KPIT

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Relevance of Hydrogen Fuel Cell based transportation for India

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Challenges

Large and ever-increasing oil import bill – bigger in the context of the ambition of $ 5 trillion economy

- India **imported 220 million ton (85%) crude oil** worth USD 88 billion in FY-18
- Around 35 million ton Diesel was consumed by public transport sector (trucks & buses)

Pollution

- India is the world's **third largest emitter of CO_2**
- 10 of world's 20 most polluted cities are from India
- Transportation contributes >30% of urban pollution

Low income of the farmers

- India's **50% population is dependent on agriculture** as its source of income
- 85% farmers own land < 5 acre and have annual income around ₹ 17,000/acre

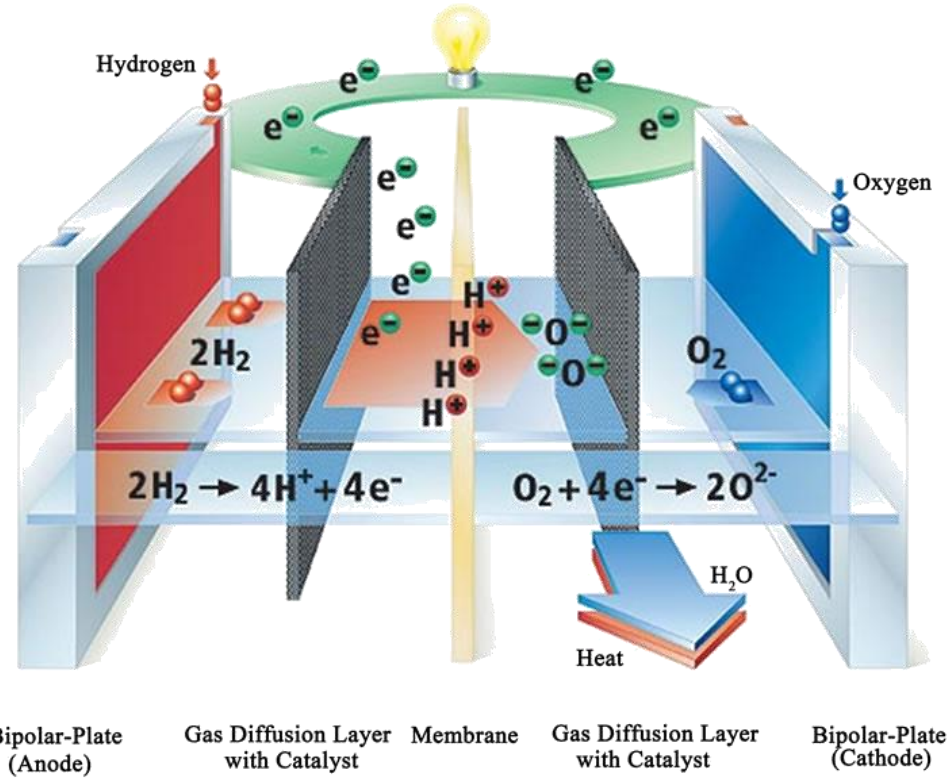
We believe that Hydrogen ecosystem can address these challenges

Global Scenario

- **Japan** has set a target of having 200,000 fuel cell vehicles on road by 2025. Toyota, Nissan and Honda formed a joint venture with major gas and energy firms to add 80 new Hydrogen stations to existing 100 ones in Japan to promote Hydrogen economy.
- **China** also aims to have one million fuel cell vehicles on the road by 2030. China has spent USD 12.40 Bn in 2018 for supporting Fuel Cell Vehicles program in ten cities.
- In **USA**, hydrogen economy developments are taking place across several states including California, Connecticut, New York, Colorado, Hawaii, Massachusetts, New Jersey, Ohio and Pennsylvania.
- Hydrogen Mobility Europe (H2ME) is a flagship project launched in 2015 to develop the network of Hydrogen refueling stations across **Europe**.

