Advocating the Energy Transition:

SEN Presents
Green Hydrogen: Where to Next?

7th October 2024

Agenda

Welcome and Emergency Response

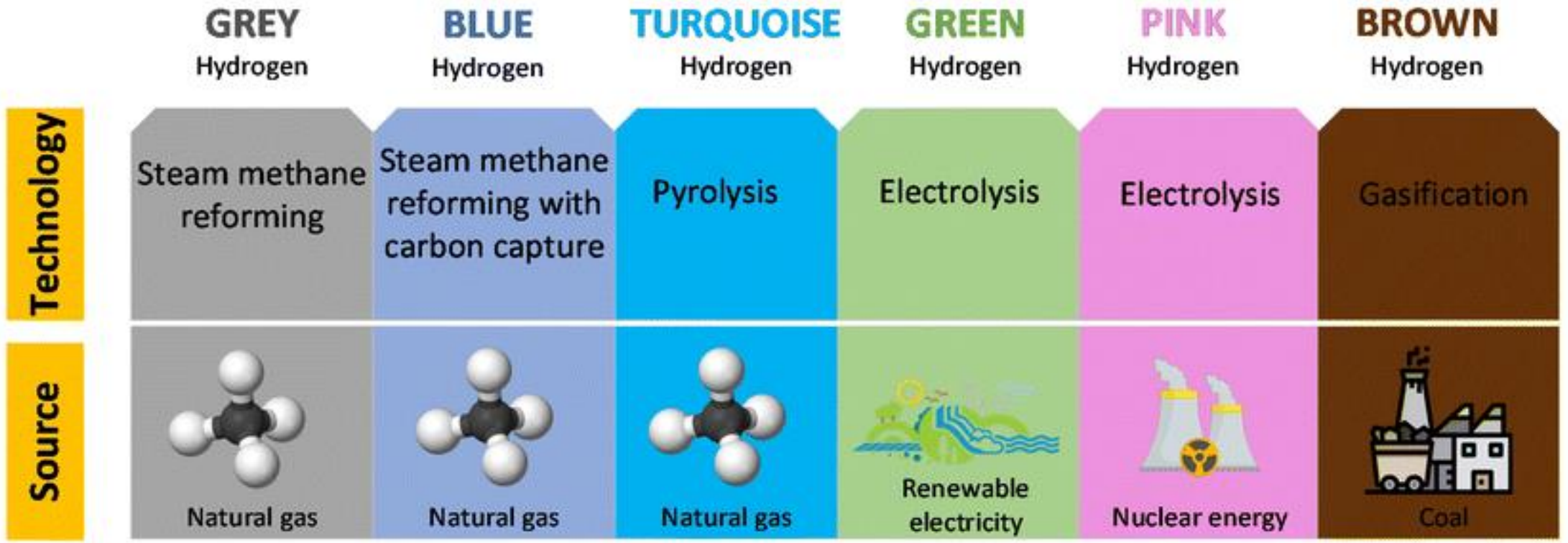
Acknowledgement of Country

1. Tonight's Theme
2. Speakers and Slido (for audience questions submission)
3. Audience Questions
4. Wrap

1

Tonight's Theme

Green / Renewable Hydrogen



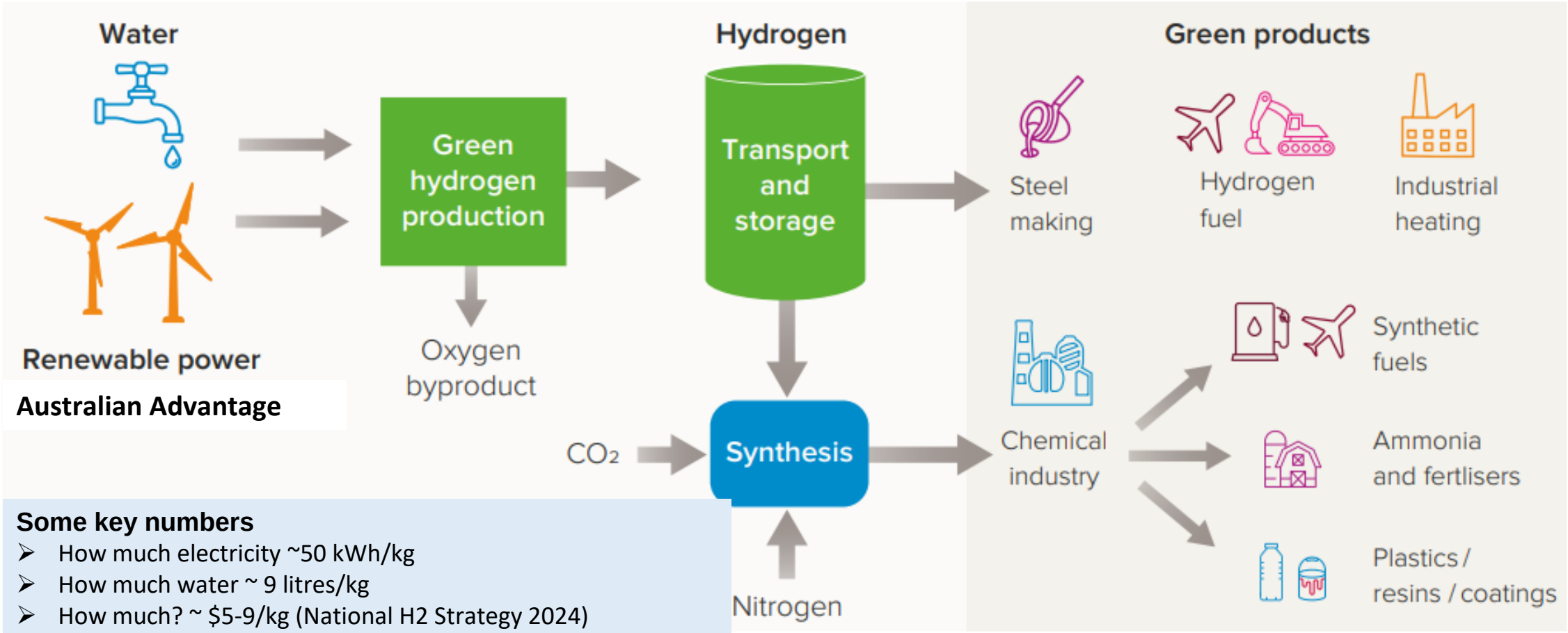
White Hydrogen – naturally occuring

Fig. 1 The spectral colors of hydrogen based on the production method (modified from Renewable Energy Agency, 2020).[9]

% of global hydrogen production (16% by-product, not shown) – International Energy Agency. Global Hydrogen Review

62% 0.7% 0.7% 21%

Green / Renewable Hydrogen



Australian Advantage

Some key numbers

- How much electricity ~50 kWh/kg
- How much water ~ 9 litres/kg
- How much? ~ $5-9/kg (National H2 Strategy 2024)
- Fossil gas hydrogen ~$4/kg (ditto)
- Typical green hydrogen plant size ~300,000 tonnes per annum
- Australia will target producing at least 15 million tonnes of hydrogen annually, with a stretch potential of 30 million tonnes annually, by 2050.

Source: the Royal Academy of Engineering.

