



Why Hydrogen Fuel Cells Make Sense

India Mobility Markets

World Hydrogen Energy Conference – Oct 2023

Murali Arikara



Racanaa Corporate Info.

4

Countries

100

Systems/month deployment
rate

3000

Systems in pipeline

A leader in providing Energy Management Solutions – Enabling Net Zero Everywhere

▶ UK based company with India subsidiary

▶ Channel Partnership in UAE, Qatar, and UK

▶ India based technology and product development

▶ Sector agnostic product, supports quick deployment



Power train transition – 20th century



- In the 19th century horses were the most popular prime movers

Self-feeding, self-controlling, self-maintaining and self-reproducing and far more economical in the energy they are able to develop from a given weight of fuel material, than any other existing form of motor

Robert Thurston – Steam Engine Expert (1894)

- There was a sixfold increase in horses employed from 4 million in 1840 to over 24 million by 1920
- Each horse dumped between 20 to 50 lbs of manure on the streets every day
 - 95% of all disease carrying flies bred in horse dung
 - Dead horses clogged streets
- It took 50 years for a transition from horses to internal combustion engines



Transition to a new prime mover

Steam Car

The NEW WHITE STEAM TONNEAU for 1903.



NEXT TO FLYING
is the motion of the incomparable WHITE—smooth, noiseless and free from all motor vibrations. A swift, gliding movement that affords the maximum of automobiling pleasure, minus its every defect.

Write for full particulars, experts' reports and official results of important endurance contests.

WHITE SEWING MACHINE CO. (Automobile Dept.),
CLEVELAND, OHIO.

28 Union Square, New York, N. Y. 219 Woodward Ave., Detroit, Mich.
500 Tremont St., Boston, Mass. 300 Ross Building, Cleveland, Ohio.
300 Post St., San Francisco, Cal. 35-36-37 King St., Regent St., London, England.

Electric

ELECTRIC
ELECTRIC CARRIAGES NOW PLAY AN IMPORTANT PART WITH PROGRESSIVE DEALERS



The BAKER
is Distinctively the Best

ATTRACTIVE STRONG DURABLE EFFICIENT
THE SIMPLEST TO RUN
THE SAFEST TO USE
THE CHEAPEST TO KEEP

If You Would Deal with the Best Class get the BAKER
WRITE FOR CATALOG

THE BAKER MOTOR VEHICLE COMPANY, Cleveland, Ohio

Internal Combustion Engine

The Ford Four Cylinder; Twenty Horse Power, Five Passenger Touring Car \$850⁰⁰ Fob. Detroit

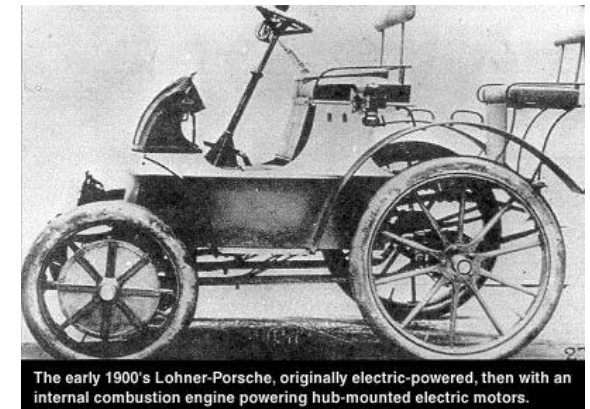
Ford Motor Company
Detroit

At the turn of the last century, 40% of cars in US were steam driven, 38% were electric and 22% were gasoline IC engine cars.

