

A decorative header at the top of the slide featuring a series of overlapping, colorful triangles and polygons in shades of red, purple, blue, cyan, and green, creating a modern, abstract geometric pattern.

Investor Presentation– H2 Technology Overview

Ravindra K U, PS/NE-IN, 27.11.2023

Investor Presentation – H2 Technology Overview

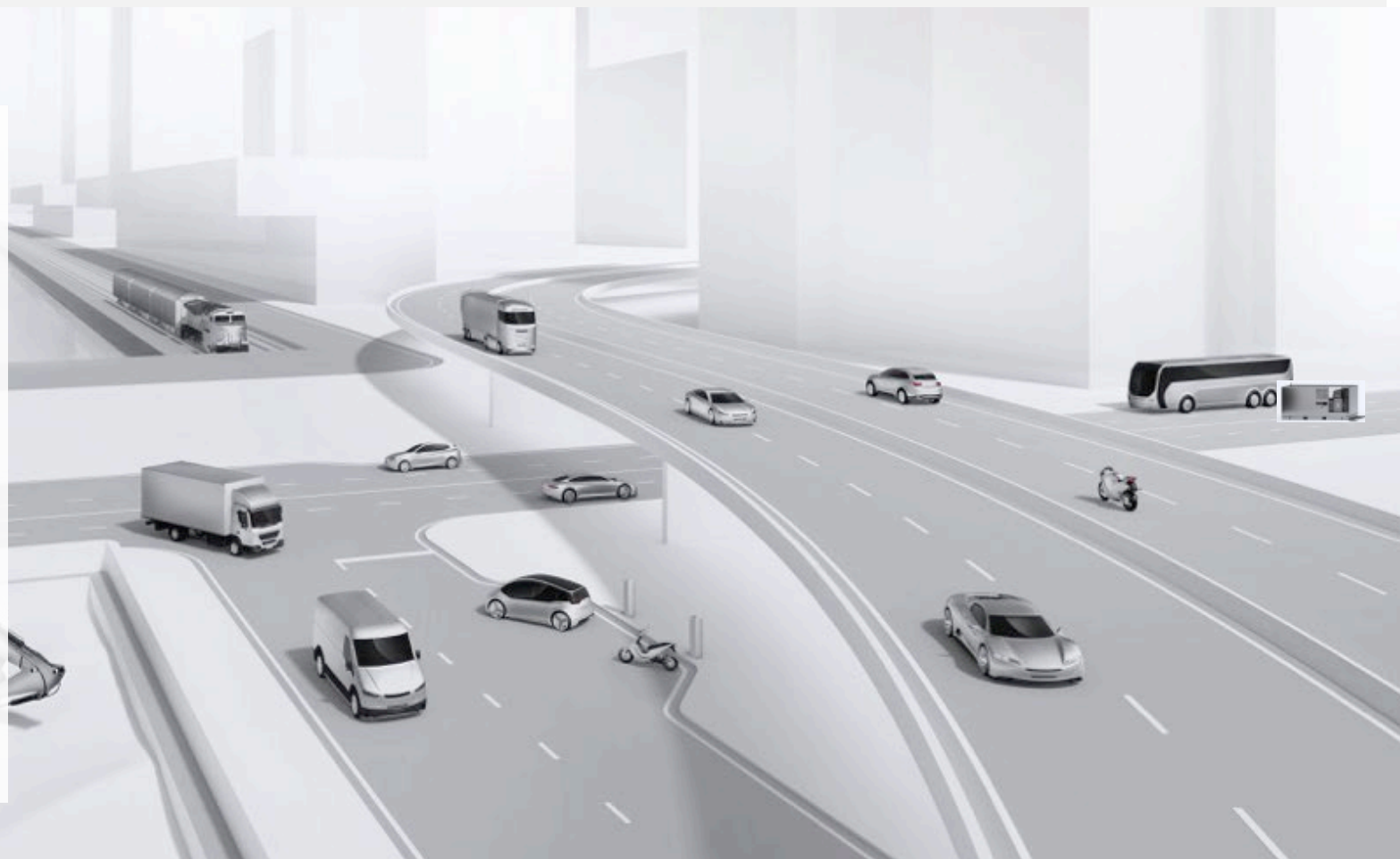
Safe Harbor Statement

At the outset, we would like to reinforce our Safe Harbor statement. In today's interactions and presentation , there may be some predictive statements that reflect our current views about Bosch Limited's future performance, but these are subject to risks and uncertainties

Future-proof solutions for all types of powertrain

We support all kind of powertrains:

- ▶ Battery-electric
- ▶ Fuel cell-electric
- ▶ H2 Engine
- ▶ Diesel
- ▶ Gasoline
- ▶ Natural gas
- ▶ Flex fuel
- ▶ Diesel hybrid
- ▶ Gasoline hybrid



