



Hydrogen in Rolls-Royce

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Tier 1

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Key areas of focus in Civil Aerospace

All closely inter-connected and being developed in parallel.

All have a role to play in the decarbonisation of our industry.

Continue to improve the gas turbine



Collaborate on drop-in SAFs



Develop radical alternatives such as electrification, hydrogen



Enhanced integration at platform level

Manufacturing, Digital and Services technologies



Recent studies outline potential for a
50-90% reduction
in CO₂
compared to
conventional kerosene



Zero CO₂ at point of use



A hydrogen fuel cell
could be a viable alternative
to a battery



Combusting gaseous or
liquid hydrogen
could be a viable alternative
to combusting kerosene

Challenges and considerations at a glance



What are the potential aircraft architectures?



Fan/Prop



Power Electronics



Fuel cell



Motor



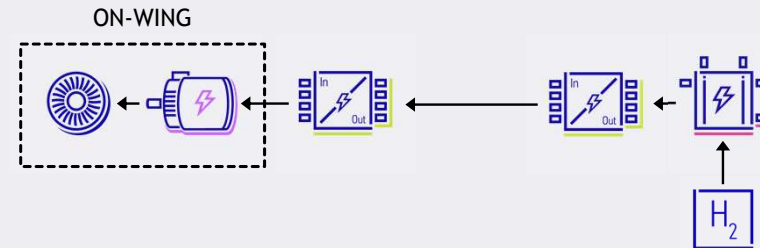
Gas Turbine



Hydrogen

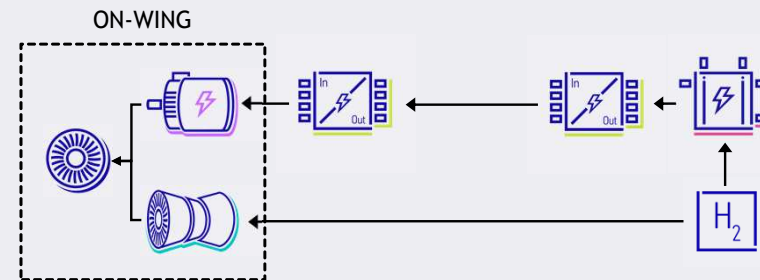
FUEL CELL

Simple, all-electric, flexible
Range challenge



FUEL CELL & GAS TURBINE

Increased power-density
Weight challenge



GAS TURBINE

Energy-dense, stable
Water vapour and NOx challenge





Parallel pathways for decarbonisation solutions

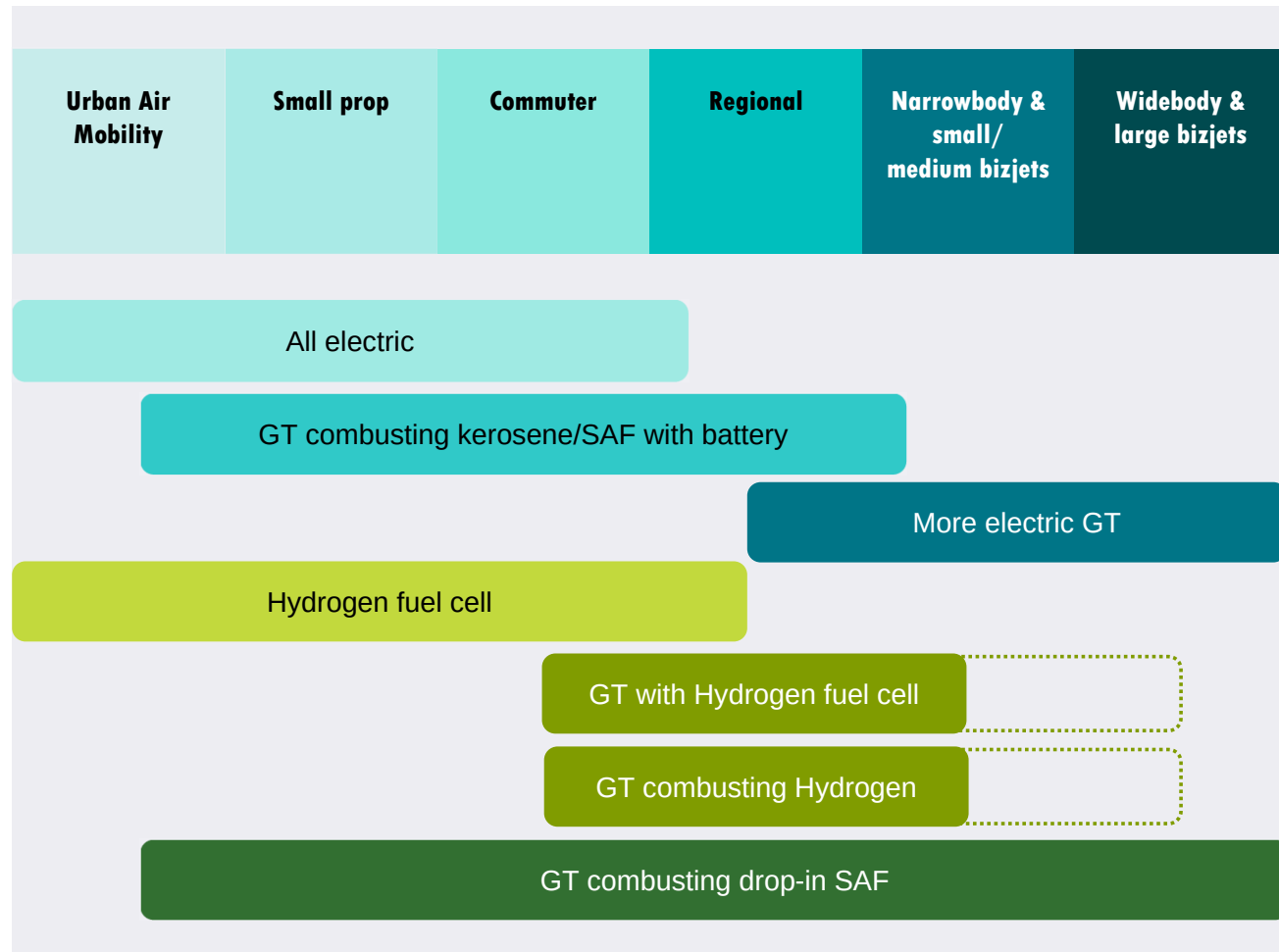
Electric-powered aircraft are already a reality and market is growing rapidly

Small hydrogen-powered aircraft could materialise in 2020s, Regional mid-2030s and Narrow body mid-late 2030s