The **internal combustion engine won** this competition because:

- The invention of the electric starter by Charles Kettering in 1912
- The Model – T which was priced at \$750 compared to \$1,750 for an electric car
- Discovery of oil in Texas that made gas affordable for the average consumer

Hybrid Electric





Our current challenge – Sustainability



Energy Security



Environment

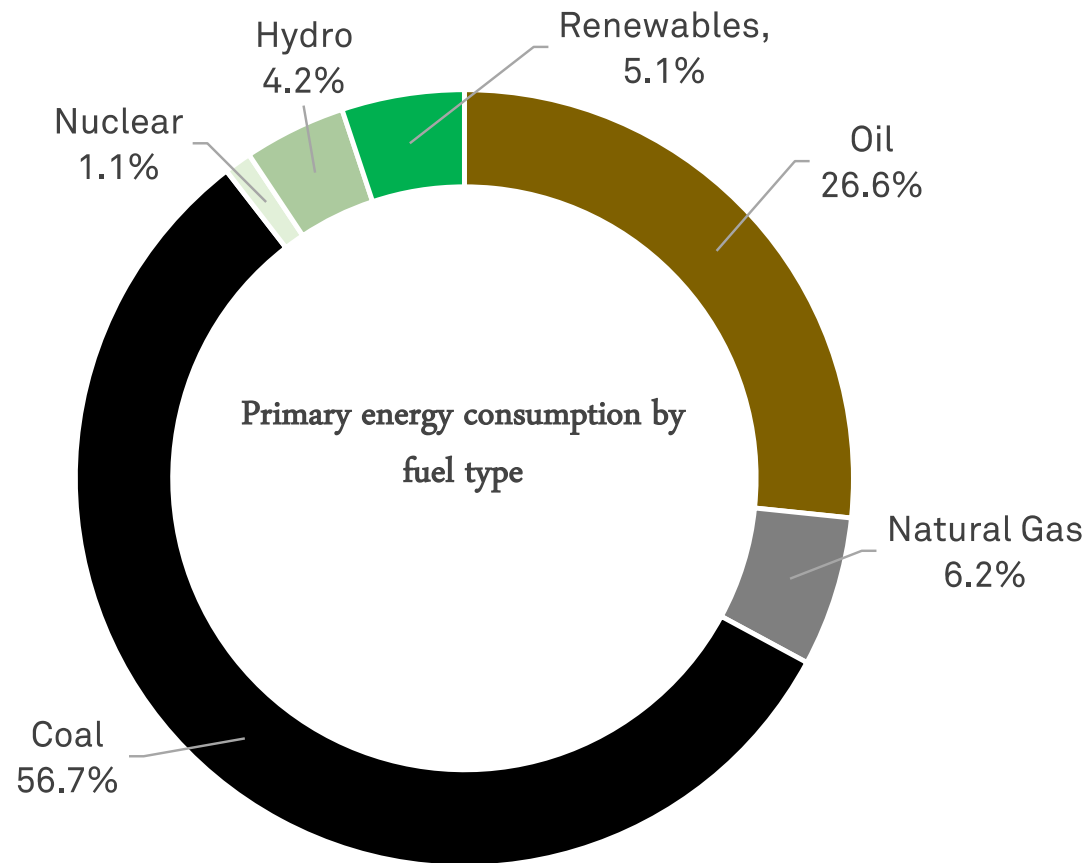


Economics

- Depleting foreign exchange reserves
- Price shocks - result of volatility in global markets
- Pressure on exchange rates
- Global geo-political developments threatening energy security of India



India's energy situation



- India has ~17.76% of the world's population
- Less than 1% of oil reserves
- 9.5% of the world's coal reserves
- **89.2% of energy from oil, natural gas & coal**



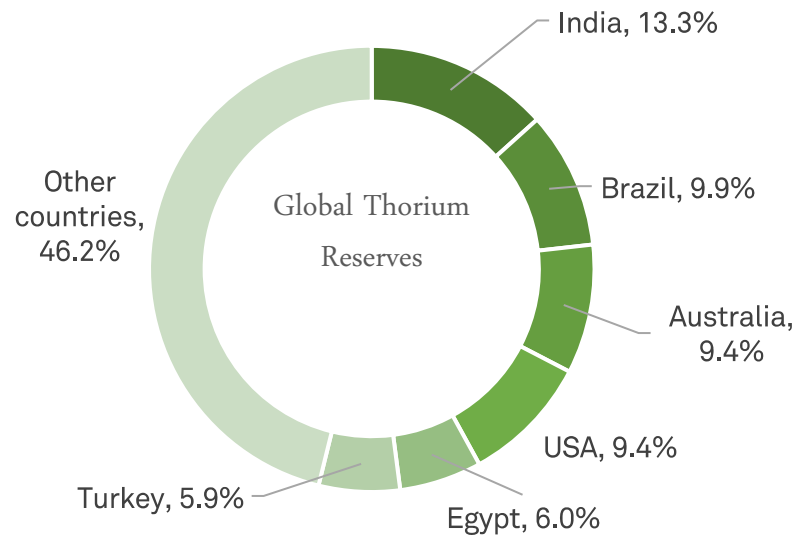
A long-term energy solution that does not depend on coal or petroleum.