Bosch will continue to offer improved solutions in ICE and zero emission technologies



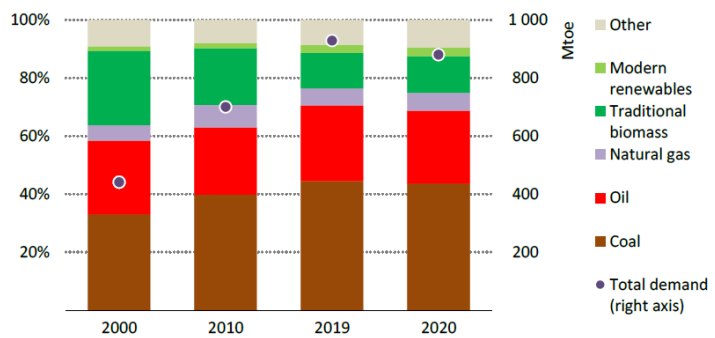
Overview of Powertrain Drivers in India

RBIN, 27-11-2023

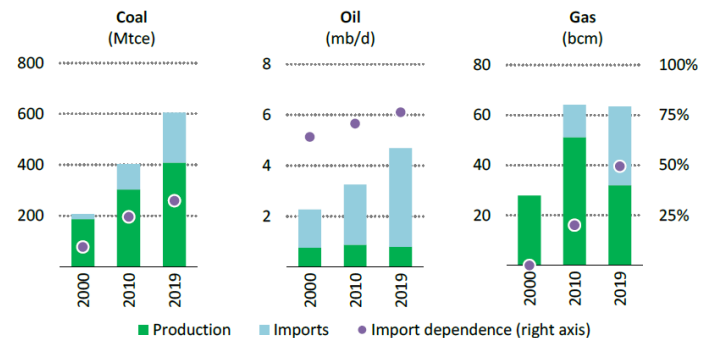
India's Automotive Industry | Energy sector trends

Energy security & sustainability are key drivers for transformation

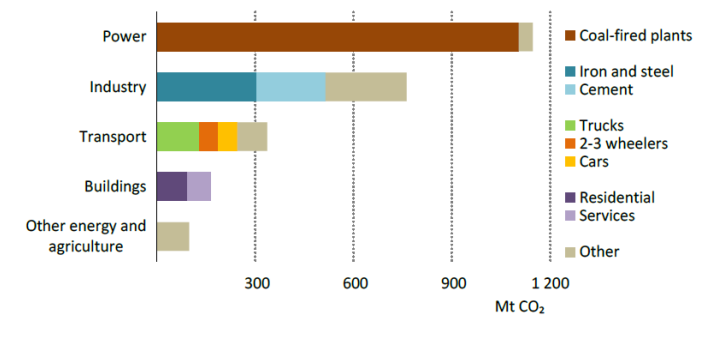
Total primary energy demand



Import dependency



CO2 emission from top sectors in 2019



India spends ~120 bio \$ in 2022

Govt. of India's mid and long-term targets

Reduce fossil fuel Import

- Energy **independent** country by 2047

Achieve goals of Decarbonization

- Reduce carbon intensity of GDP by less than 45% (Vs. 2005 level) by 2030
- SDS scenario by 2040 (IEA reference)
- Net Zero Emission by 2070**

Energy Importer to Exporter

- Aim 10% of the global Green H2 market **>10MMT/a** by 2030

Transformation through - Affordability, Accessibility, Clean and Indigenous criteria

India's Automotive Industry

Electric, Hydrogen and Biofuels are future energy for automotive Industry

- **Oil and coal** consists of **~70%** of **primary energy demand**
- **High import bill:** **~75%** of oil and **~30%** coal is imported
- Top **3** CO2 emission sectors: Power, Industry and **Transport**
- **~90%** of Gasoline imported used in **PC, 2W and 3W**
- **~70%** of the diesel imported is consumed by **CV segment**

Alternate fuels for Automotive Industry and enablers

eMobility and biofuel for 2W, 3W, PC, LCV and Bus segment

- Battery price reduction (<90\$/kWh by 2030)
- FAME, PLI policy and charging infrastructure development
- Biofuels: Global biofuel alliance

Green Hydrogen for CV segment

- Affordable solar energy: **~0.02\$ / kWh** by 2030
- National Hydrogen mission w/ **2.4 b\$** budget
- **>150 b\$** Industry investment in Green Hydrogen sector
- Affordable Green Hydrogen production cost

Adequate Hydrogen filling and EV charging stations in tandem w/ favorable policy to enable the transformation