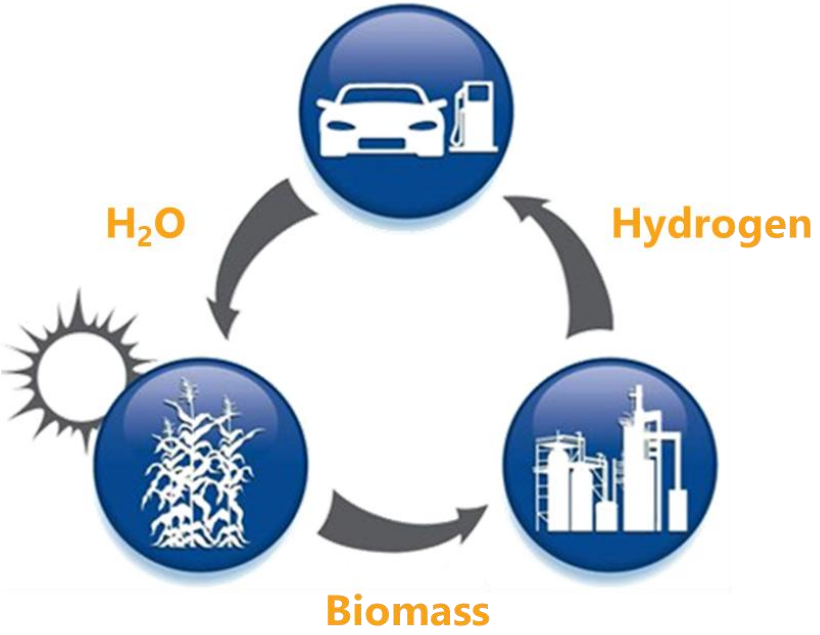
Fuel Cell Technology

- Utilizes Hydrogen as fuel
- Fuel cell generates energy with 50% efficiency. (Conventional engines have efficiency of around 30%)
- Zero emission of pollutants - Output is electrical energy and water vapor.
- Silent and vibration free operation
- Ideal solution for long distance intra-city and intercity transportation. Battery electric vehicle (BEV) solution will not be appropriate for long distance transport due to high battery weight and longer charging time.



Hydrogen as Fuel

- Fuel with highest specific energy (33.3 kWh/kg as against 11.8 kWh/kg of diesel)
- Carbon neutral fuel if generated from renewable sources - Potential to substitute conventional fossil fuels
- Additionally, when Hydrogen is generated from biomass it has advantages beyond pollution reduction.
- Almost any biomass can be used to generate hydrogen by using different pathways.



Hydrogen generation from biomass

- Annual consumption of diesel by public transport 35 million tons (buses and trucks) can be replaced by 8 million tons Hydrogen, which will require 400 million tons biomass.
- India generates 200+ million ton waste biomass (agricultural residue, Bagasse, waste grains, etc.)
- Dedicated biomass farming where waste biomass is not readily available. Systematic cultivation of certain varieties of Bamboo and/or Cane can yield 30 ton biomass per acre per year.
- Thus, overall land required to meet this Hydrogen demand through dedicated biomass farming (even ignoring the available waste) is 8 million acres, which is **1.5% of cultivable land** (or 7% of fallow land) in India.

Why are FCEVs not present in large numbers?

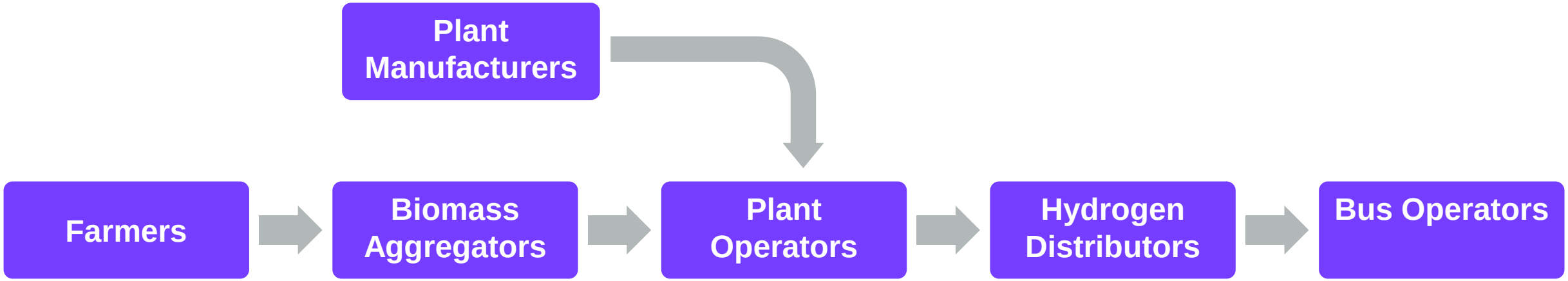
- As of 2018, 12,000 FCEVs are operating globally
- The primary reason is –
  - high cost of fuel cells
  - lack of easy and affordable availability of Hydrogen at the point of use
- We have been working on both these problems for the past few years. We now have a solution in our sight for shared vehicles.