SAF and GT (gas turbine) will be required to power most applications, particularly larger, longer-range aircraft, without more radical designs

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Widescale adoption of a Hydrogen economy and cost-effective scale-up of green hydrogen production



Significant infrastructure investments



Specialist storage and distribution



Operational implications, e.g. increase in aircraft turnaround times



Certification & Safety for flight

Challenges and considerations at a glance

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Generates water vapour
which can form contrails
at high altitudes

Combusts at higher
temperatures which
can generate NOx



3x the energy density
but occupies

4x the volume
of kerosene



GH2

requires specialist pressurised
(700 bar) heavyweight storage
tanks



LH2

requires complex pressure
and thermal management

Technical challenges and considerations of flying Hydrogen



ARCHITECTURES & CYCLES

Advanced
thermo-dynamic cycles

Fuel recuperator
technology

Fuel turbine

Inter cooling

Heat exchanger

COMBUST

Lean-burn micro-mixing or
lean direct injection

Combustor design &
component sizing

Manufacturing

Materials

Control system

CONVEY & CONTROL

Pump –
especially main fuel

Heat exchanger

Metering system

Piping system

Pre-burner

Hydrogen in a gas turbine

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A unique position

Rolls-Royce is in a unique position to play a key role in understanding the true feasibility of hydrogen for aviation and other sectors.