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Speakers and Slido

Tonight's Speakers

Hydrogen Society of Australia

SEN Sustainable Energy Now

Lalit Dogra
Director- Hydrogen Energy Transition Strategies JTSI

Leigh Holder
Director of Business Development
Yara Clean Ammonia Australia

Kelsey Cross
Technology Development Manager
Fortescue Hydrogen Systems

Max van Someren
Renewable Energy techno-economics expert Net Zero Network

slido

Meeting Number #1890622

2.1

Lalit Dogra Director - Hydrogen
Energies Transition Strategies Division - JTSI

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GOVERNMENT OF WESTERN AUSTRALIA

Invest & Trade WESTERN AUSTRALIA

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Western Australia's Renewable Hydrogen Industry

October 2024

Acknowledgement of Country

The Western Australian Government acknowledges the Traditional Custodians throughout Western and South Australia and their continuing connection to the land, waters and community. We pay our respects to all members of Aboriginal and Torres Strait Islander communities and their cultures; and to Elders past, present and emerging.

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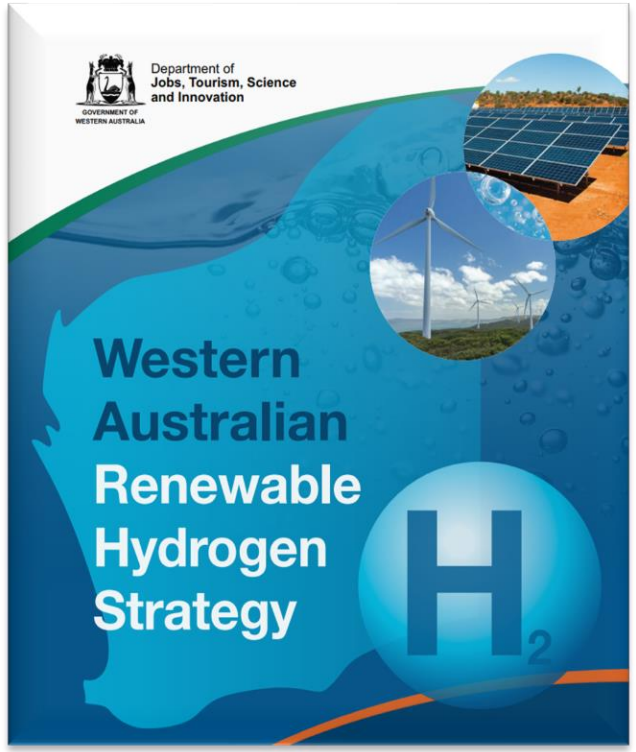
Western Australia's Renewable Hydrogen Opportunity

Targeted sector-specific diversification opportunities

Renewable hydrogen Produce and scale	**Critical minerals** Advanced processing	**CCUS technology** Develop and commercialise	**LNG decommissioning** Develop and commercialise	**High-value food and beverage** Manufacture and export
Naval vessels Construct and maintain	**Medical products and digital health** Manufacture and commercialise	**Space and cross-sector technologies** Manufacture, utilise and maintain	**Regional tourism destinations** Develop and maintain	

Western Australian Renewable Hydrogen Strategy 2019



Vision:

- WA will be a significant producer, exporter and user of renewable hydrogen

Mission:

- Develop industry and markets for domestic use and export
- Decarbonise local and global markets
- Increase diversification of the State's economy

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2022 Goals Achieved

Yuri Renewable Ammonia Project

ATCO Gas Blending Project

Denham Hydrogen Demonstration Project

ATCO Refueller

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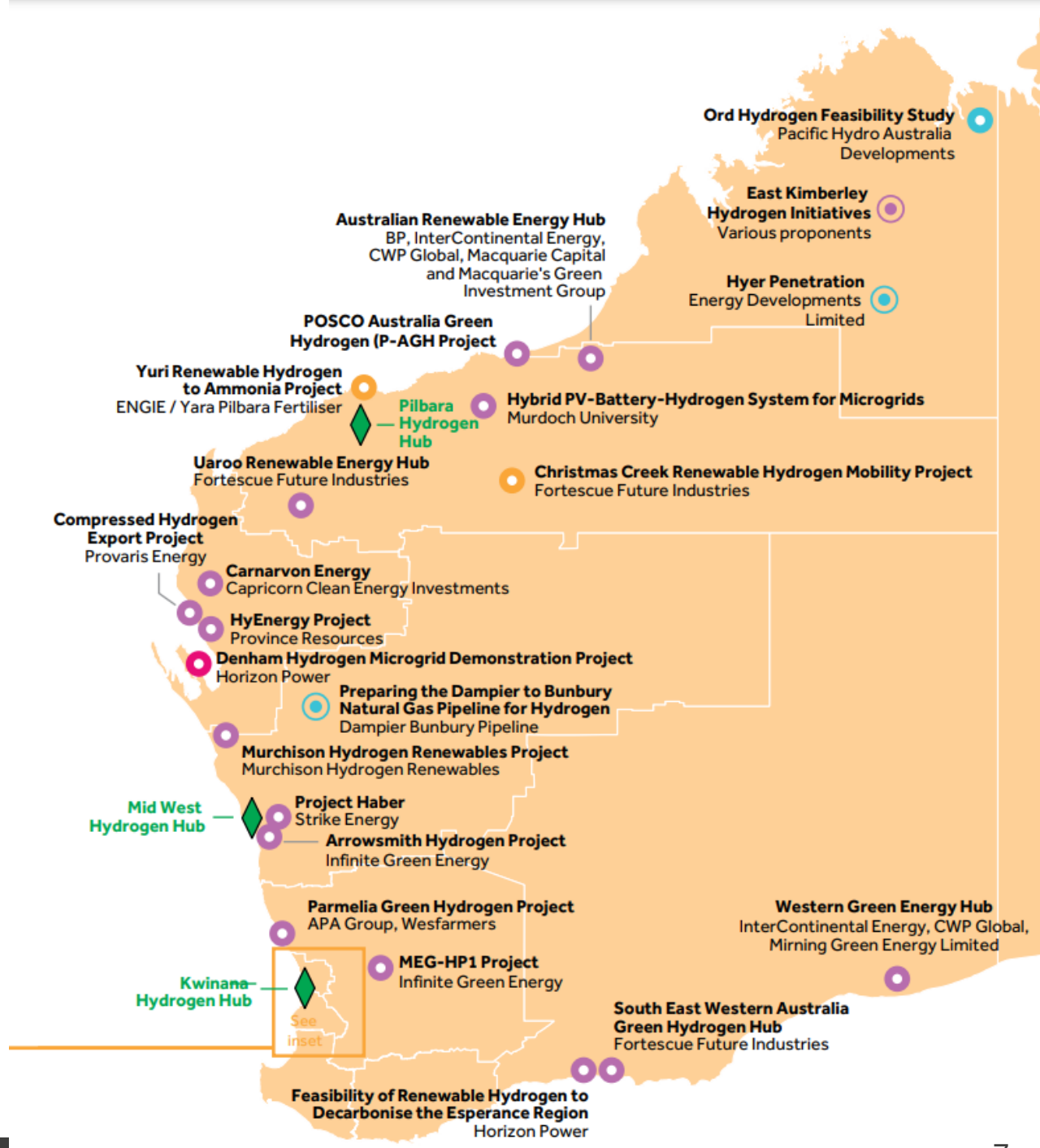
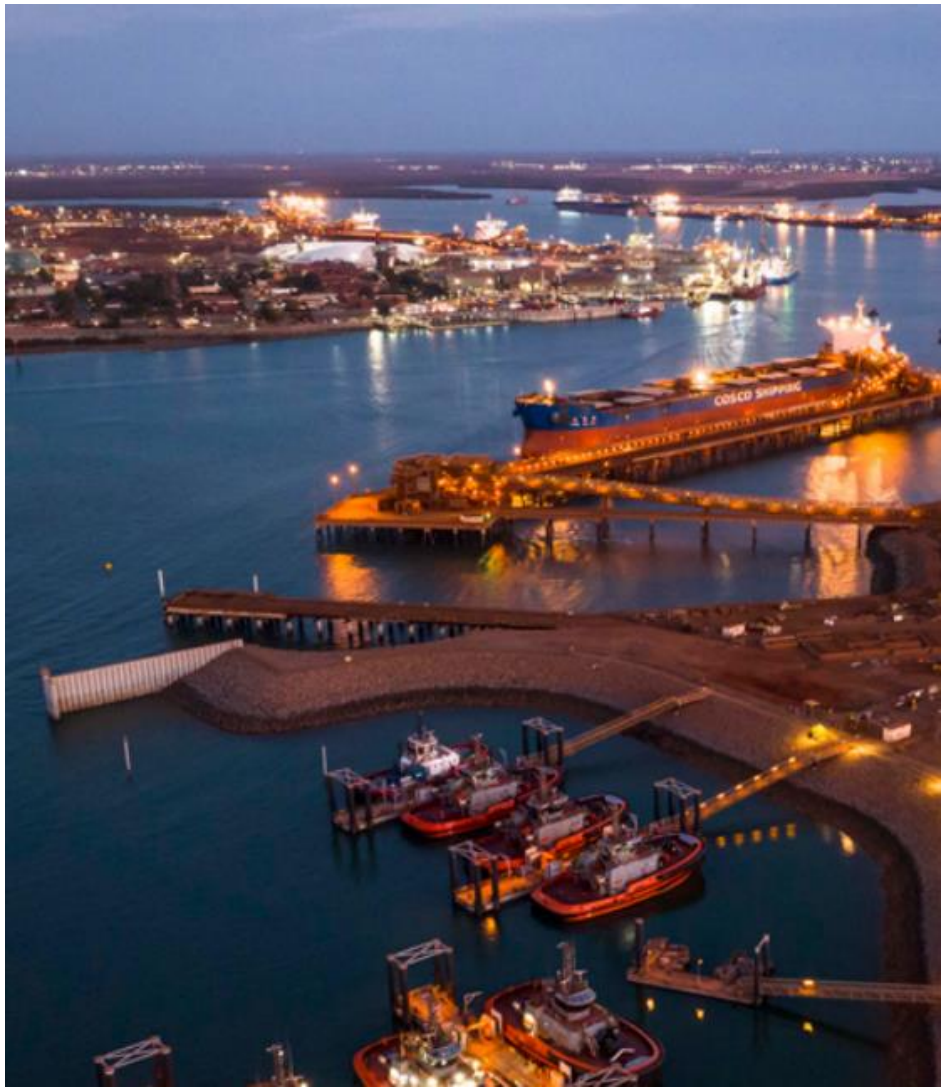
WA's Hydrogen Hub Developments

