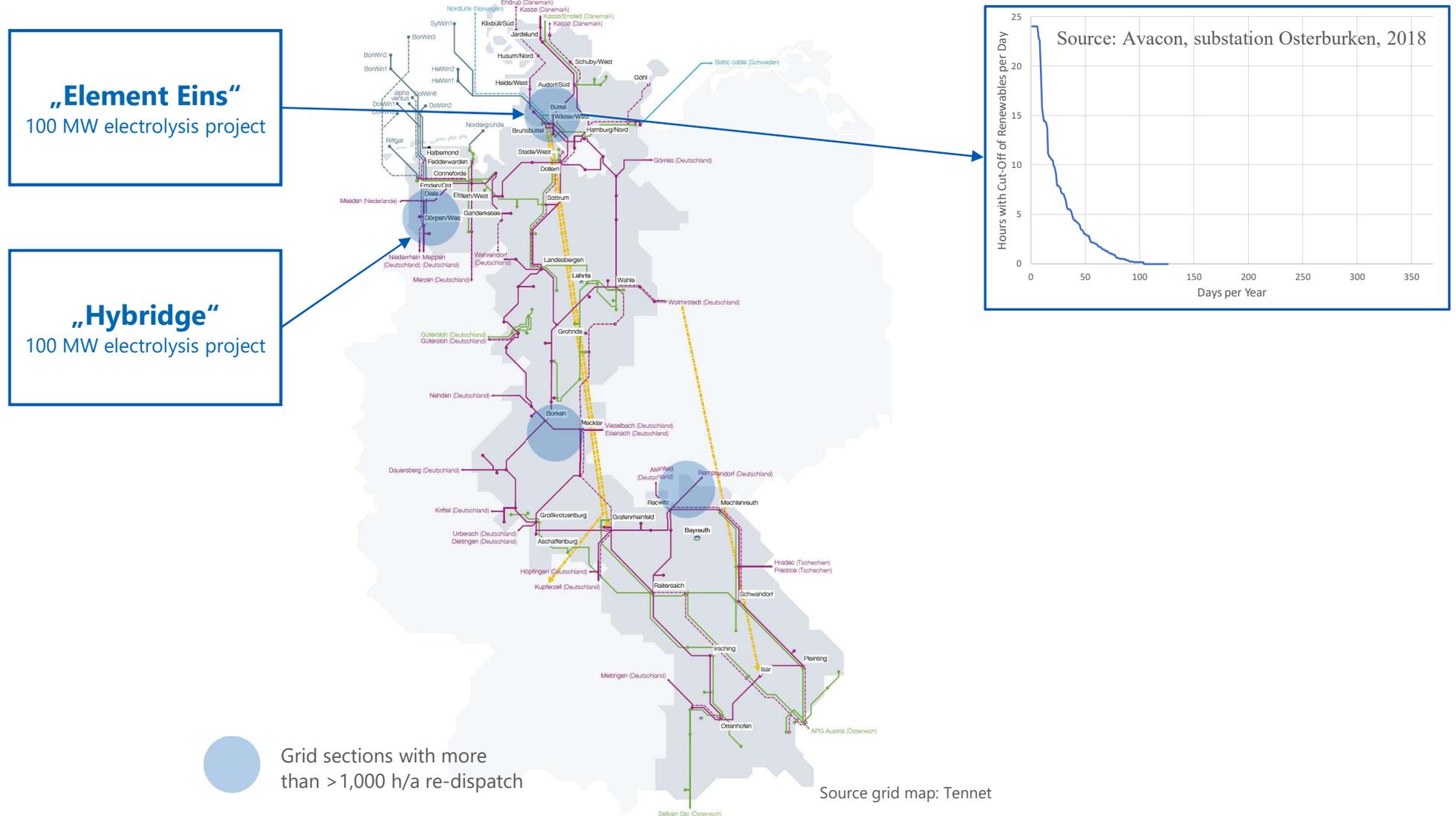
Value chain 1 : Hydrogen as electricity storage



- Fixed Costs Electrolysis (per MWh H₂)
- Fixed Costs Electrolysis (per MWh Electricity)
- Fixed Costs Electrolysis + Fuel Cell (per MWh Electricity)

