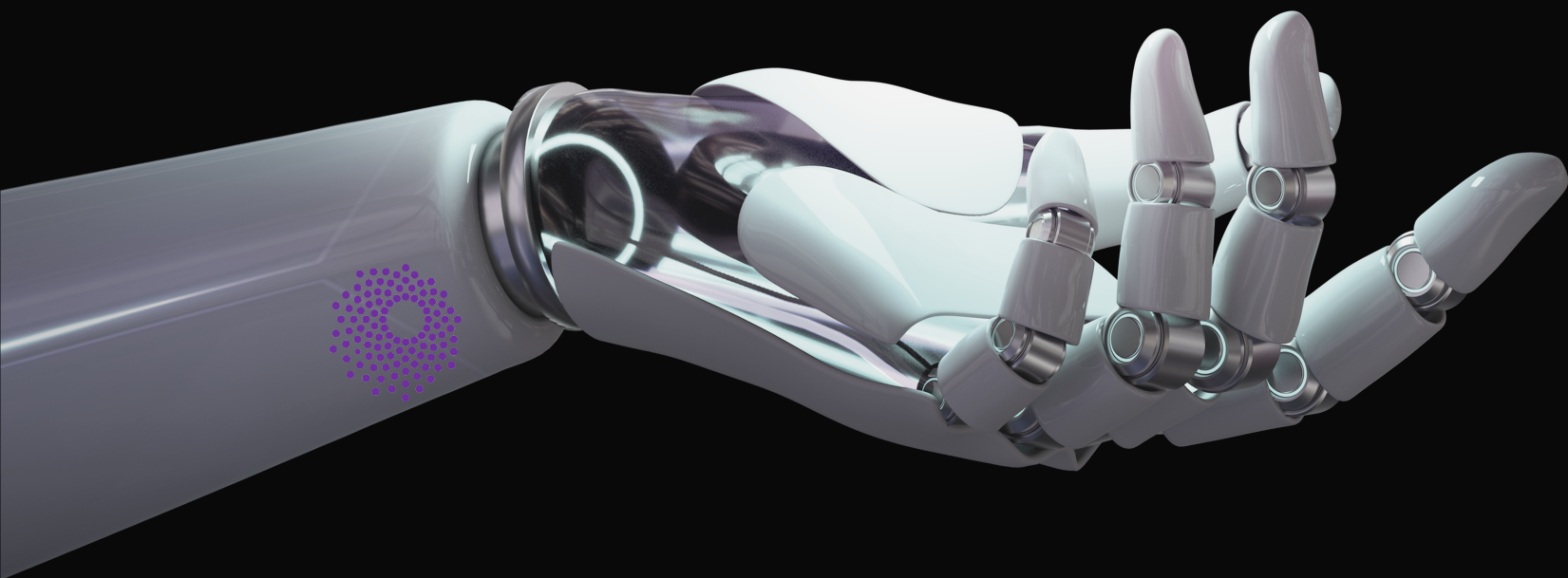


# CATALYSING INNOVATION

for

Building Coal2CNG infrastructure at scale to  
make India the largest producer of CNG  
globally



Concept sharing with the Leadership team of Coal India  
May 12, 2023



# To enable AtmaNirbhar Bharat

***There is no short cut for transformation of India to an Atma Nirbhar Bharat.***

*Radical transformation needs policy and government support. Innovation and investment cannot thrive in a regulatory vacuum. Money is a necessary - but not sufficient - condition for accessing technology. Whereas technology access is clearly the starting point for the transformation.*

*One of our mission drivers is the realisation that the global IIT alumni network can deliver technology solutions which no commercial player or incumbent can do.*

*The most striking example of this ability was the 800-bed Covid hospital in the NSCI Dome sports stadium in Mumbai, which treated 20,000 covid patients without single mortality and with just one doctor. The Rs 700+ cost of the Covid initiative was raised entirely from private sources and led to a mRNA vaccine candidate, an indigenous ventilator, mass produced disposable paper beds and new generation of sanitisers based on iodine.*

*Attaining Atma Nirbhar Bharat across the needed energy basket is our target in this project.*



”



**Ravi Sharma**  
President & Chief Volunteer

IIT Alumni Council  
Chief Volunteer  
Retired Corporate Leader  
Full-time Philanthropist

IIT Roorkee Distinguished Alumnus



# To catalyse a three way energy basket - coal, thorium, solar.

**Coal is a hydrocarbon with approx 3% hydrogen content. The methanogenesis process uses nutrients in an aqueous medium to produce methane (25% hydrogen content).**

*Underground methanogenesis of coal requires suitable micro-organisms, an appropriate nutrient system and a real time bio-reactor system based on hyperspectral imaging to manage production levels, conversion rate and methane concentration. An indicative cost of production for a typical underground coal mine would be Rs 16 per kg of CNG without taking into consideration the cost of servicing the infrastructure cost of Rs 9 crores per ton of CNG.*

*The Coal Task Force of the IIT Alumni Council has built upon the ten year work of Prof Prasad Durjoti, an alumnus of IIT Kanpur and faculty member of University of Delaware who passed on in 2020. His work was improved upon by the MegaLab team led by Dr Arindam Bose - who is a batchmate of Prof Durjoti and who retired as CTO of Pfizer. He led the original team which developed the mRNA vaccine.*

*The three key technology pieces - microbes, nutrients and monitoring - have been addressed through donor funded startups under the Engineered Biomolecule incubator initiative.*



”