Energy sources for India

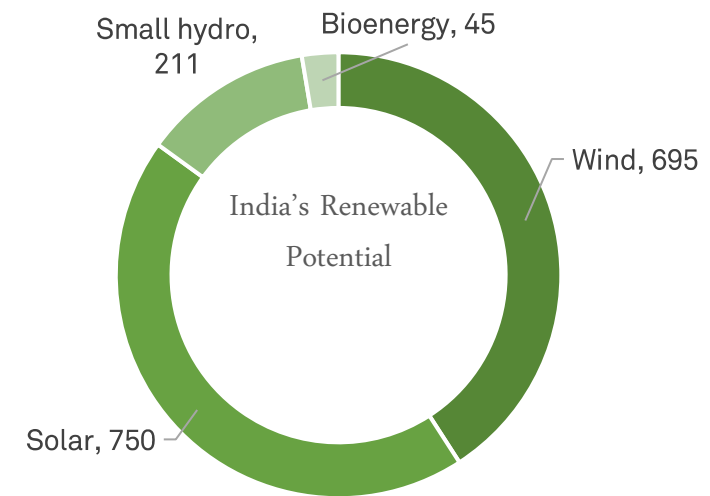
Nuclear

- ~850,000 tonnes of Thorium reserves
- 1 ton of Thorium can generate 1 GW for a year
- ~ 650,000 Mtoe or ~ 750 years of 2020 consumption



Renewables

- Potential of 1700 GW
- Average PLF assumed 26.4%
- 338 Mtoe/year of energy capacity (38.8% of 2020 consumption)



Sources:

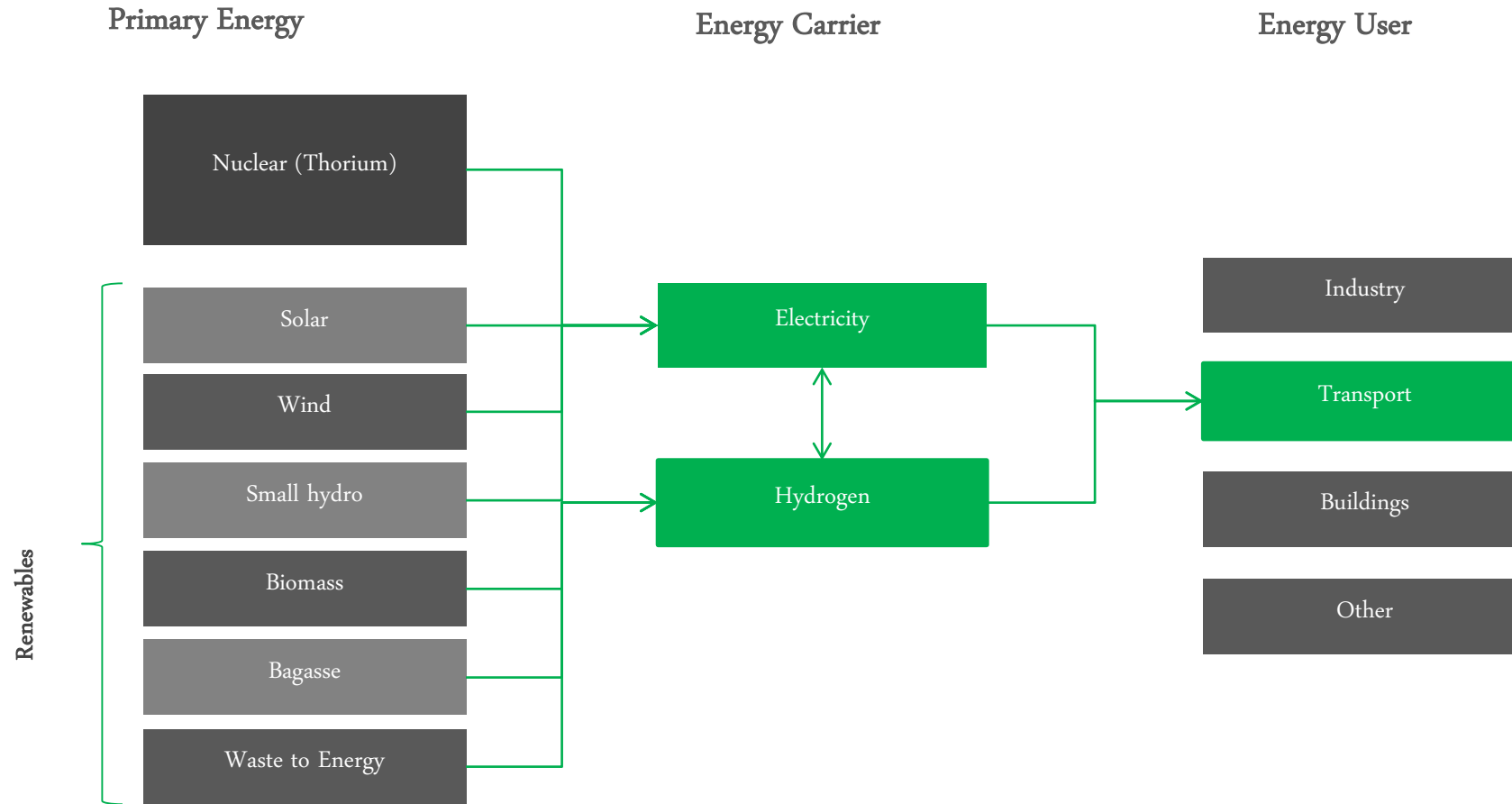
<https://world-nuclear.org/information-library/current-and-future-generation/thorium.aspx>

<https://www.tdworld.com/renewables/article/21212417/india-taps-into-renewable-energy-potential>

<https://www.pas.va/en/publications/acta/acta24pas/revol.html>



Future energy pathways for India





Are hydrogen & electricity competing?

“Fuel cell electric vehicles are mind bogglingly stupid”

Elon Musk (CEO- Tesla)

“(Battery)electric cars are not practical”

Yoshikazo Tanaka (Chief Engineer – Mirai Toyota)



FCEV – Toyota Mirai (an example)

VEHICLE TYPE

mid-motor, rear-wheel-drive, 5-passenger, 4-door sedan

BASE PRICE

XLE, \$50,455; Limited, \$66,955

MOTOR

synchronous AC, 182 hp, 221 lb-ft; 1.2-kWh lithium-ion battery pack

FUEL-CELL

solid-polymer-electrolyte proton-exchange membrane, 172 hp

TRANSMISSION

direct drive

PERFORMANCE (C/D EST)

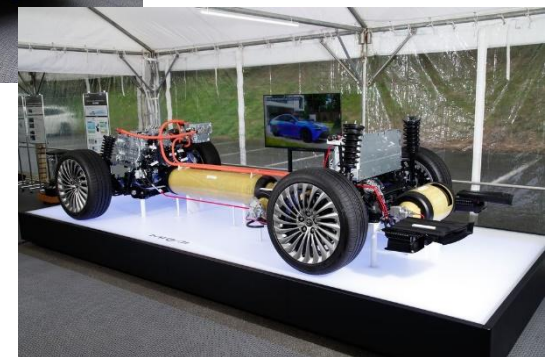
0 to 60 mph: 9.1 sec

Top speed: 106 mph

EPA FUEL ECONOMY (MFR'S EST)

Combined/city/highway: 65–74/67–76/64–71 MPGe

Range: 357–402 miles



Sources: <https://www.caranddriver.com/toyota/mirai>



Fuel cell versus battery electric for India

Fuel Cell Electric Vehicles

- Hydrogen as fuel and hence need a developed hydrogen infrastructure
- Can refuel in 5 minutes and get a range of 400 kms to 500 kms