- Pilbara Hydrogen Hub - $140 million
  - $70 million (matched with C'wealth)
- Mid West Hydrogen Hub - $60 million
- Kwinana Hydrogen Hub
  - $70 million (C'wealth)
- TrHyHub study





Western Australian Government 2024-2025 Budget

- $1.8 billion commitment in the Western Australian Government 2024-2025 budget to diversify and decarbonise our economy
  - $500 million Strategic Industries Fund
  - A further $500 million to upgrade the State's main electricity grid and construct common user electricity network infrastructure in the Pilbara
  - $44.3 million to continue our approvals reform and slash red tape by establishing cross-government teams

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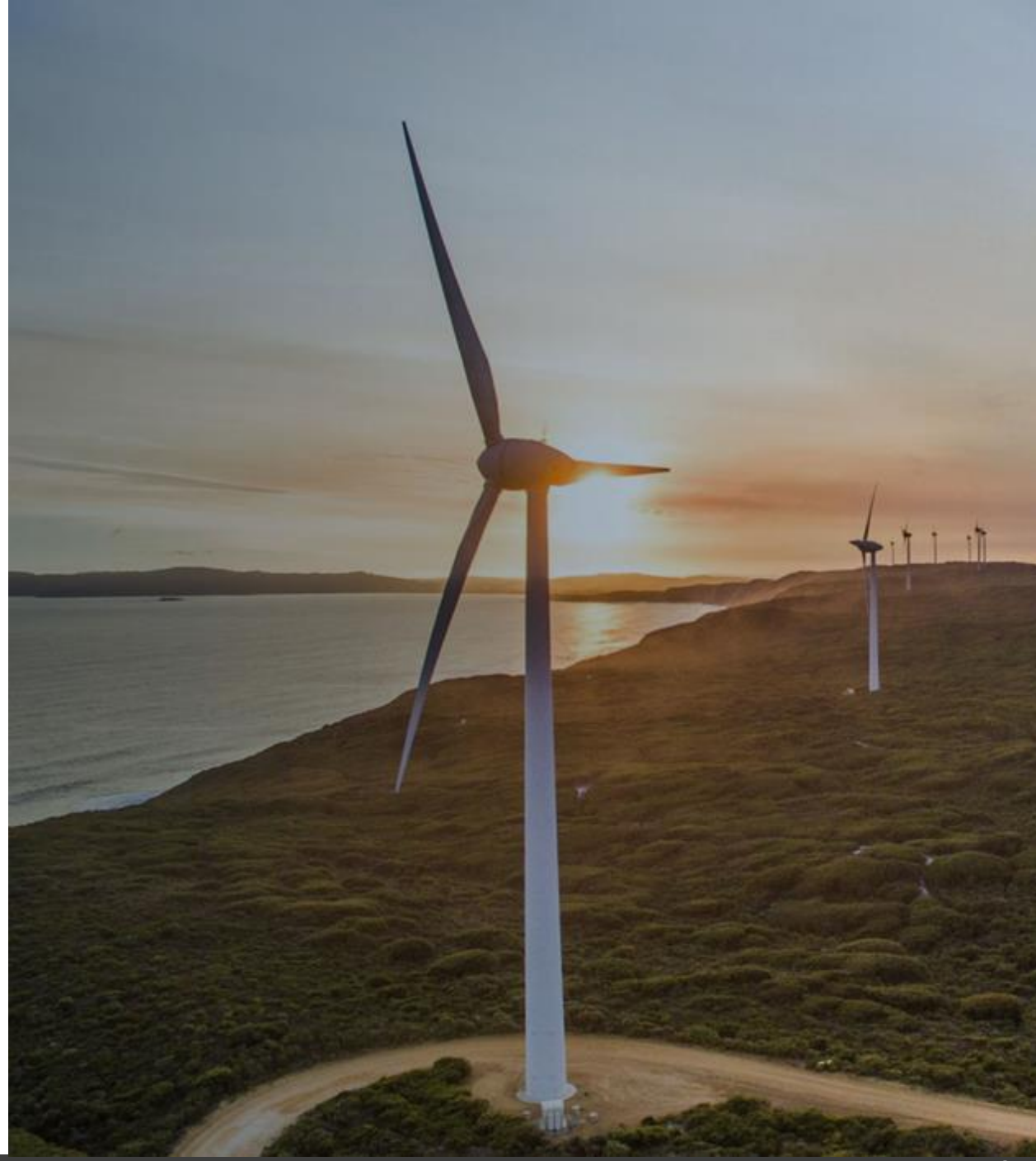
Federal Government's Support in the 2024-2025 Budget