**Satish Mehta**  
**Coal Task Force**

IIT Alumni Council  
Investment Banker  
Committed to helping solve  
hard problems

IIT Bombay Chemical Engineer  
Acharya PC Ray Award, 1987  
Technology Day Award, 2008  
IIT Alumni Life Fellow, 2020

**Russia's Gazprom is the largest producer of natural gas in Russia and the world in 2021. It was responsible for producing 515.6 billion cubic meters, which translates to 18.2 trillion cubic feet of natural gas. The company had revenues of \$137.71 billion in 2021 for approx 386 million tpa (USD 356 per ton or Rs 28.54 per kg translating to a landed price of Rs 45 per kg in India at 2021 pre Ukraine war prices).**

**If India were to optimally utilise its existing underground coal reserves using microbial conversion, it could produce more than 400 million tpa of gas annually. This would complete the Indian energy basket alongside thorium powered nuclear power and solar - to make India self sufficient.**

**The capital investment required to create this capacity would be an indicative USD 250 Billion or approx Rs 20,00,000 crores. If implemented over ten years - this would translate into an affordable Rs 200,000 crores per annum and yield an imports saving of Rs 36,00,000 crores\* in those ten years.**

**\*assuming Rs 45 per kg realisation Rs 9 crores per ton capcost for infrastructure.**



# Executive Summary

The Coal Technology Task Force conclusion is that commercialisation of the in-situ underground microbial methanation process was the only viable, scaleable and suitable technology to use the vast underground coal deposits of India.

One of the findings of the task force is that annual CNG imports would top USD 100 billion a year (at current levels of indigenous CNG production) to meet the demand from just four segments - fuel for public transport vehicles, piped cooking fuel, mission critical data centres and non solar hours power generation. The primary driver for electrification of transportation is the lower fuel cost per km even if electricity is generated onboard - using fossil fuel such as CNG - via internal combustion engines or fuel cells. The task force noted that a Maruti Ertiga CNG engine could power a full sized DTC bus leading to substantial saving in fuel consumption.

There is a need for a concerted national effort across public and private enterprises, which could lead to global leadership for India in the area of microbial conversion of underground coal directly into methane. This methane can complement biogas, directly mined natural gas and coal bed methane (CBM). CBM, by itself is undesirable for environmental reasons.

India already has substantial infrastructure to distribute CNG to all three key segments – power generation, transportation and cooking gas. The primary problem is the reliance on imported CNG, which has led to thousands of MW of gas-based power plants lying unused.

# Challenges with other options

It is very difficult for conventional hydrocarbon production processes to compete with anything natural. In theory any hydrocarbon can be made from carbon and hydrogen. As a result there is no dearth of vanity projects. A classic example is a swiss attempt to convert carbon dioxide from the atmosphere or from flu gases into aviation turbine fuel (essentially a form of kerosene). Indian R&D establishments like Netra too have experimented with this. The issue is the cost of generating pure carbon dioxide itself is more than the cost of the finished fuel produced by fractional distillation of crude oil. In fact production of hydrocarbons from syngas which is derived from coal are similar. In our estimate the total cost of producing CNG from partial oxidation of coal at current prices would exceed Rs 100 per kg.

Another widely touted option is coal bed methane. Over hundreds of thousands of years, some combination of thermal conditions and pressures OR bacterial activity have led to the formation of methane in coal seams. Because of recent advances in fracking technology in USA - there is considerable progress in the ability to simulate the coal seams and then to accurately cut through the seams of coal to collect the gas. This conversion has helped USA become a net exporter of gas and a leading producer globally. The challenge however with CBM is the need to pump water into the coal seams to push the gas out. Often this is done with sea water to preserve fresh water sources. This leads to contamination of ground water and the land all around the CBM mine could become arid.

CBM can supplement microbial conversion without the environmental side effects or the need to pump water into the mine.

# Presentation Objectives

- 1 The core objective of this presentation is to get the buy-in of all stakeholders in India to support a technology development initiative which has the potential of saving Rs 80 lac crores (USD 1 trillion) in forex over its useful life.
- 2 The IIT Alumni Council is catalysing a large technology development program built around funding requisite startups. This will facilitate the indigenous development of three key technologies: characterisation and culturing of the microbes required for the conversion, development of cost effective nutrients to support the self propagating microbial colonies and hyperspectral imaging in-situ to track and monitor the bioreactors carved into the underground coal seams.
- 3 Being an introductory presentation, the slides are configured to address the macro business issues. This is not a technology presentation.
- 4 The target outcome from this presentation is support and suggestions for bringing these projects to life as early as possible.



# Financial Overview

## Mining Automation

**Mining Capacity:** 10 million tons pa

**Operation:** 24/7, 365 days

**Workflow:** Underground drilling to create bioreactors where in-situ coal is used to produce methane based on nutrient feed from the ground level.