India's Automotive Industry | Green Hydrogen

National Green Hydrogen policy: Govt aims > 5 MMT green H2 by 2030

UNION CABINET APPROVES NATIONAL GREEN HYDROGEN MISSION

EXPECTED DELIVERABLES BY 2030

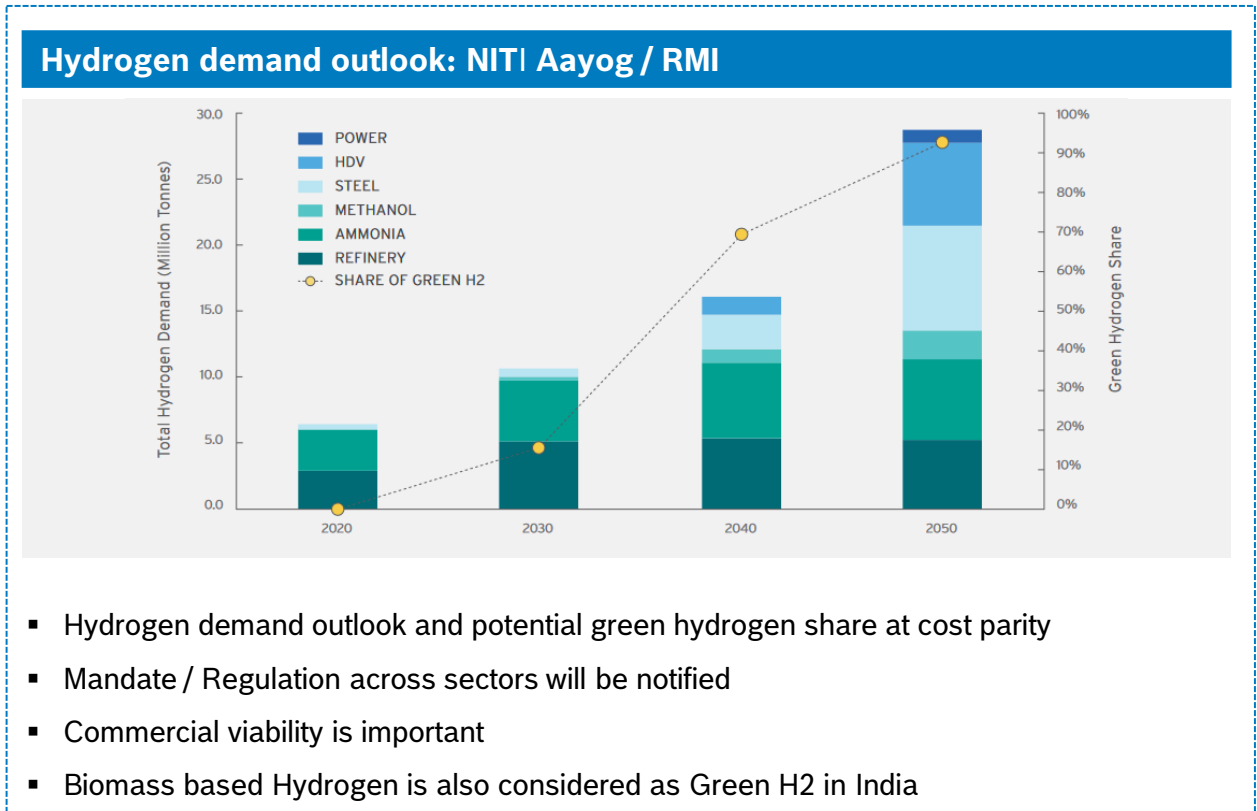
At least **5 MMT** GH₂ annual production | **60-100 GW** electrolyser capacity | **125 GW** RE capacity for GH₂ generation and associated transmission network