- $6.7 billion Hydrogen Production Tax Incentive of $2 per kilogram
  - Encouraging the production of renewable hydrogen over the next decade
- $2 billion investment in a new round of the successful Hydrogen Headstart program
  - Providing long-term certainty for the nascent industry, which will be critical for green iron and steel opportunities



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Western Australia's Green Iron Opportunity

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Hydrogen Fuelled Transport

- Hydrogen Fuelled Transport Program
  - $10 million contribution
- Christmas Creek Mobility Project
  - $2 million contribution
- Hydrogen Highways Business Case


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Thank you
For further details please visit our website www.wa.gov.au

2.3

Kelsey Cross Technology Development Manager, Fortescue Hydrogen Systems

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Fortescue

We are Fortescue

KELSEY CROSS
7 OCTOBER 2024

2.4

Max van Someren - Renewable energy techno-economics expert Net Zero Network

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ARIA
CAPITAL MANAGEMENT

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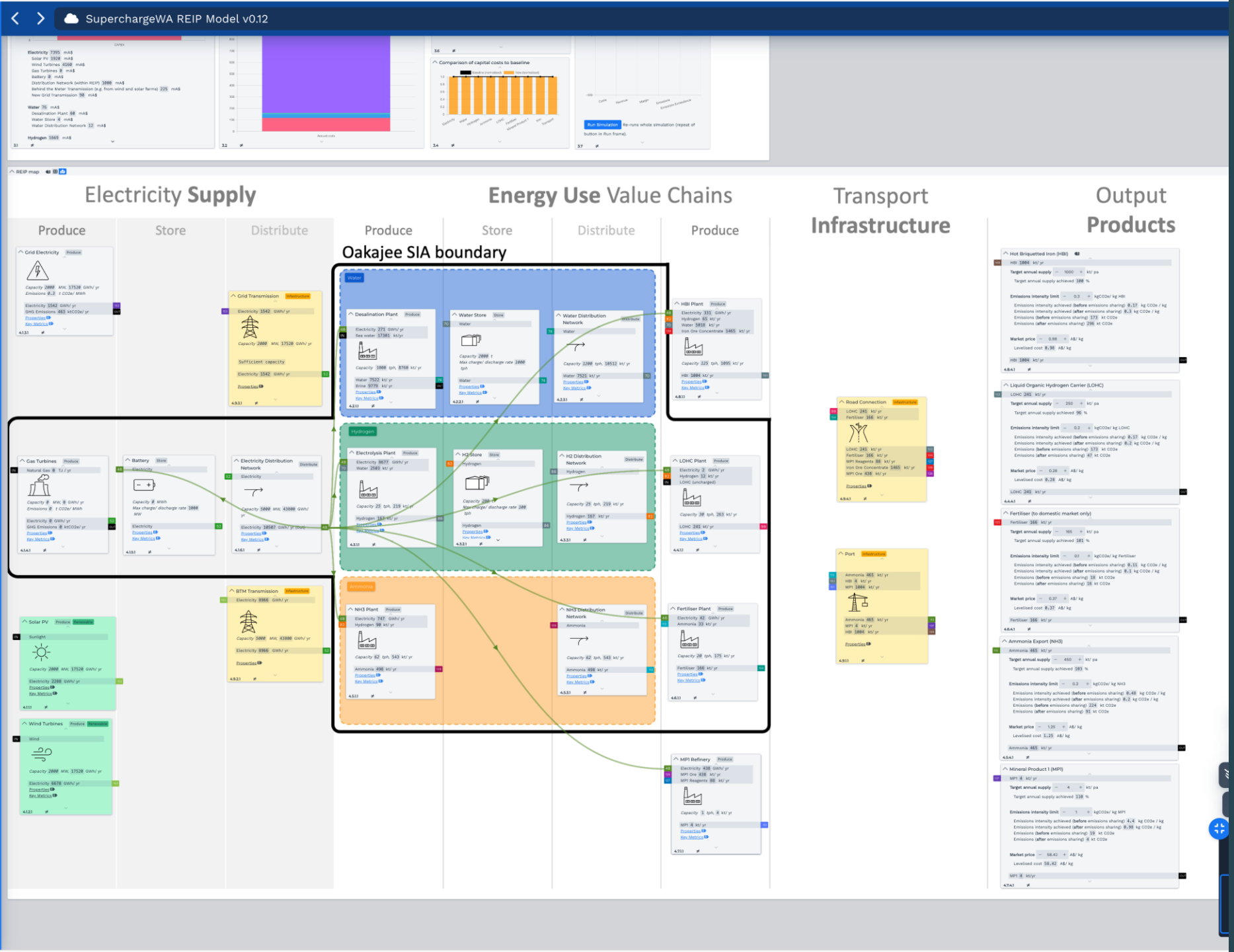
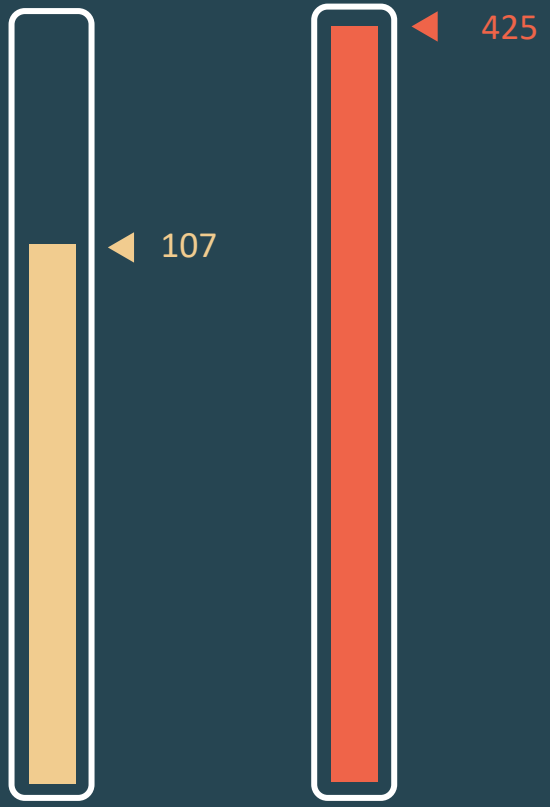
SIMCITY™


SuperchargeWA REIP Model v0.12
Electricity Supply
Energy Use Value Chains
Transport Infrastructure
Output Products
Produce
Store
Distribute
Produce
Store
Distribute
Produce
Oakajee SIA boundary
Grid Electricity
Grid Transmission
Gas Turbines
Battery
Electricity Distribution Network
BTM Transmission
Solar PV
Wind Turbines
Water
Desalination Plant
Water Store
Water Distribution Network
Hydrogen
Electrolysis Plant
H2 Store
H2 Distribution Network
Ammonia
NH3 Plant
NH3 Distribution Network
HBI Plant
LOHC Plant
Fertiliser Plant
MPI Refinery
Road Connection
Port
Hot Briquetted Iron (HBI)
Liquid Organic Hydrogen Carrier (LOHC)
Fertiliser (to domestic market only)
Ammonia Export (NH3)
Mineral Product 1 (MPI)