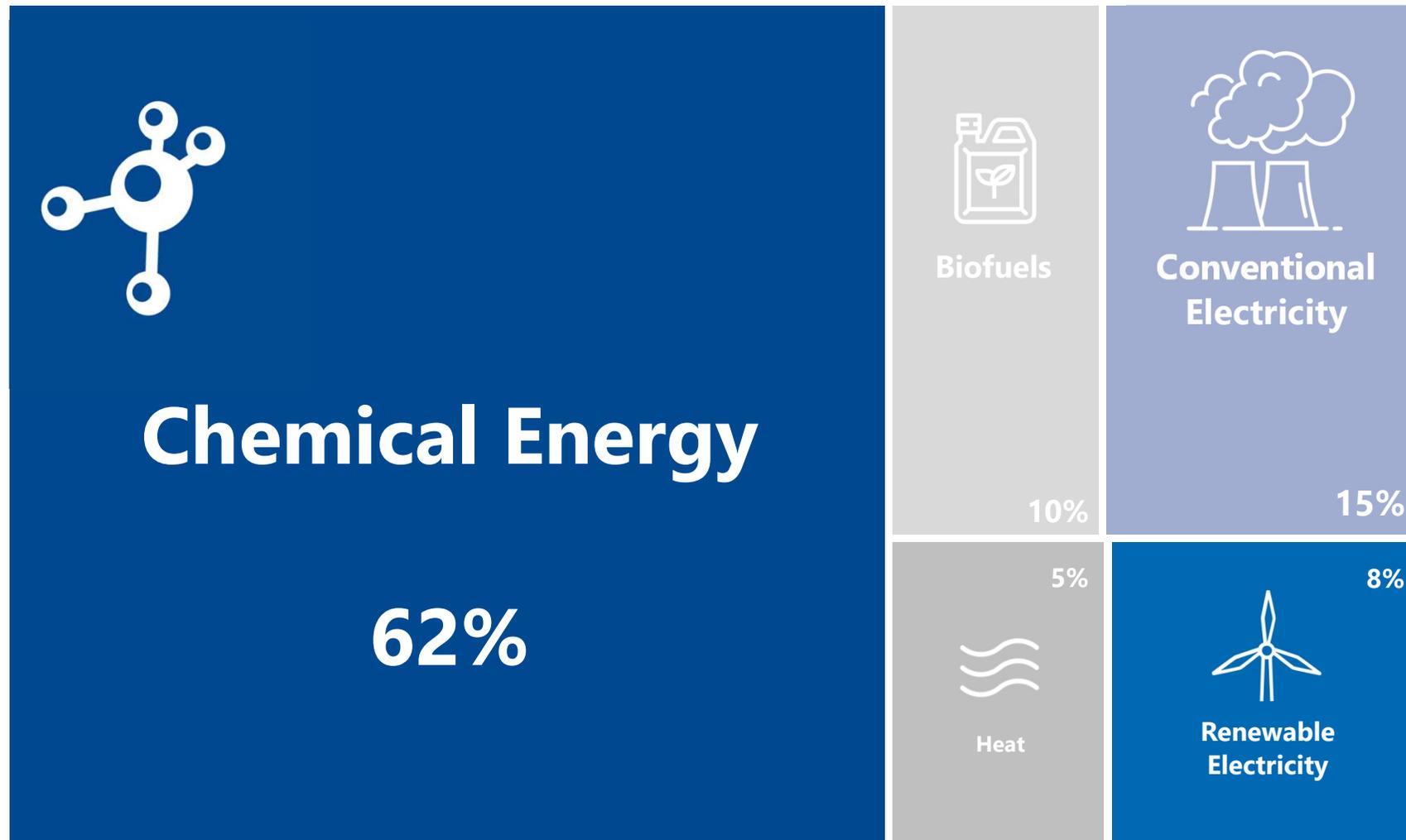
Curtailed green energy is currently limited to specific grid sections. Even there, annual availability of curtailed power is low

Value chain 2: Hydrogen from excess electricity



Large parts of the European energy system can only be decarbonized through the import of green chemicals