Battery Electric Vehicles

- Electricity to recharge batteries and need a developed electrical grid infrastructure
- Requires 3 to 12 hours for a full recharge and a range of 150 kms to 300 kms



The Indian Challenge

Significant investment is required to develop both the hydrogen and the electric infrastructure to support large scale deployment of either fuel cell or battery electric vehicles



Infrastructure - refuelling and recharging

Fuel Cell Electric Vehicles

“One to Many” or “Public” Infrastructure

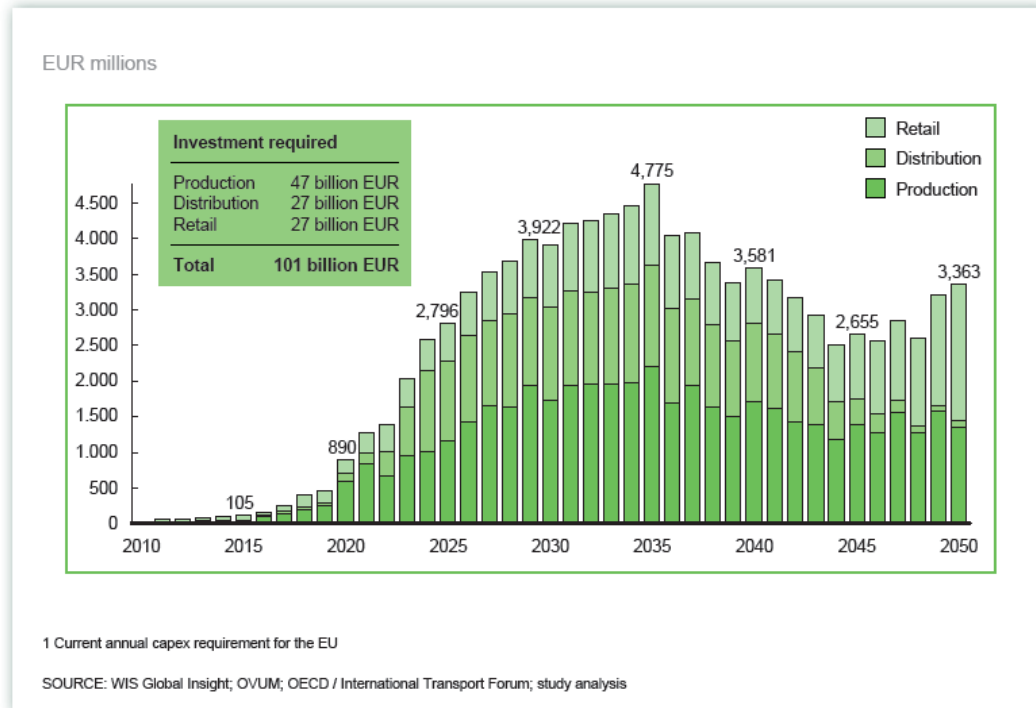


Exhibit 37: Total capital investment for a large-scale roll-out of hydrogen supply infrastructure in Europe is estimated at €100 billion over 40 years