City
7:41 AM
Monet Plateau
1,229,111
+614 / HR
5,474

Cost of electricity

Emissions

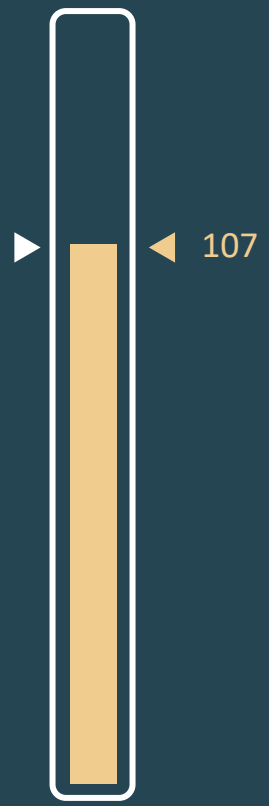


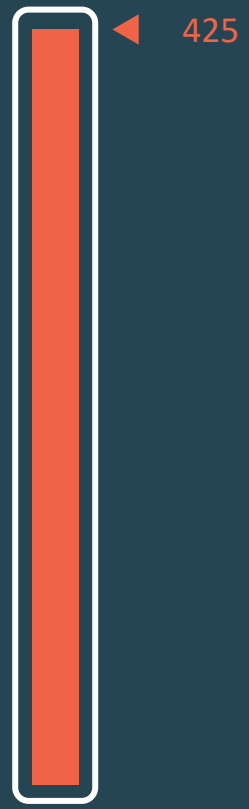
$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions





$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions

425

107

$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions

104

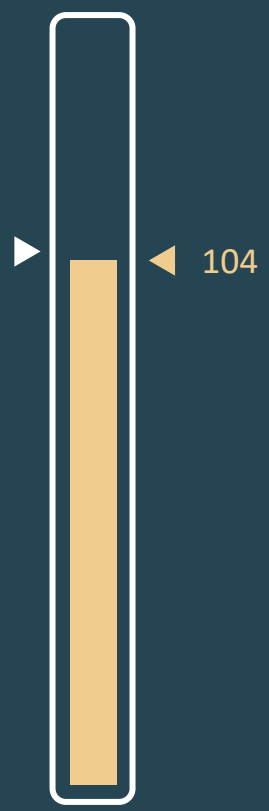
337

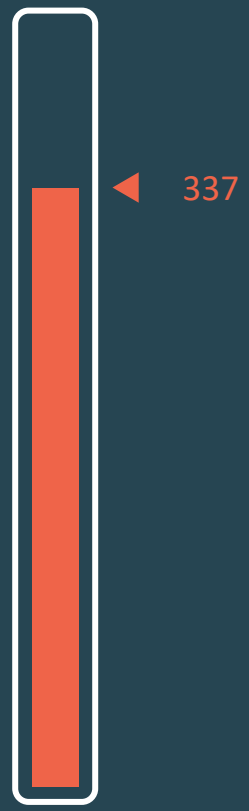
$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions



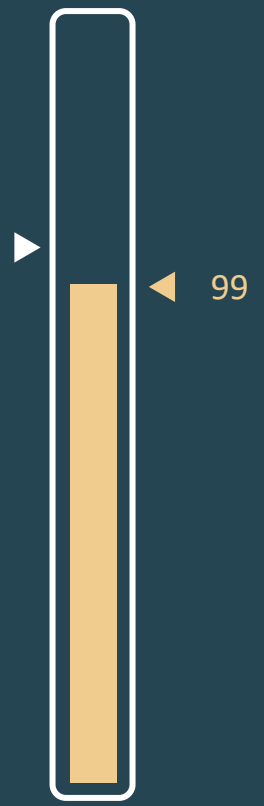


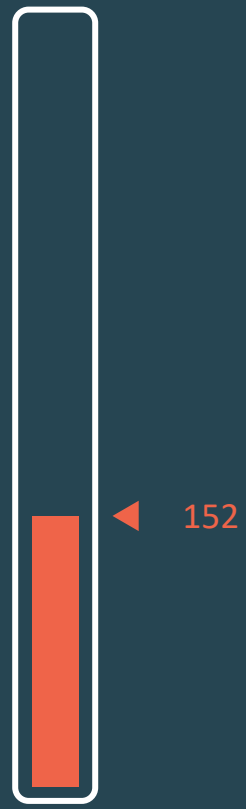
$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions





$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions

99

152

$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions

115

118

$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions

115

118

$/ MWh

tCO_2e/ MWh

Cost of electricity

Emissions

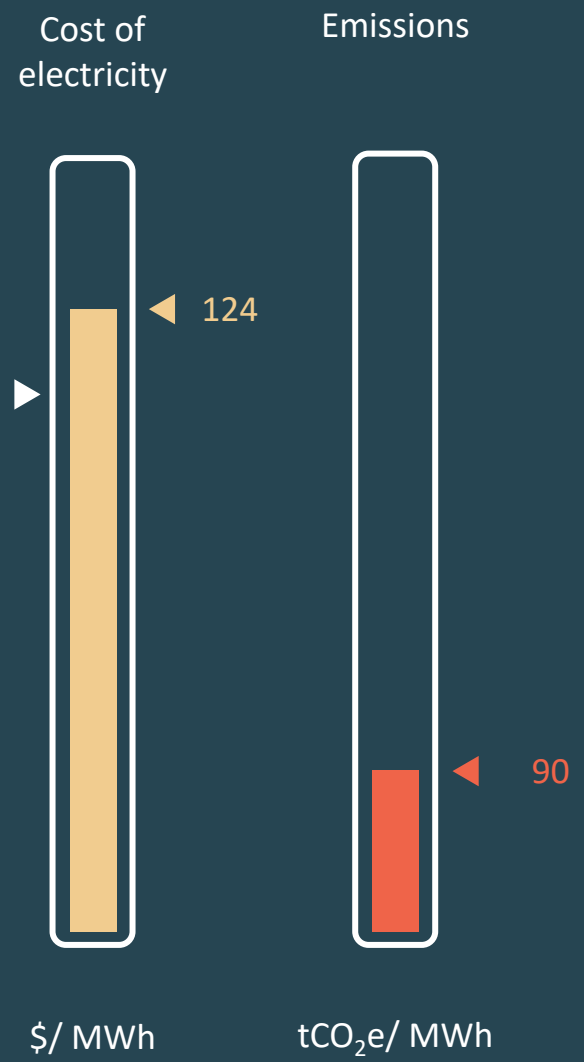
124

90

$/ MWh

tCO_2e/ MWh


150 MW Electrolyser
$120m
24% utilised
25 year life
150 MW
100 MW
150 MW
City
7:41 AM
Monet Plateau
1,229,111
-1,971 / HR