Our Goal and Comparison with the Market

Parameters	Market	Our Goal
Cost of Fuel Cell	$ 1,000 /kW	~ $ 500 /kW
Cost of Hydrogen	₹ 800-1,600 /kg	~ ₹ 250 /kg

- At these price-points, it would be cheaper to use a FCEV bus than a diesel vehicle.
- This can be achieved through -
  - Technology innovations
  - Partnership-based business model

Business Value Chain



Our Approach

- We are keen to build a partnership model which will involve all the stakeholders in the value chain.
- The Financial returns for all the participants of the Value Chain are more than reasonable.

Going Beyond Bus Transportation

Trains	• Potential Hydrogen Market – 0.7 Million ton/year • Potential ForEx savings – $ 1.6 Billion/year
D.G. Sets	• Potential Hydrogen Market – 2.5 Million ton/year • Potential ForEx savings – $ 6.8 Billion/year
Agricultural applications	• Potential Hydrogen Market – 2.7 Million ton/year • Potential ForEx savings – $ 7.4 Billion/year
SUVs	• Potential Hydrogen Market[1] – 1.9 Million ton/year • Potential ForEx savings – $ 5.1 Billion/year
Trucks	• Potential Hydrogen Market – 5.9 Million ton/year • Potential ForEx savings – $ 16.3 Billion/year
Buses	• Potential Hydrogen Market – 2.0 Million ton/year • Potential ForEx savings – $ 5.4 Billion/year

Total Potential Hydrogen Market of **16 Million ton/year**, resulting in annual forex savings worth **$ 42 Billion** and equivalent domestic income generation

* ForEx Savings Calculated considering base price of diesel at ₹40/ liter without any taxes
1. Estimated consumption for SUVs

Potential Environmental Impact

POLLUTION REDUCTION

- Displacement of every ton of diesel results in CO_2 reduction of 2.7 tons
- Potentially, proposed solution can **reduce ~165 Million tons of CO_2** emissions per annum. The solution, thus have potential to achieve 50% of our country's commitments under COP21 to create carbon sink of 3 billion ton CO_2 equivalent by 2030.

AGRO-RESIDUE DISPOSAL

- In 2017 alone, ~125 Mn tons of crop residue was burnt in northern India, releasing ~210 Mn tons of Green House Gases
- The proposed technology can meaningfully alleviate the adverse impact of crop residue burning

Potential Socio-Economic Impact

FREEDOM FROM FOSIL FUELS

- Price competitive solution with the conventional technologies.
- Annual savings of **₹2,900 billion*** corresponding to reduction in diesel consumption.
- The crude saved can be better used for chemicals and high end products.

BOOST TO AGRICULTURE SECTOR & ECONOMY

- Potential surplus income of ₹2,000 to ₹2,500 per acre from sale of crop residue.
- Assured income of ₹25,000 per acre per year to **10 million farmers** from dedicated farming of bio mass.
- Potential incremental income of **₹1,450 billion** to the agriculture sector.
- GDP addition of more than **₹11,000 billion** which will be 6% annual contribution to GDP.

JOB CREATION

- Can potentially create **500,000+ jobs** in Bio-hydrogen plants, supply chain management for skilled/ unskilled workforce and opportunities of rural entrepreneurship in biomass aggregation.

* Calculated considering base price of diesel at ₹40/ liter without any taxes

Benefits of Hydrogen economy for India

Large and ever-increasing oil import bill – bigger in the context of the ambition of $ 5 trillion economy

- No dependency on middle east for energy needs
- Reduction in import of ₹2,900 billion/year*