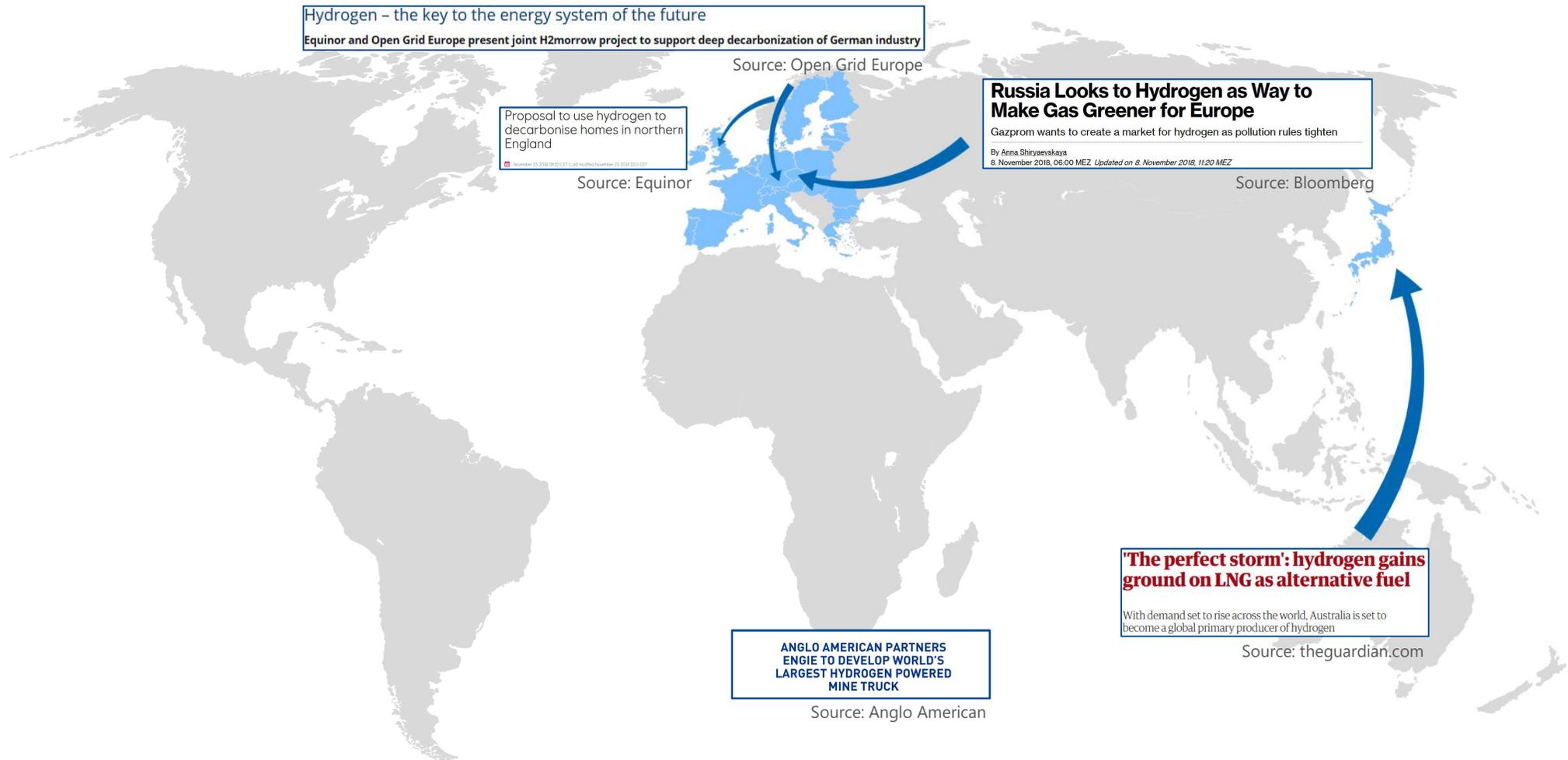
Value chain 3: Hydrogen as a commodity



Source: calculations by Fichtner based on Final Energy Consumption EU-27, Eurostat 2017

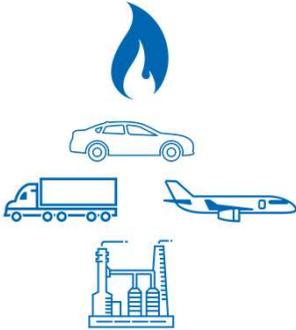
A global supply chain for hydrogen is forming. Large players are already positioning themselves to deliver hydrogen to consumers

Value chain 3: Hydrogen as a commodity - global developments



Hydrogen produced as a commodity with a dedicated value chain is the only option to deploy it in at scale in mobility and industry