Cost of electricity
Emissions
124
90
$/ MWh
tCO2e/ MWh

Cost of electricity

Emissions

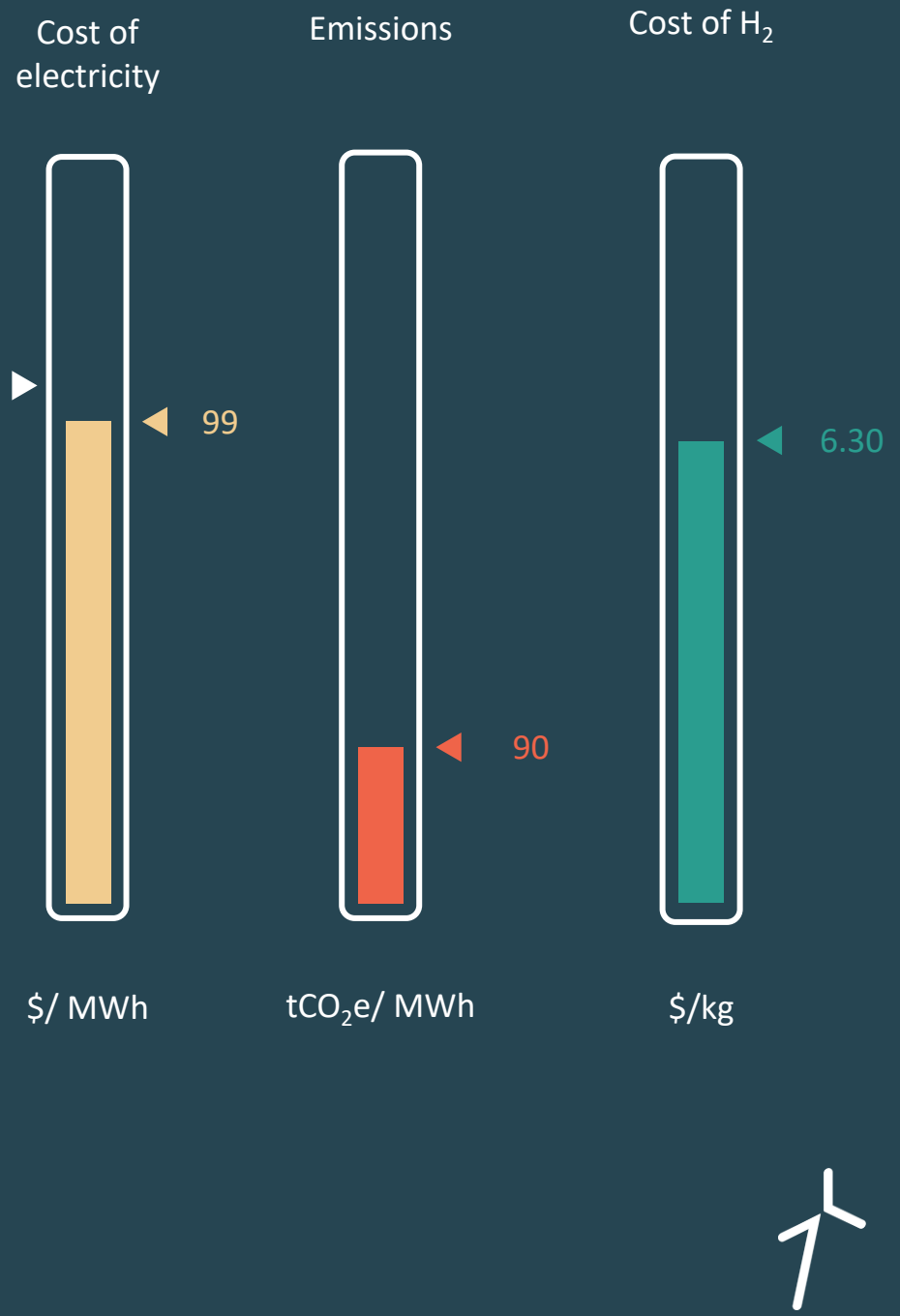
99

90

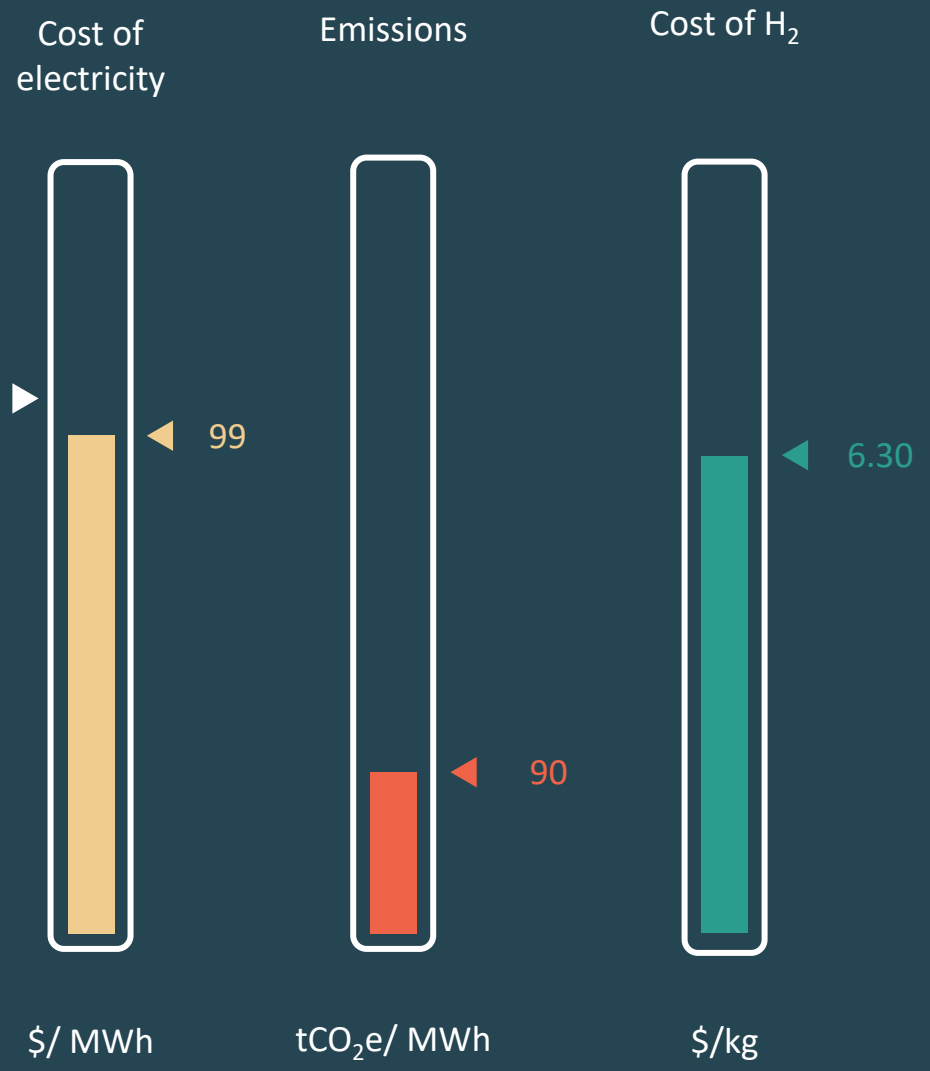
$/ MWh

tCO_2e/ MWh

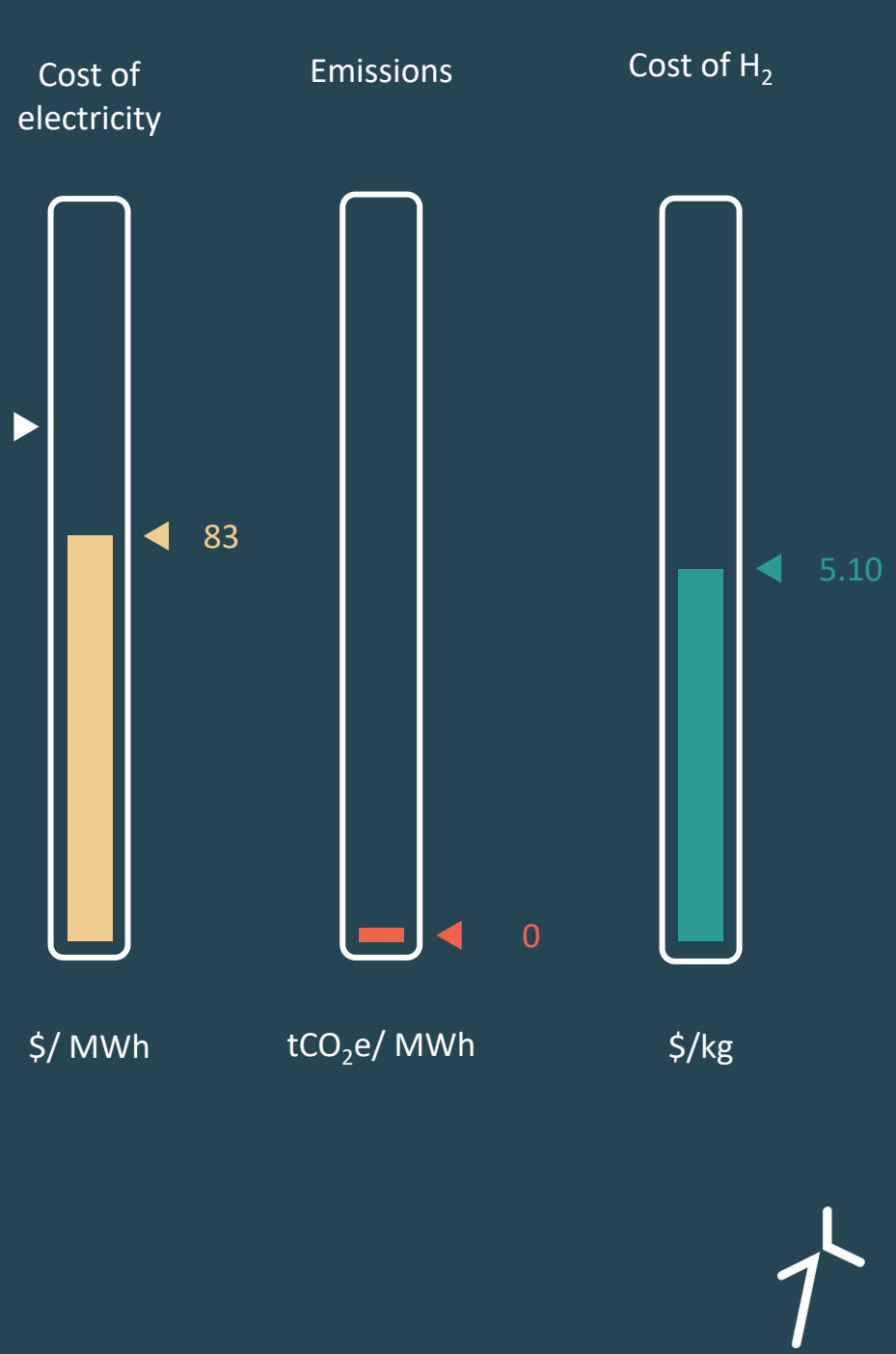

150 MW
150 MW
150 MWh
150 MW
100 MW
City
7:41 AM
Monet Plateau
1,229,111
-1,971 / HR
5,47


Cost of electricity
Emissions
Cost of H_2
99
90
6.30
$/ MWh
tCO_2e/ MWh
$/kg


150 MW
150 MW
150 MWh
150 MW
City
7:41 AM
Monet Plateau
1,229,111
-1,971 / HR
5,47

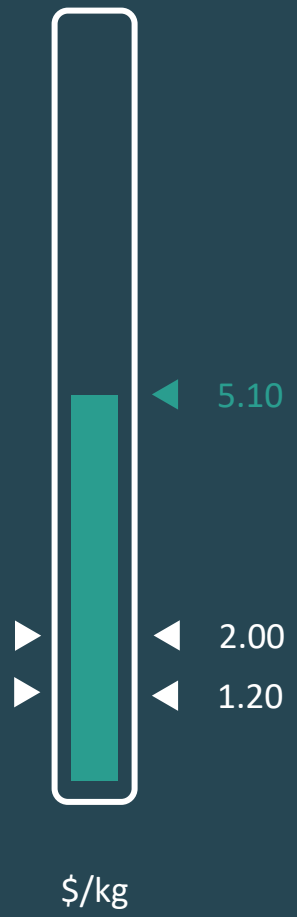

Cost of electricity
Emissions
Cost of H_2
99
90
6.30
$/ MWh
tCO_2e/ MWh
$/kg


150 MW
150 MW
150 MWh