Total outlay approved: ₹ 19,744 crore

Rs 1 lakh crore import savings | **50 MMT** CO₂ annual emissions averted

6 lakh jobs | **Rs 8 lakh crore** investment

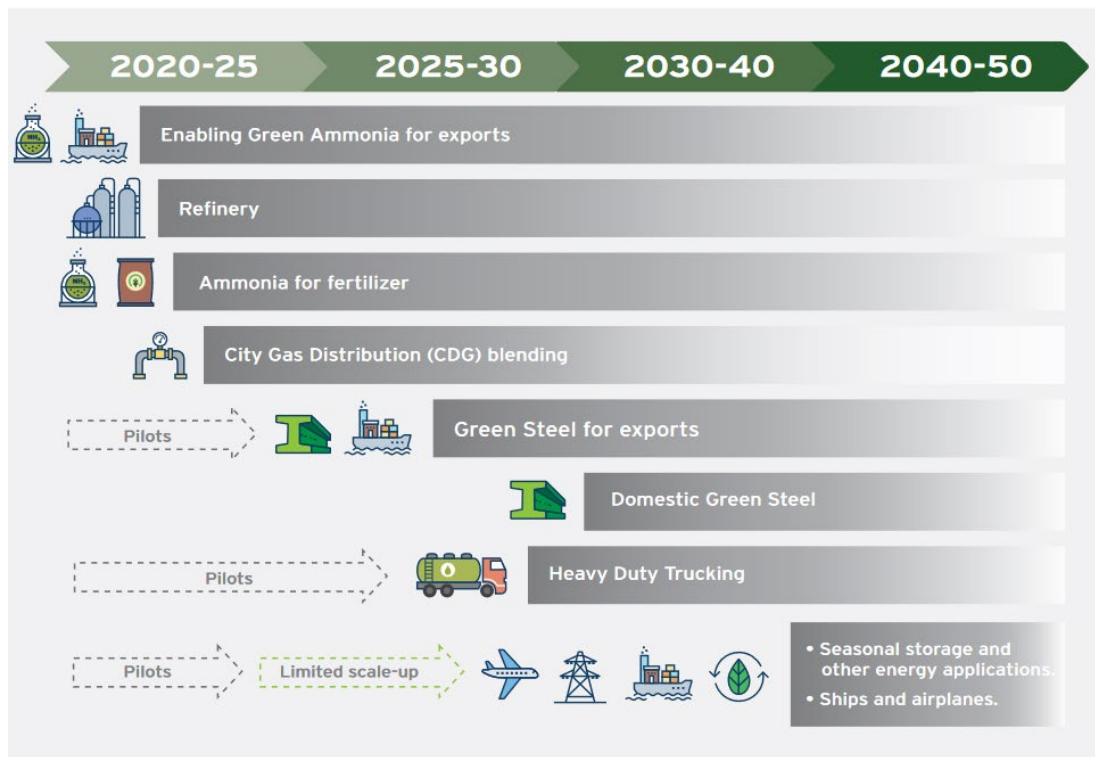
- Focus sectors are **Green Steel, Transport, Green Fertilizer, Shipping, Methanol** and **Export**
- Govt to allocate budget for **Strategic Intervention of Green H2 prod., Pilot projects, R&D projects and Skill Development**



India stands better chance to produce Green H2 at competitive price

India's Automotive Industry | Green Hydrogen

NITI Aayog roadmap for Green H2 deployment across sectors



Potential mandates for existing applications

Sector	Target Type	Mandate	Cut-off Date for the Sector to go 100% Green
Refinery	Corporate level targets	50% by 2030	2035
Fertilizers	Import substitutions	100% by 2030	2040

Aspirational targets for new applications

Sector	Type	Targets
Steel	Old plants	Fleet level carbon intensity by 2035 should be less than 2 tonnes of CO ₂ per tonne of steel
	New capacity	At least 20 million tonnes of green hydrogen-based green steel to be made in India primarily for exports
City Gas Distribution (CDG)	Pilot and subsequent scale-up	10% blending by 2025 and 20% by 2030
Green Ammonia	Exports	25 million tonnes of exports to countries such as Japan, Korea, and the European Union
Heavy-Duty Vehicles (HDVs)	Pilots on specific routes	1,000 trucks, 50 boats, and 10 aircrafts to be piloted by 2030. Three hydrogen corridors to be developed across the country based on state grand challenge.
Power	Allow participation in RTC tenders	Where economics makes sense, allow hydrogen to compete with other storage technologies in Round the Clock tenders by SECI.

**Govt. of India is promoting Green Hydrogen both on demand and supply side
Deployment mandates awaited**

India's Automotive Industry | Green Hydrogen

Key takeaways

Key driver and enabler for Green Hydrogen Market

Reducing import bill is the key driver | India's abundant and affordable renewable energy is a key enabler(inc Biomass based)

Hydrogen price

Affordable price at pump is critical to drive Hydrogen in Heavy-duty long-haul truck sector

Bosch portfolio for H2 mobility

H2 Engine and fuel cell for mobility sector

For our Customers

Mature technology, global presence and dedicated engineering support



Overview of BOSCH offering in H₂ mobility

RBIN, 27-11-2023

Overview of BOSCH offering in H₂ mobility

National Green Hydrogen Mission – Overview

Mission objective : To make INDIA the global hub for production, usage and export of Green H₂ and its derivatives

Phase 1 (2023 – 26)

Phase 2 (2027 – 30)

Create demand

- Export markets
- Substituting imports
- Domestic demand

Promotion through incentivizing supply

- for increase local manufacturing of ELY
- Green Hydrogen Production through Biomass

Cost competitive with fossil fuels

- By accelerated growth in production
- Commercial scale green hydrogen projects in steel, mobility and shipping sector
- R&D activities (SHIP*) will be scaled up for continuous development of products.