Pollution

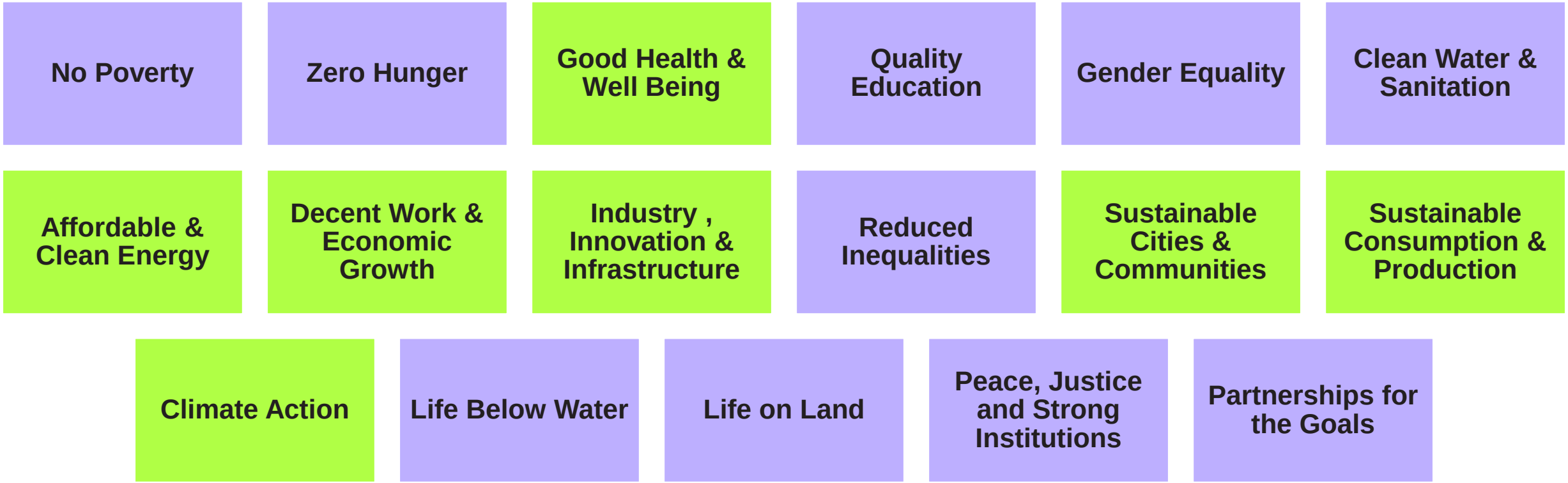
- Can reduce ~165 Million tons of CO2 emissions per annum
- Potential to achieve 50% of the country's commitments under COP21

Low income of the farmers

- 25% increase in the farmers' income
- Potential incremental income of ₹1,450 billion to the agriculture sector
- Opportunities for rural entrepreneurship

Sustainable solution to address the challenges

Meeting Sustainable Development Goals through Hydrogen Economy



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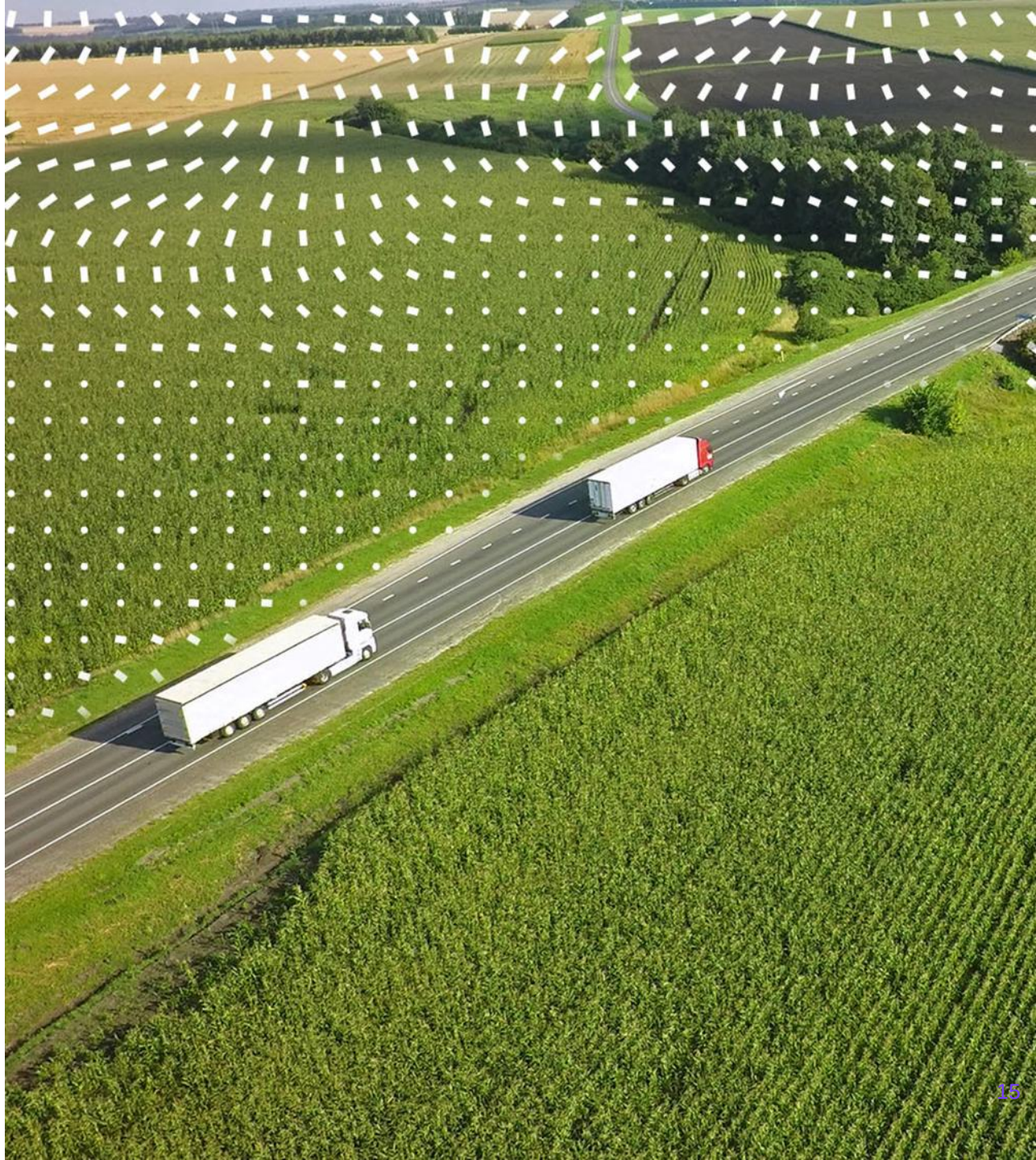
KPIT