150 MW
City
7:41 AM
Monet Plateau
1,229,111
-1,971 / HR
5,47


Cost of electricity
Emissions
Cost of H_2
83
0
5.10
$/ MWh
tCO_2e/ MWh
$/kg

Equivalent of $1000/tonne **very low sulfur fuel oil**

Equivalent of $10/ GJ **natural gas**

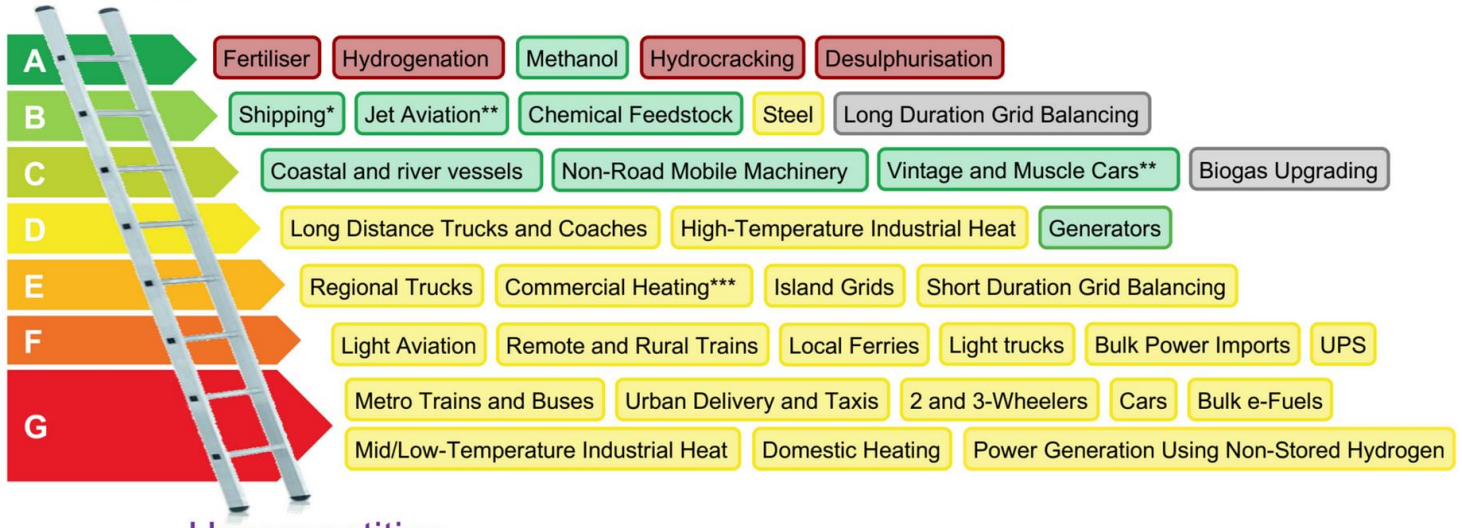


Hydrogen Ladder 5.0

Liebreich Associates

Key: No real alternative | Electricity/batteries | Biomass/biogas | Other

Unavoidable



Uncompetitive

*As ammonia or methanol **As e-fuel or PBTL ***As hybrid system

Source: Michael Liebreich/Liebreich Associates, Clean Hydrogen Ladder, Version 5.0, 2023. Concept credit: Adrian Hiel, Energy Cities. CC-BY 4.0