**Automation:** Completely autonomous operation

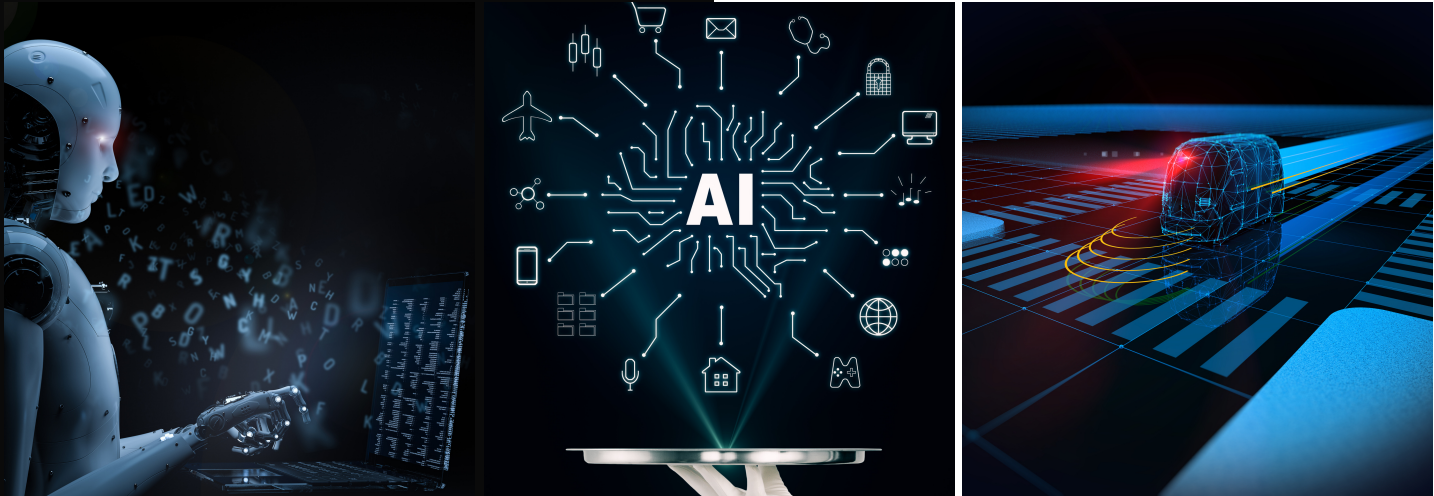
**Surveillance:** Hyperspectral imaging of the bioreactors to continuously monitor microbial density and conversion rates for the purpose of nutrient feed regulation.

**Capital cost estimate:** Rs 30,000 crores for drilling to create the initial bioreactor capacity. This is only the initial drilling cost

**Total number of mine locations:** Twenty with each mine having a capacity of 0.5 million tpa.

**Useful life of mine:** Ten years with one year gestation between bioreactor creation and start of production.





# Biomethanation

|                       |                                                                       |
|-----------------------|-----------------------------------------------------------------------|
| Methane capacity      | 0.5 million tpa per mine<br>(on 100% methane basis)                   |
| Total mine heads      | 20                                                                    |
| Annual production     | 10 million tons                                                       |
| Distribution          | Compressed gas pipeline<br>or cylinders                               |
| Alternate use         | Excess gas fed into 75 MW gas<br>engines for power generation         |
| Expected gas revenue  | Rs 450 Billion (Rs 45K crores) pa                                     |
| Capital cost estimate | Rs 60,000 crores.* (excludes<br>drilling capcost of Rs 30K<br>crores) |

# Thermolyser Fuel Cell

|                     |                                   |
|---------------------|-----------------------------------|
| Power capacity      | 75 KW to 75 MW                    |
| Annual production   | 10 GW at Rs 15/W                  |
| Expected revenue    | Rs 150 billion (Rs 15,000 crores) |
| Technology dev cost | Rs 500 crores*                    |

*\*subject to detailed project report final findings. Figures are indicative and tentative*



# India Coal Overview

Coal is the primary fossil fuel of India and constitutes 55% of India's energy basket.

Coal-based power generation accounts for around 70% of electricity produced in India.

Coal is abundant, available and affordable.

About 85% of India's coal is made by Coal India, a listed corporate controlled by the Government of India under the Coal Ministry.

Coal India produces around 600 million tpa of coal, a lot of it is high ash and low calorific value.

Overburden removal is around 2x the coal output. Surface miners account for an indicative 50% of the production.

Around 95% of output is from open pit mines.

Coal India plans to substitute the 200+ mtpa import through mine developers and operators who would produce 160+ mtpa.

Coal prices in India are among the lowest in the world. So is the cost of production.

As a result, Coal India makes an annual profit of over USD 2 billion.





Capacity expansion projects with a total outlay of over Rs 100,000 crores are underway.

Annual revenue net of taxes is around Rs 100,000 crores – and over 50% of the costs are manpower costs.

Contracting and outsourcing costs are around 33% of the direct manpower cost.

CIL has about 250,000 blue collar staff and nearly 15,000 officers.

Annual reduction is an indicative 5% pa.





## Strategic Imperatives

Increase production and reduce imports through the use of four basic concepts:

Conversion of underground coal deposits into methane using microbial conversion. Autonomous bioreactor management on a 24/7 basis using hyperspectral imaging and deep learning. (disruptive innovation)

Onboard conversion of methane into hydrogen using thermolysis of water using CNG as a fuel. (disruptive innovation)

Electrification of drive trains in public vehicles. This helps realise the benefits of electrification without the need for electric charging points and the downtime taken by charging. (already existing technology)

Production of hydrogen from CNG using reforming at hydrogen filling and production centres. (already existing technology)





**Total Capcost  
Estimate**                      Rs 90,000  
crores

**Implementation  
Time**                              48 months

**Annual Import  
Substitution**                      Rs 45,000  
crores





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## Climate Change Objective

To replace gasoline in transportation, coal in power generation, LPG in cooking gas and diesel generators in data centres.



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## Production Objective

To monetise unused underground mines.

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## Technology Objective

To produce CNG indigenously from unmined underground coal by microbial conversion.





# Biomethanation



CIL has several underground coal mines which are either unviable or out of service for other reasons.