OUTCOME

5MMT GH₂ Annual Production (+10MMT export)

50 MMT CO₂ Annual Emissions Averted

125 GW RE Capacity for GH₂ Generation & Tx Network

600k Jobs & \$96bn (₹8L Cr) Investment

Key Enablers



Resources

Renewable energy - Banking & storage, transmission, finance, land, water



Ease of doing business

Simpler procedures, taxation, SEZ, commercial issues, single window



Regulations & Standards

Testing facilities, standards, regulations, safety & certification



R&D

Result oriented, time- bound, including through PPP (purchasing power parity), grand challenges



Infrastructure & Supply Chain

Ports, Re-fueling, Hydrogen Hubs, pipelines

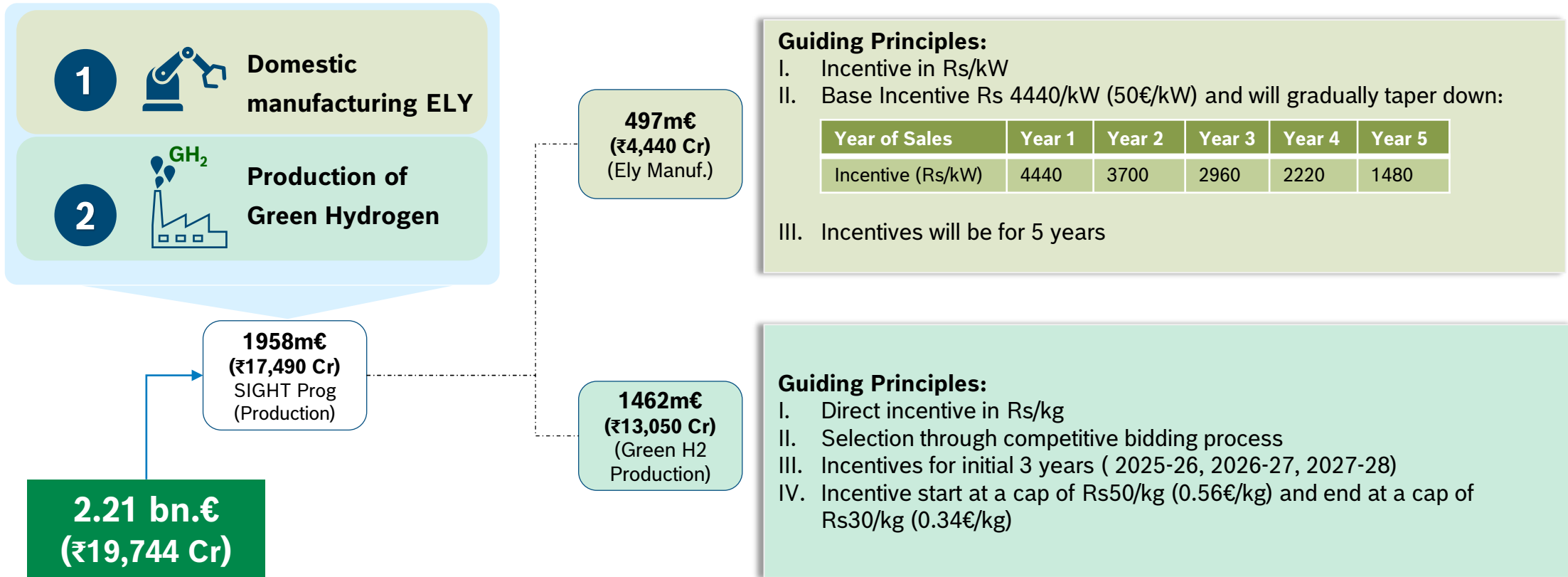


Skill Development, Public Awareness

Coordinated skilling programme
Online portal

Overview of BOSCH offering in H₂ mobility