About Us



KPIT at a glance

6800+
Automobelievers

25
Innovation Awards

51
Global Patents

4%
of Revenue spent on R&D

Delivering robust solutions over two decades

Americas

- Novi, MI
- Columbus, IN
- Bettendorf, IA
- Sao Paulo

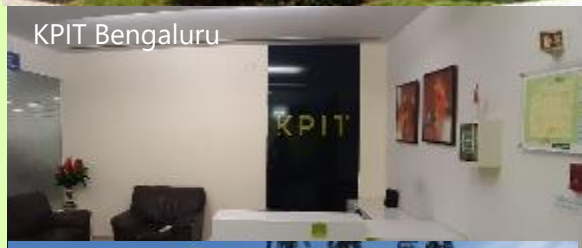
Europe

- Munich
- Coventry
- Gothenburg
- Wolfsburg
- Dortmund
- Amsterdam
- Milan
- Stockholm

Asia

- Pune
- Bengaluru
- Singapore
- Bangkok
- Shanghai
- Tokyo
- Seoul

Software Development Excellence Centers



KPIT is present where the mobility ecosystem is transforming

Driving the future of mobility

Powertrain
(HEV, BEV and FCEV)

Clean Energy Solutions

Connected Vehicles

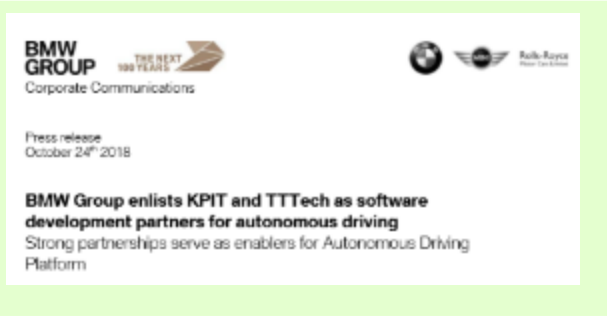
AUTOSAR

Autonomous Driving

Vehicle Diagnostics

Creating win-win strategic partnerships

BMW Partners with KPIT for AD


BMW GROUP
Corporate Communications

Press release
October 24th 2018

BMW Group enlists KPIT and TTTech as software development partners for autonomous driving
Strong partnerships serve as enablers for Autonomous Driving Platform

Eaton partners with KPIT on electric mobility

Several Millions
Of Vehicles uses KPIT software

300+
Vehicle production Programs

10+
Customers for more than a decade

Key Customers

BMW, Honda, FCA (Fiat Chrysler Automobiles), Volkswagen, Jaguar Land Rover, Volvo, Cummins, GM, Tata, Alexander Dennis, John Deere, Kostal, Hitachi (Inspire the Next), Renault Nissan, Eaton, Continental, Denso, Magna, Panasonic

Note :Illustrative list of also includes customers published in Hansen report


Thank You