Hydrogen value chains - summary

Option	Applications	Assessment
Value Chain 1 Hydrogen as electricity storage		Energy (electricity sector) <ul style="list-style-type: none"> High cost Decarbonization of electricity sector only
Value Chain 2 Hydrogen from excess electricity		Mainly energy (heat and electricity sector) <ul style="list-style-type: none"> High cost even at low electricity prices Limited potential due to availability of excess electricity Only viable under specific circumstances
Value Chain 3 Hydrogen as a commodity		Energy Mobility Green chemicals <ul style="list-style-type: none"> Lowest cost alternative Largest market potential Production mix of large-scale centralized and smaller de-centralized plants possible Import enables large-scale decarbonization of European energy sector

What are Europe's main
success factors for
developing hydrogen?

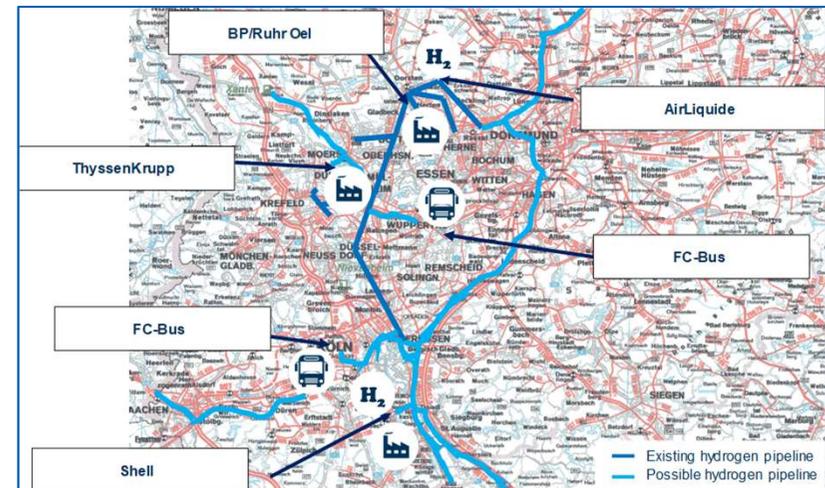
In order to be successful, Europe must develop an integrated strategy covering the entire hydrogen value chain: production, infrastructure and applications

Success factors for hydrogen in Europe

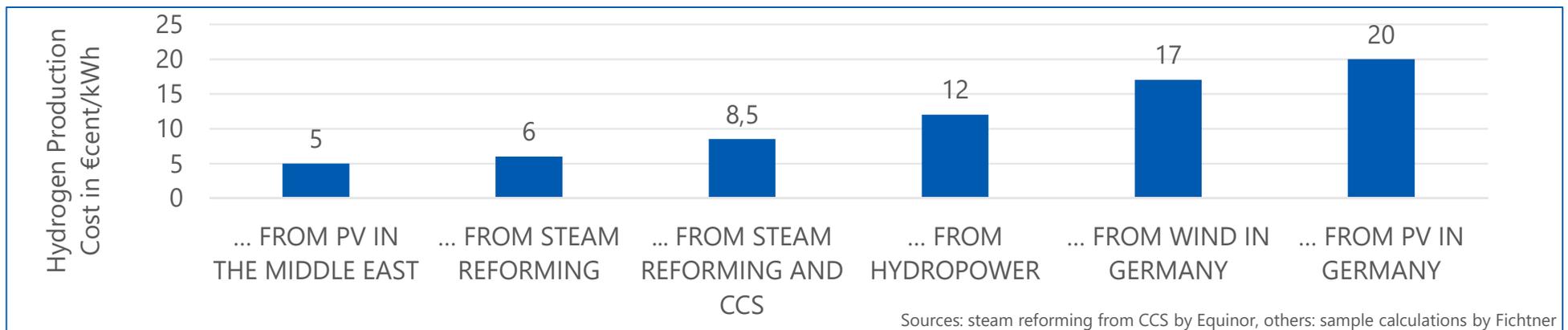


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Developing applications where hydrogen provides added value



Creating a hydrogen infrastructure using local synergies



Sources: steam reforming from CCS by Equinor, others: sample calculations by Fichtner

Finding a good mix of de-centralized and centralized production as well as imports

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