There are over 200 such mines in India.

These mines have rich coal reserves, which are difficult to excavate and bring to the surface.

In areas like Meghalaya, rat hole mining has been banned for various reasons, including the risk to the miners.





India has an established end to end ecosystem for compressed natural gas. However, India is a large importer of natural gas for a variety of applications -from transportation to power generation to fertiliser production. Natural gas can also be feedstock for hydrogen production.

The IIT Alumni Council's engineered biomolecule incubator has developed bacteria-based enzymatic solutions which can convert underground coal into methane.

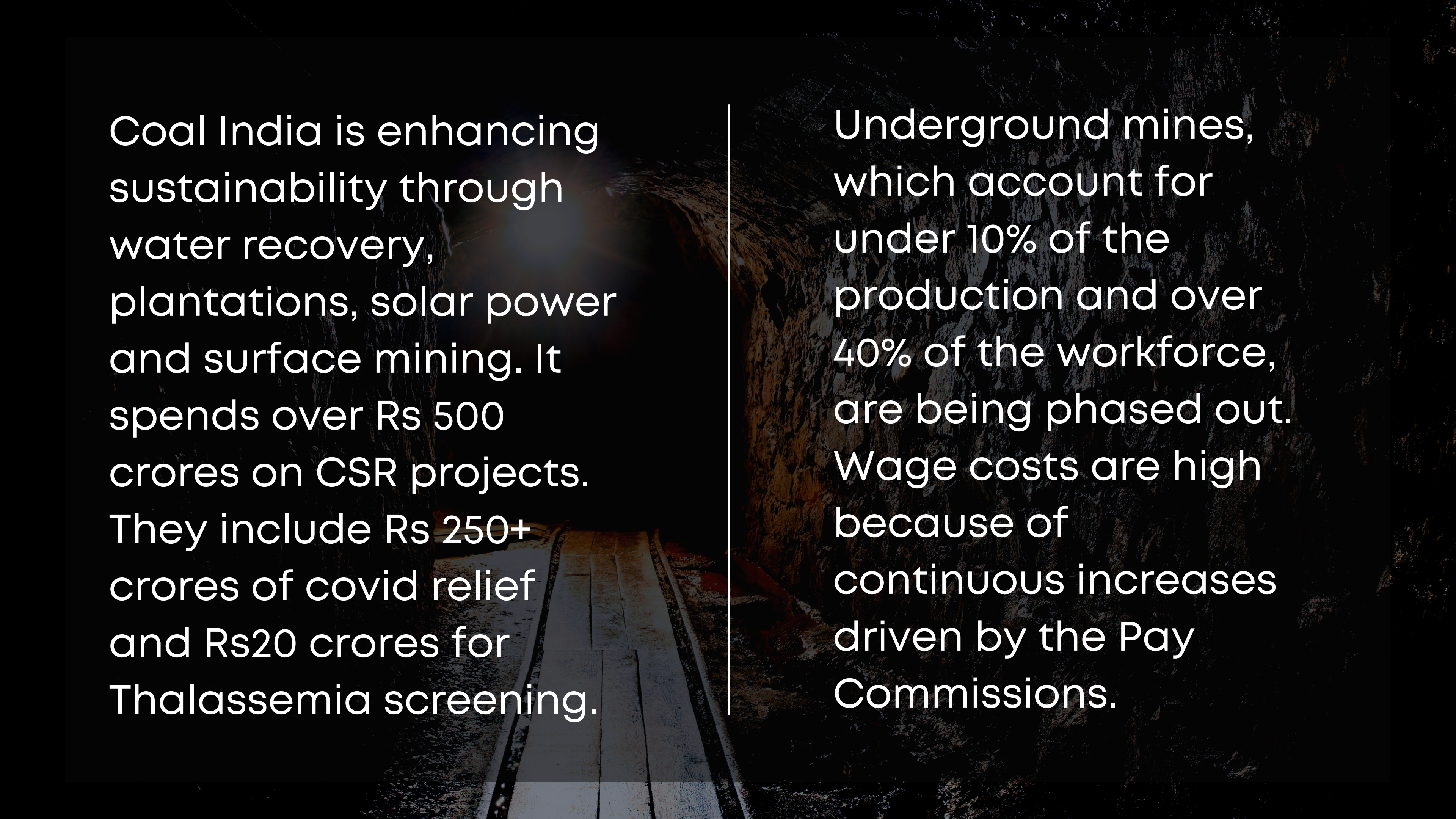
This methane can be pumped out and used as a CNG replacement. Using a local gas turbine or engine, the CNG can also be used for superheating or power generation applications.





# Sustainability Overview





Coal India is enhancing sustainability through water recovery, plantations, solar power and surface mining. It spends over Rs 500 crores on CSR projects. They include Rs 250+ crores of covid relief and Rs20 crores for Thalassemia screening.

Underground mines, which account for under 10% of the production and over 40% of the workforce, are being phased out. Wage costs are high because of continuous increases driven by the Pay Commissions.



In order to pivot focus onto the blue economy and green chemistry paradigms, the MegaLab initiative which has developed significant competencies in the creation and propagation of micro-organisms was brought into the project.

This helped to view the problem from the lens of biotechnology rather than from a thermochemical perspective.





# Challenge 1

Global leadership in microbial conversion of coal.

The bulk of India's coal is now produced from open pit mining. India a large importer of coal for two reasons - insufficient production and poor quality of domestic coal.

The production issue can be solved by increasing production from existing and new open pit mines.