SIGHT – Strategic Interventions for Green Hydrogen Transition



NGHM budget allocation

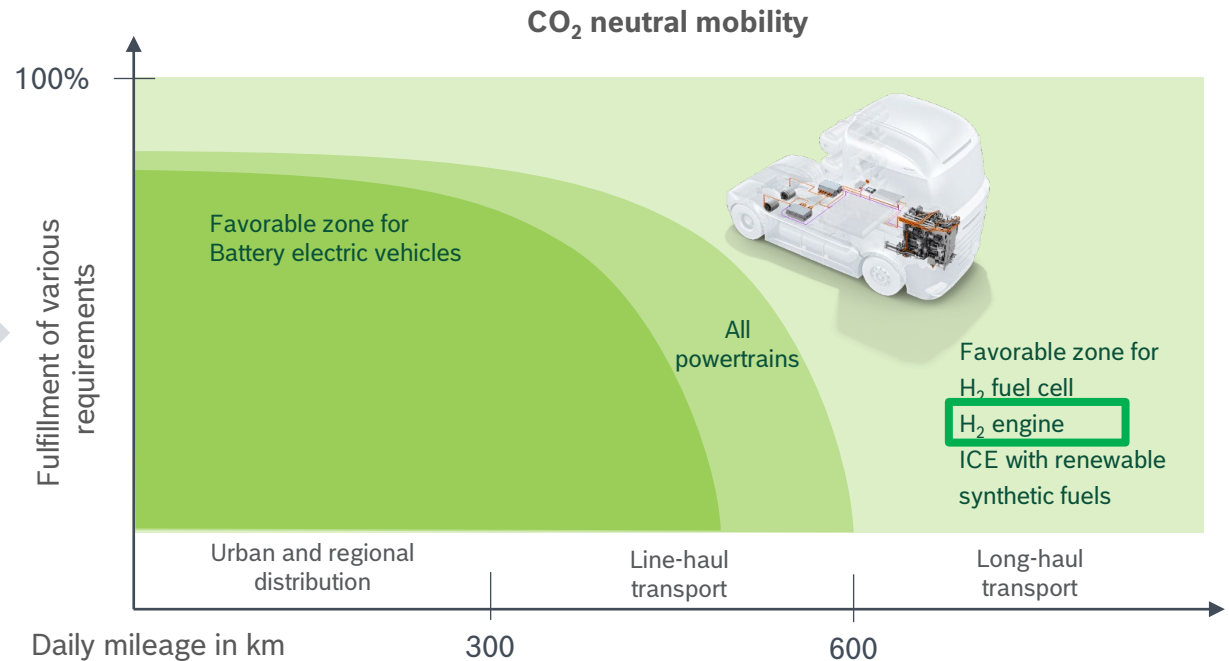
Overview of BOSCH offering in H₂ mobility

Motivation: Paths towards CO₂-neutral mobility

Today
ICE as “all-rounder”



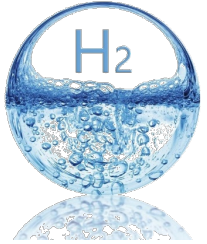
Example: Commercial Vehicles



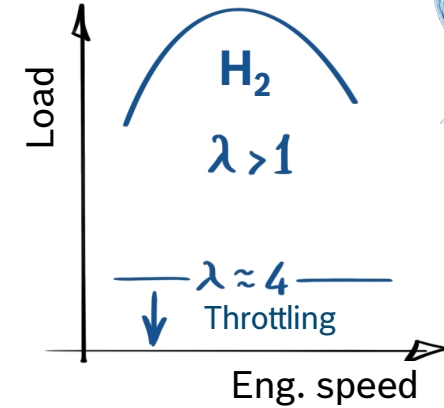
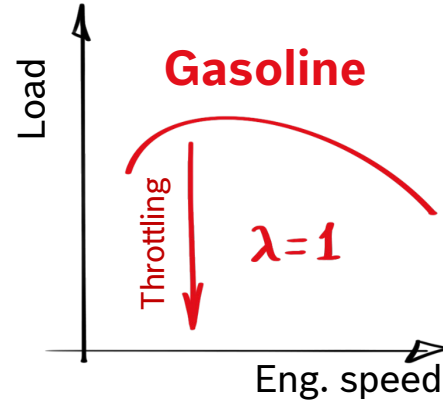
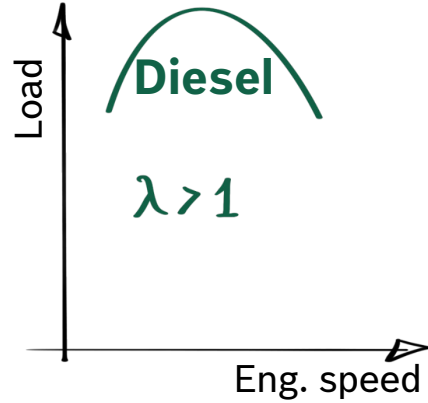
Commercial vehicle applications are highly heterogeneous (e.g. load, power, range, terrain,)
We need all technologies, to meet customer and societal needs of all applications

Overview of BOSCH offering in H₂ mobility

Motivation: Arguments for the Hydrogen Engine powertrain



Lambda Mapping



Relevant Control Parameters

- Lean
- Self ignition
- Qualitative load control
- External EGR
- EGT: SCR system