AEROSPACE

Intensive research programme underway across the Rolls-Royce group including our UTC network

Consultations underway with our customers and (potential) industry partners

Fly Zero initiative (UK)

Clean Aviation programme (Europe)

Future Flight initiative (UK)

Clean Hydrogen initiative (Europe)

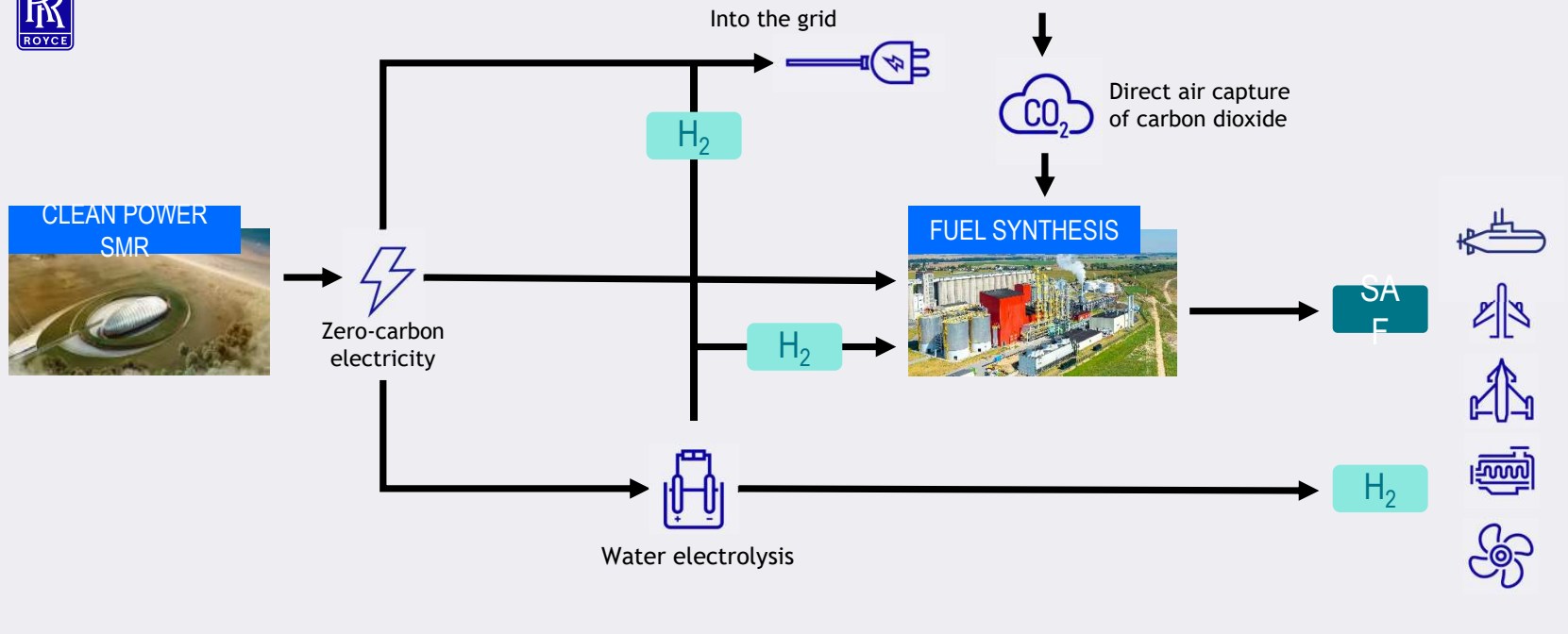
POWER SYSTEMS

Hydrogen fuel cell generators as an emissions-free alternative to diesel engines for facilities such as datacentres

Hydrogen fuel-cell generators for heavy-duty vehicles and other applications

Hydrogen on-demand power system for autonomous underwater vehicles

Small Modular Reactors (SMRs) could be used to generate green electricity, hydrogen and SAF



A unique opportunity to generate clean, versatile power