The unmined underground coal can be used by converting the same into CNG by microbial conversion. There is no proven existing player in this field. The underlying science of microbe amplification and genetic alteration is now well understood.

India has little chance for global leadership in highly automated open pit mining. However, global leadership is possible in creation of underground bioreactors which are created using advanced methodologies used in fracking and the coal bed methane industry.



## Challenge 2

Domestic coal needs upgradation of calorific value.

India is a net importer of coal to meet demand from existing users. It would thus not be advisable to divert existing or proposed/ work in progress open pit mining capacity for CNG production.

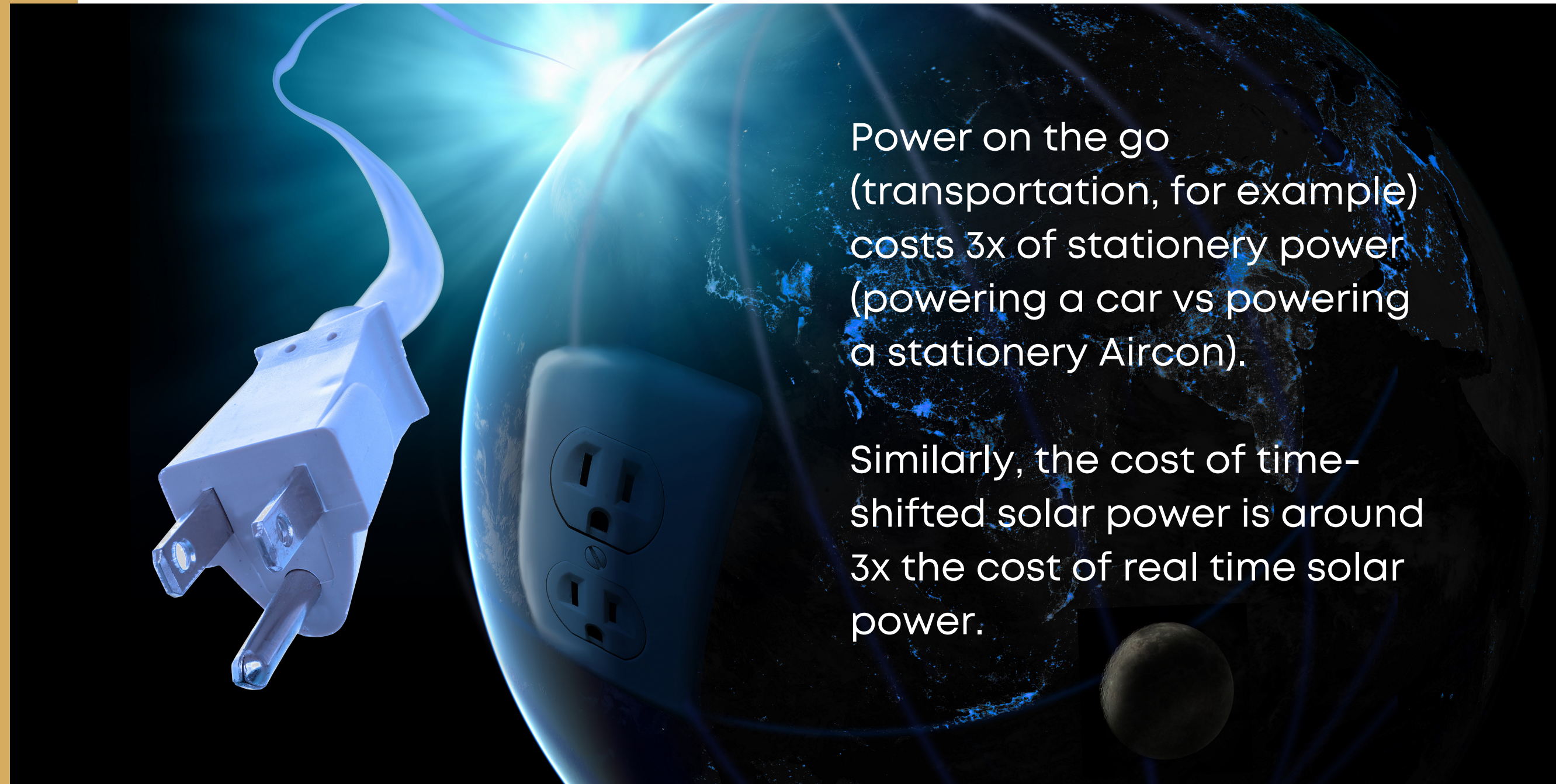
Indian coal is of poor quality in terms of calorific value. Thus the challenge is to replace imported coal by increasing the calorific value of Indian coal complementing it with CNG.

This approach could take the calorific value of the coal to match the best quality imported coal (and at a substantially lower cost)



## Challenge 3

Peak power and base load power continue to be a challenge



Power on the go (transportation, for example) costs 3x of stationery power (powering a car vs powering a stationery Aircon).

Similarly, the cost of time-shifted solar power is around 3x the cost of real time solar power.



## Challenge 4

Global warming and electrification are leading to new challenges.

GDP growth in India will lead to an improvement in quality of life which in turn will lead to higher energy requirement per capita. The energy mix is shifting towards electricity. A large chunk of this electricity demand could be met by rooftop solar.

Telecommunications and the electrification of transportation will lead to new demand profiles. Global warming will increase power consumption for air conditioning. This would put new kinds of pressure on the electric grid.