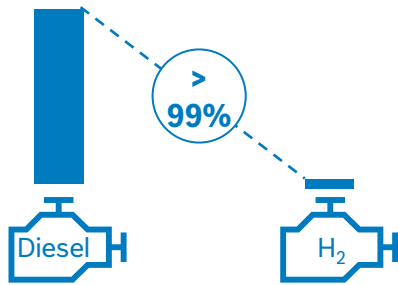
- Lambda 1
- Spark plug ignition
- Quantitative load control
- EGR: mostly not
- EGT: Three way catalyst

- Lean
- Spark plug ignition
- Qualitative & quantitative control
- External EGR
- EGT: SCR system

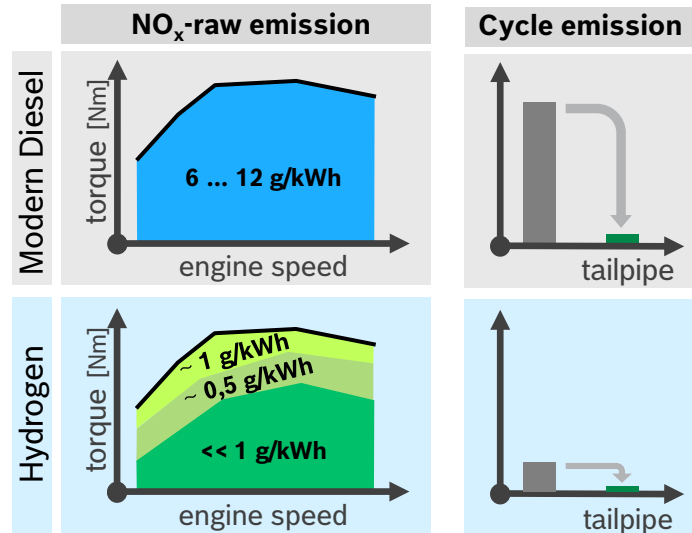
Control of Hydrogen engine is a combination of known Diesel and Gasoline concepts
Evolution from existing powertrain solutions

Overview of BOSCH offering in H₂ mobility

Motivation: Arguments for the Hydrogen Engine powertrain!



- **No CO₂ from combusting H₂**
- CO₂ due to a small amount of engine oil burning