Battery Electric Vehicles

“One to Few” or “Private” Infrastructure

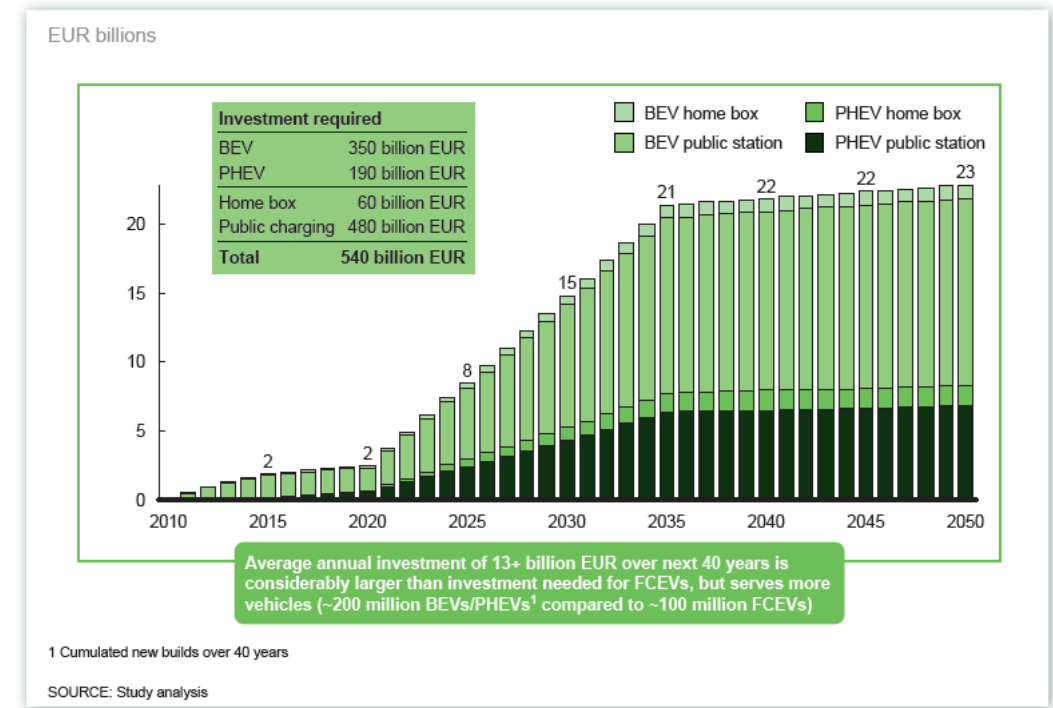
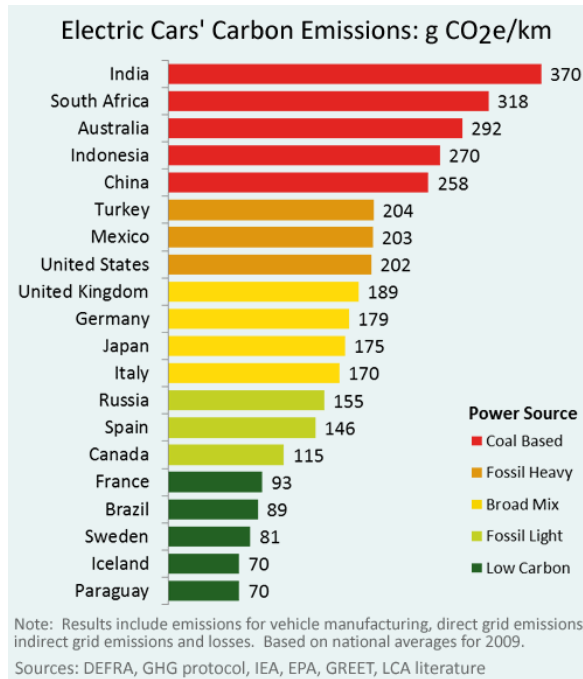


Exhibit 38: A large-scale roll-out of BEVs and PHEVs in Europe could require up to €500+ billion over the next 40 years



A view forward for India



Production of hydrogen from natural gas by reforming and its use in a fuel cell vehicle has the potential to save as much greenhouse gas emission as substituting coal by natural gas in power generation

European Joint Research Centre (JRC)
well-to-wheels report 2014

Parameter	Units	Diesel	BEV	FCEV
CO ₂ Emissions	gm/km	350	0	0
Range	km	>400	400	>400
TCO		Lower upfront higher running costs	Higher upfront lower running costs	Higher upfront lower running costs
Refuel Time	minutes	3 to 5	60 to 360	3 to 8

- FCEV are most suitable when addressing energy security, emissions and economics for India
- Fuel cells have already started competing with diesel engines when it comes to stationary backup power applications
- Investment will be needed to develop the infrastructure and ecosystem for hydrogen refuelling and fuel cell development & manufacturing in the near to medium term

Murali Arikara

Chief Technology Officer

murali.arikara@racanaa.com

Why Hydrogen Fuel Cells make sense

A fuel cell future for the Indian automotive market