Cost of H_2

Equivalent of $1000/tonne **very low sulfur fuel oil**

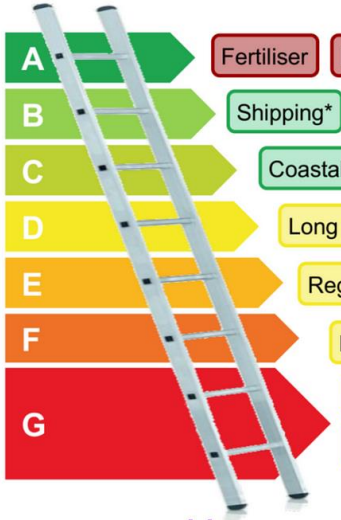
Equivalent of $10/ GJ **natural gas**

Hydrogen Ladder 5.0

Liebreich Associates

Key: No real alternative | Electricity/batteries | Biomass/biogas | Other

Unavoidable



A	Fertiliser	Hydrogenation	Methanol	Hydrocracking	Desulphurisation					
B	Shipping*	Jet Aviation**	Chemical Feedstock	Steel	Long Duration Grid Balancing					
C	Coastal and river vessels	Non-Road Mobile Machinery	Vintage and Muscle Cars**	Biogas Upgrading						
D	Long Distance Trucks and Coaches	High-Temperature Industrial Heat	Generators							
E	Regional Trucks	Commercial Heating***	Island Grids	Short Duration Grid Balancing						
F	Light Aviation	Remote and Rural Trains	Local Ferries	Light trucks	Bulk Power Imports	UPS				
G	Metro Trains and Buses	Urban Delivery and Taxis	2 and 3-Wheelers	Cars	Bulk e-Fuels					
	Mid/Low-Temperature Industrial Heat	Domestic Heating	Power Generation Using Non-Stored Hydrogen							

Uncompetitive

*As ammonia or methanol **As e-fuel or PBTL ***As hybrid system

Source: Michael Liebreich/Liebreich Associates, Clean Hydrogen Ladder, Version 5.0, 2023. Concept credit: Adrian Hiel, Energy Cities. CC-BY 4.0

net zero network

www.netzeronetwork.org

bivios

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3

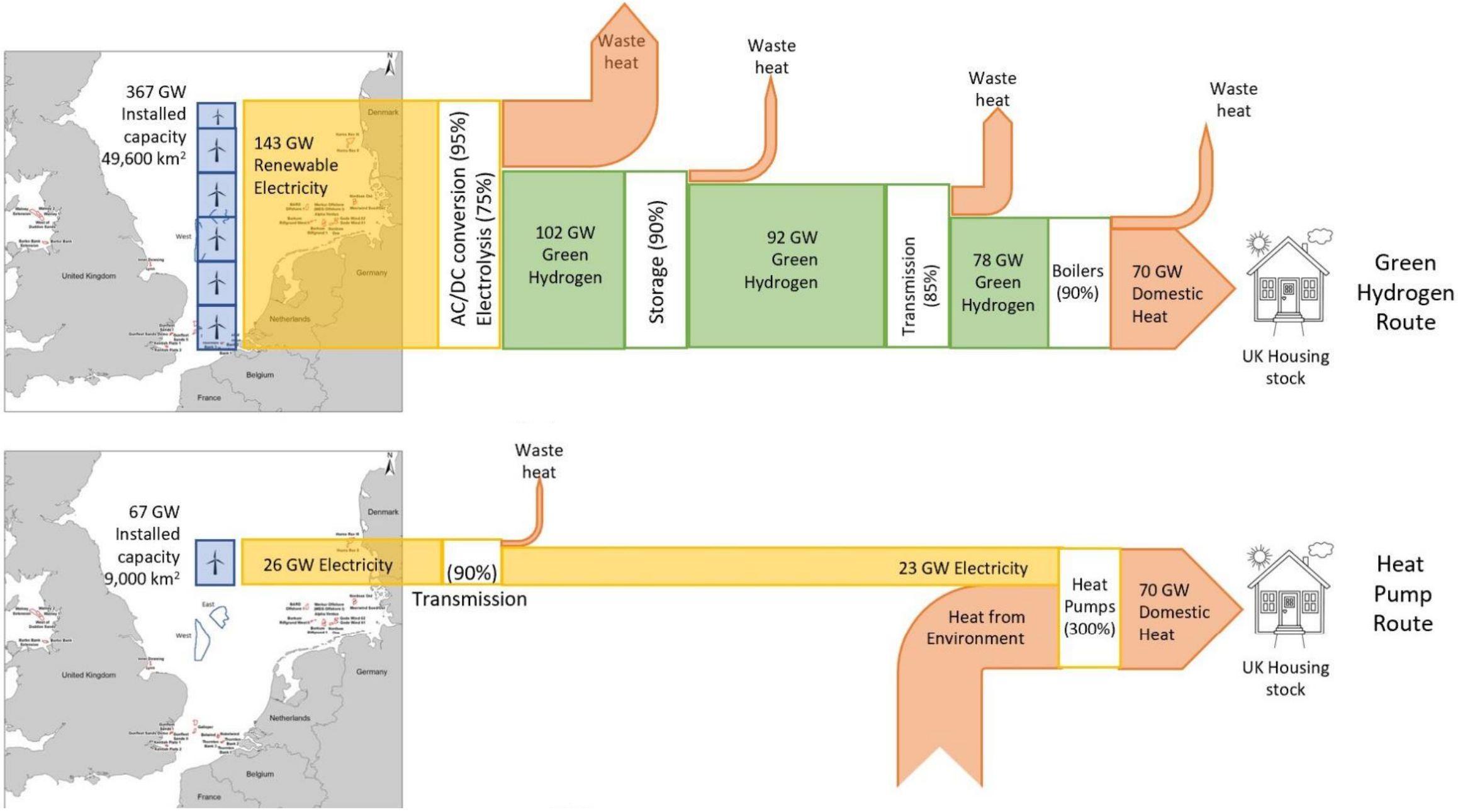
Audience Q&A

slido

Meeting Number
#1890622

4

Wrap-up


367 GW
Installed
capacity
49,600 km²
143 GW
Renewable
Electricity
Denmark
West
Germany
United Kingdom
Netherlands
Belgium
France
AC/DC conversion (95%)
Electrolysis (75%)
Waste heat
102 GW
Green
Hydrogen
Storage (90%)
Waste heat
92 GW
Green
Hydrogen
Transmission
(85%)
Waste heat
78 GW
Green
Hydrogen
Boilers
(90%)
Waste heat
70 GW
Domestic
Heat
UK Housing
stock
Green
Hydrogen
Route
67 GW
Installed
capacity
9,000 km²
East
West
Denmark
Germany
United Kingdom
Netherlands
Belgium
France
26 GW Electricity
(90%)
Transmission
Waste heat
23 GW Electricity
Heat from
Environment
Heat
Pumps
(300%)
70 GW
Domestic
Heat
UK Housing
stock
Heat
Pump
Route