The fastest growing energy needs are transportation, Aircon and cooking fuel. The cost of batteries (and import requirements for lithium and cobalt) and peculiar needs of Indian cooking have made it challenging to replace gas-fired, flame-based cooking systems with electric/ induction systems.



## Challenge 5

Hydrogen is not yet there and batteries need more development.

The universal fuel emerging is electricity. But not yet for transportation and cooking. Batteries need to be made cost effective and produced at 10x or 100x current volumes.

The raw material supply chain is a challenge, and new chemistries like lanthanide are still in development. H<sub>2</sub> is still futuristic. Interestingly, most of the world's hydrogen is produced from methane / CNG





# The conclusions

- 1 Coal is a hydrocarbon and not just carbon.
- 2 The reality is that we do not have wind, crude oil, natural gas or lithium/cobalt. We only have solar and coal.
- 3 We need at least three energy sources – electricity, CNG and kerosene – besides solar.
- 4 In the absence of crude oil, possible sources for kerosene (C10 to C14) could be a direct conversion from coal or conversion from carbon dioxide and methane or conversion from carbon dioxide and water.
- 5 The bio-methanation process has direct applications for several other raw materials, including biomass.



# Conclusion 1

Coal is a hydrocarbon and not just carbon.

Indian coal is low in calorific value but is ideal for in-situ bio-methanation in underground mines.

India has the biotech ability to manage the micro-organism cultures and the skills in hyperspectral imaging to use long wave infrared based imaging to track the methane from the ground level.





## Conclusion 2

The reality is that we do not have wind, crude oil, natural gas or lithium/cobalt. We only have solar and coal.

The only way to navigate the expected increase in energy needs and the shift in energy mix towards electricity is to strengthen rooftop solar and produce CNG and liquid fuels from coal.

India has tens of billions of tons of underground coal, which will, in all probability, never be mined using conventional mining techniques – whether manned or autonomous.

These offer the most attractive raw material possibilities for in-situ bio-methanation



## Conclusion 3

We need at least three energy sources – electricity, CNG and kerosene – besides solar.

Electricity could cater to growth in air-conditioning and industry. CNG can drive transportation and cooking gas. Kerosene can drive aviation and shipping.

The last couple of decades has seen substantial shifts in natural gas production. Prime examples are the shale revolution in USA and coal bed methane in Australia. Both countries now export more gas than Qatar.

Hydrogen, as and when required to meet demand, can be generated from renewables or CNG using hydrogen production with carbon sequestration.

At some stage, hydrogen could power fuel cells for demand-responsive power generation.