- **Clearly very low engine level emissions**



Technology evolution
From current engines

Robustness
Like Diesel for different use cases

Mainly steel and aluminum
Processing & Recycling known

Engine Production & Assembly
Same as current engines

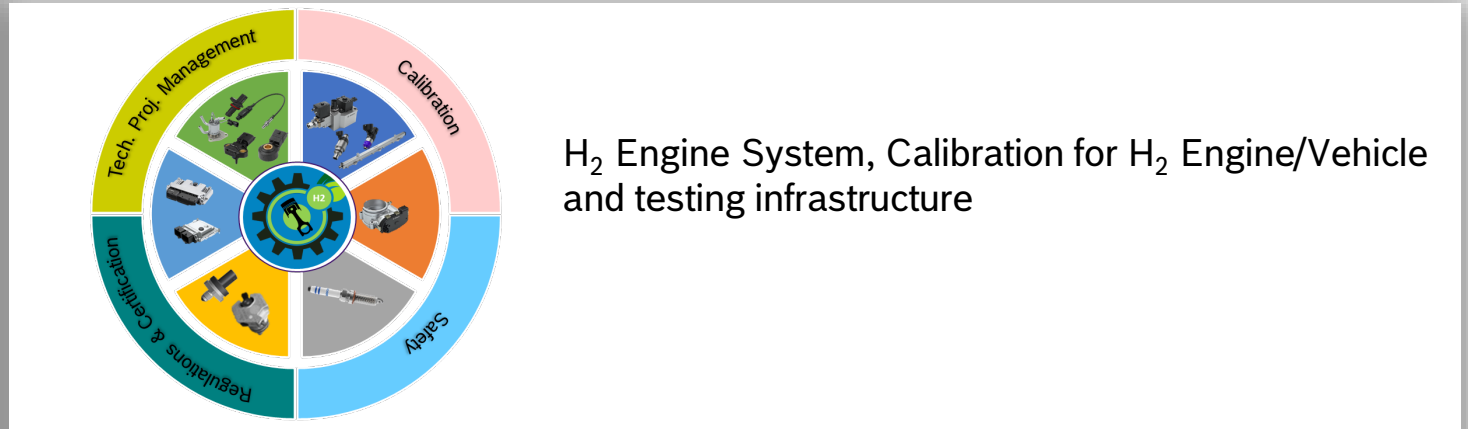
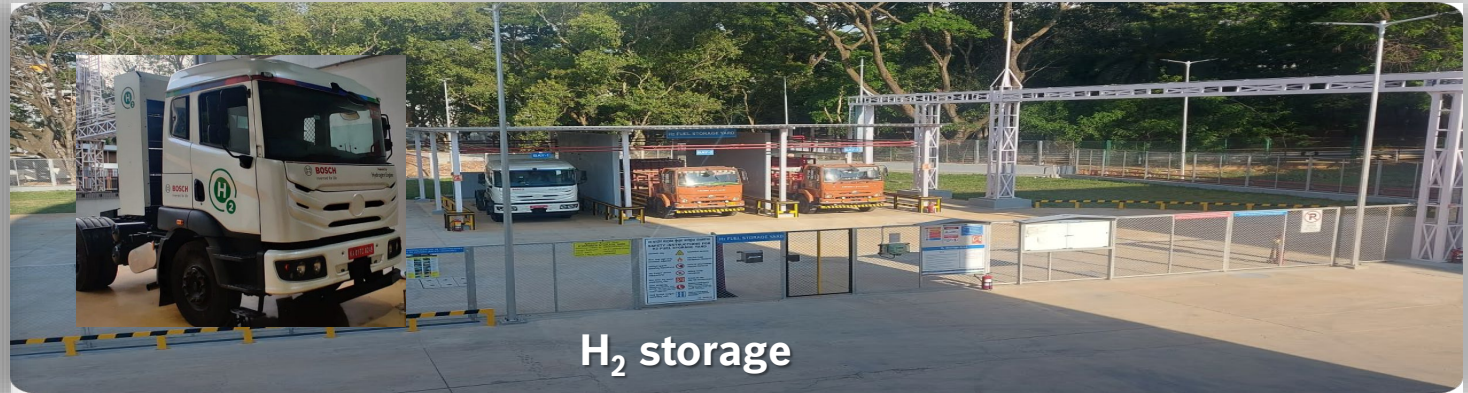
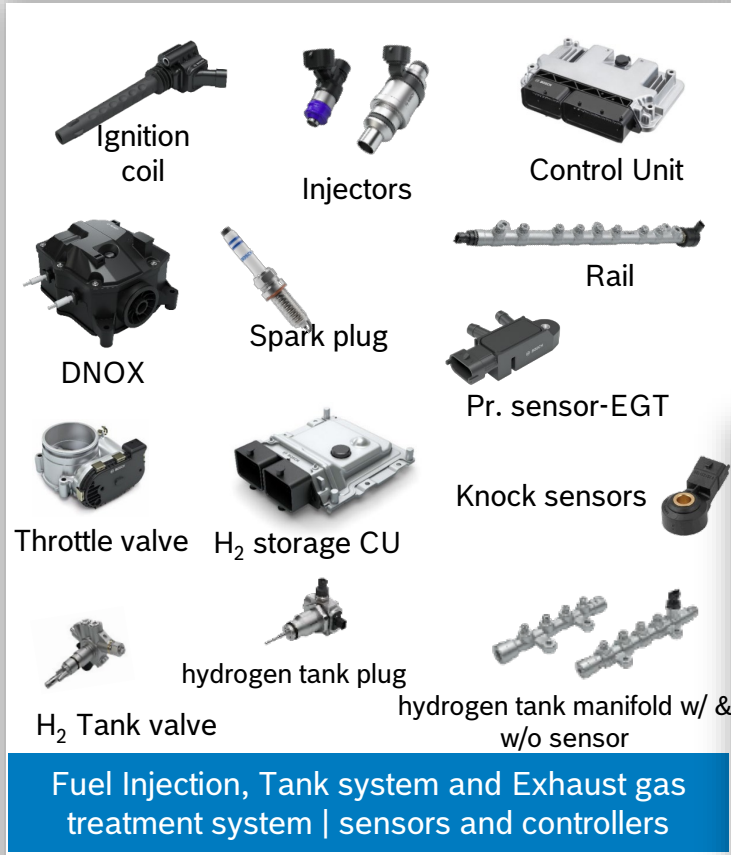
Diagnostics and Service
Same as current engines

Lower Upfront Cost
compared to other new powertrains --TCO

H₂ Engine technology likely to be preferred in Heavy duty segment

Overview of BOSCH offering in H₂ mobility























Our approach to H₂ Engine Technology



Bosch India is prepared to enable H2E technology for long haul trucks with right products, services & infrastructure

Overview of BOSCH offering in H₂ mobility

Extensive portfolio for every need

Segment	FC modules	Stack	FC kit
 SUV  LCV  Pick-up	 80 – 132 kW		Balance of plant Components & submodules 
 City bus  MD  Municipal	 112 kW  75 kW		Sensors & valves 
 Coach  HD  HD	 224 kW / 300 kW  132 kW  190 kW  250 kW	Single stack up to 132 kW	FCCU  Hydrogen storage system 

Bosch India's focus currently is to consolidate market requirements and develop competency for future

THANK YOU