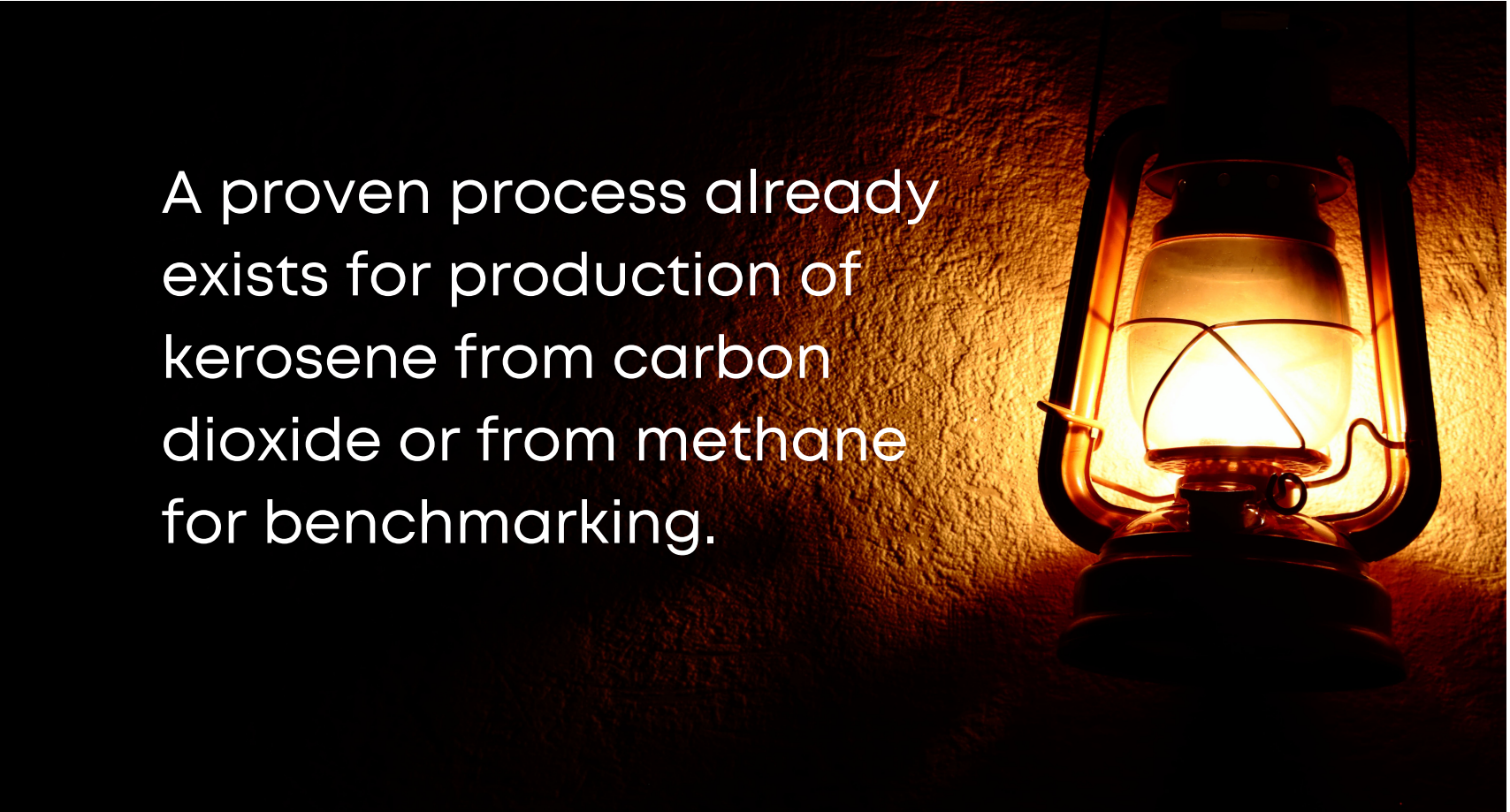


## Conclusion 4

In the absence of crude oil, possible sources for kerosene (C10 to C14) could be direct conversion from coal or conversion from carbon dioxide and methane or conversion from carbon dioxide and water.

All three options involve syngas as an intermediate product. The Reliance plant already converts 5 million tpa of petroleum coke into syngas using broadly indigenous technologies.

The high temperature process for direct production of syngas from carbon dioxide and water seems to hold promise. But bioconversion is cheaper and far more efficient. It is also greener.

A glowing lantern with a warm, yellow light emanating from its glass chimney. The lantern is positioned on the right side of the image, casting a soft glow on the textured, slightly mottled wall behind it. The background is dark, making the light from the lantern stand out.

A proven process already exists for production of kerosene from carbon dioxide or from methane for benchmarking.



## Conclusion 5

The bio-methanation process has direct applications for several other raw materials including biomass.

The production of ethanol from cellulosic waste has not been commercially successful anywhere in the world, even though billions of dollars have been invested in the sector.

The bio-methanation process has been adequately proven with coal on the surface. It needs to be extended to an underground coal mine for in-situ production.



The Investment committee team found five specific opportunities in existing national and global policy gaps which could be exploited to national benefit.

- 1 Methane instead of ethanol, methanol and hydrogen
- 2 Extending bioconversion
- 3 Zero emission methane to hydrogen
- 4 Hybrid in place of battery only electric vehicles
- 5 Kerosene in place of other liquid fossil fuels

In addition the team  
found five other  
peripheral opportunities:

- 1 Hyperspectral imaging for  
bioconversion enhancement
- 2 Underground gas storage for  
continued methanation
- 3 Fuel cells for power generation using  
low cost electrodes
- 4 Telecom approach to CNG pipelines
- 5 Using nuclear forces for high quality  
heat production



# Opportunity 1

Methane instead of ethanol, methanol and hydrogen

Methane is a smaller molecule compared to ethanol and methanol. Whilst methane cannot be used to blend with liquid fuels like petrol, it is far easier to produce.

Fuels like petrol are themselves on the way out and therefore it may not make long term commercial sense to invest in ethanol production capacity.

The other source of ethanol is food material such as grain or molasses - all of which involve diverting food material towards ethanol production.

Hydrogen can be manufactured from water by electrolysis using renewable energy such as solar panels. However, this is currently not yet cost effective.

**Compelling argument: Methane has higher calorific value than ethanol or methanol.  
And is heavier than hydrogen.**

Methane instead of ethanol, methanol and hydrogen ...

The primary superiority of methane stems from the fact that there are multiple sources and multiple pathways to get to methane. At the most fundamental level, it is found in oil wells to be used directly as CNG or converted into LNG for transportation.

For over four decades, India has been pursuing a program to produce biogas from organic waste.

Methane can also be produced from carbon dioxide and hydrogen using methanation bacteria supplemented by electric power or thermal energy. It is also possible to produce methane from underground coal deposits by in-situ bio-methanation.

It is important to note that adequate infrastructure already exists in India for the distribution of CNG/ methane for applications such as transportation fuel and cooking gas.

A spate of recent regulatory changes pertaining to licensing for retail and paradigms for transportation through pipelines have made the sector attractive for investors.



# Opportunity 2

## Extending bioconversion

Once the process for bio-methanation is proven, it can almost completely replace thermochemical conversion in a wide range of applications. The top five applications for bioconversion could be:

- Biomass /cellulosic or organic waste to methane
- Power from renewable sources to methane for storing hydrogen
- Fertiliser production as a replacement for high temperature high, pressure processes for the production of ammonia/ urea
- Electro synthesis based applications where conversion energy is provided by electrolysis type systems to alter yield and rate of production
- Carbon sequestration and removal of greenhouse gases from the atmosphere

# Opportunity 3

Zero emission  
methane to  
hydrogen

Most conversion processes to extract hydrogen from methane such as steam reforming will yield carbonaceous by products like carbon monoxide or carbon dioxide. These have the potential to damage noble metal types of fuel cells such as PEM fuel cells.

There have been several innovative approaches to extracting hydrogen such that carbon gets sequestered.

One such approach is to use a liquid metal molten nickel and bismuth so that the surface area available does not reduce as carbon sequestration proceeds = and the collected carbon floats on the metal for removal.

The use of liquid metal forces deployment of high temperature conditions.



Zero emission methane to hydrogen...

Emerging bioconversion paradigms could enable two way reactions - production of hydrogen by cracking hydrocarbons or just water on one side - and the production of hydrocarbons from hydrogen.

The conventional heat of combustion approach does seem to be a limiter for many real world reactions - though yield and rate of production will continue to be challenges, to be overcome.



# Opportunity 4

Hybrid in place of  
battery-only electric  
vehicles

Electric drivetrains are far more efficient than internal combustion engine based transportation.

However a full electric drivetrain will need onboard battery capacity proportional to the range in addition to needing charging infrastructure and downtime for the charging.

The best social return is from public vehicles such as taxis, trucks and buses since they clock substantial average kilometres per day compared to private vehicles.

The current cost of lithium cobalt batteries is an indicative USD 200+ per KWH. Even if we were to build the battery manufacturing capacity in India, we would be dependent on imported raw materials.



The largest component of capital cost are the batteries. And in any case, because most of our power is coal derived, charging is not going to be based on green power.

Rooftop solar have not yet taken off in a big way. For use cases like intercity buses and trucks, charging downtime is a drain on transport capacity per annum.

Thus the best option for India till the hydrogen economy takes off is to use electric vehicles with onboard charging infrastructure based on CNG.

India already has the ability to manufacture some of the worlds most cost effective small engines powered by CNG.

To give an example, a bus carrying 30 passengers in airconditioned comfort can be charged by a CNG engine from Maruti similar to the one used by the Ertiga car (40 KW continuous charging).



In terms of fuel efficiency, it would imply that a passenger bus would consume the same amount of CNG as an Ertiga car (which typically seats six passengers).

Because the battery pack is smaller, the capital cost and dead weight would be substantially lower than a full electric bus



# Opportunity 5

Nuclear in place of  
other liquid fossil  
fuels

There is no known way to fuel aircraft and ships with renewable power. A fully electric or solar option does not currently exist. Planes currently use a form of kerosene as their primary fuel. This is supplemented by Nickel-cadmium batteries (which are carcinogenic but do not cause fires). Ships are unlikely to have charging stations on the high seas.

There is thus no escape from fossil fuels for these two categories in transportation. In addition, electric heating has not found much favour with Indian homemakers who prefer a naked flame for their cooking (think brinjal bharta and fresh chapattis).

Nuclear based on thorium is an excellent medium term solution. This would be especially useful for underwater mining and other underwater applications.

# Peripheral opportunity 1

Hyperspectral imaging  
for bioconversion  
enhancement

The primary challenges in bioconversion are yield and rate of production.

These could vary substantially depending on the type of fossil deposit. The historical challenge has thus been the methodology to characterise the deposit.

Breakthrough technologies such as hyperspectral imaging can now facilitate real time tracking of underground coal seams.

Underground robotic cameras could complement these to create a digital twin of the deposit.

Similar approaches have been used successfully for shale gas in the USA. And can be used in India.



## Peripheral opportunity 2

Underground gas  
storage for continued  
methanation

Underground reservoirs have been used for almost a century to store gas. These could be unused mines, depleted gas wells, water aquifers or salt caverns.

Many of these gas storage options will continue to be used to store gas for time shifted delivery or simply for storage.

As electricity markets shift to rooftop solar and geothermal, the utility grids will primarily be used for load balancing, peak load and nighttime use.

The electricity grid will thus need to be far more responsive to demand changes. This will necessitate a smart generation which closely follows demand changes.

Such generation is possible by using gas engines with highly variable output levels and fuel cell based systems.

# Peripheral opportunity 3

Fuel cells for power  
generation using low  
cost electrodes

Current fuel cell technologies rely on hydrogen as the primary fuel and platinum as the primary electrode material. Platinum is susceptible to poisoning by carbon.

Several approaches are currently being tried, including ammonia based fuel cells and esoteric methods wherein the fuel cell absorbs carbon dioxide.

None of the alternate approaches has been successful commercially as yet. At the same time, large volumes for PEM-type fuel cells have led to a reduction in cost for a large variety of applications, from onboard power generation in transportation to drones and mainline power generation.

The next expected innovation in fuel cells is de Nuvo electrodes, which have a much lower capital cost and may work reliably using CNG as the primary fuel. Some early movers like BloomEnergy already produce over 2 GW of power in mission-critical applications like Data Centres using CNG as the primary fuel.



# Peripheral opportunity 4

CNG thermolysers  
for green hydrogen  
production

Over the last few decades, several policy frameworks have emerged for production of green energy. Various projects range from using solar electricity to drive electrolysis at one end of the spectrum to producing hydrogen from methane.

The most economic way to produce green hydrogen is to split water by thermolysis using heat generated by nuclear fission or fusion.

Thermolysers do not have any moving parts. Similarly fuel cells do not have any moving parts. A thermolyser requires water as fuel and some source of heat.

The source of heat can be solar thermal, lasers, CNG or nuclear.

Thermolysis generates 100% carbon free hydrogen. The chances of contaminating the noble metals in the fuel cell are minimal even if we use CNG as the energy source.

This is a far better approach than generating hydrogen from the CNG

# Peripheral opportunity 5

Using nuclear forces for  
high quality heat  
production

Almost all processes which involve the conversion of greenhouse gases to usable hydrocarbons need a large amount of energy in the form of high quality heat.

This heat needs to be produced cost effectively as waste heat is rarely of the desired quality.

One approach to do that is to use concentrated solar thermal assisted by nuclear heaters based on thorium fuel abundantly available in India.

Thorium-based reactors can be produced in very compact forms, do not produce nuclear grade uranium as a by-product, have lower half life and do not have the risk associated with conventional nuclear reactors. In the last decade, driven by funding by foundations, substantial progress has been made.

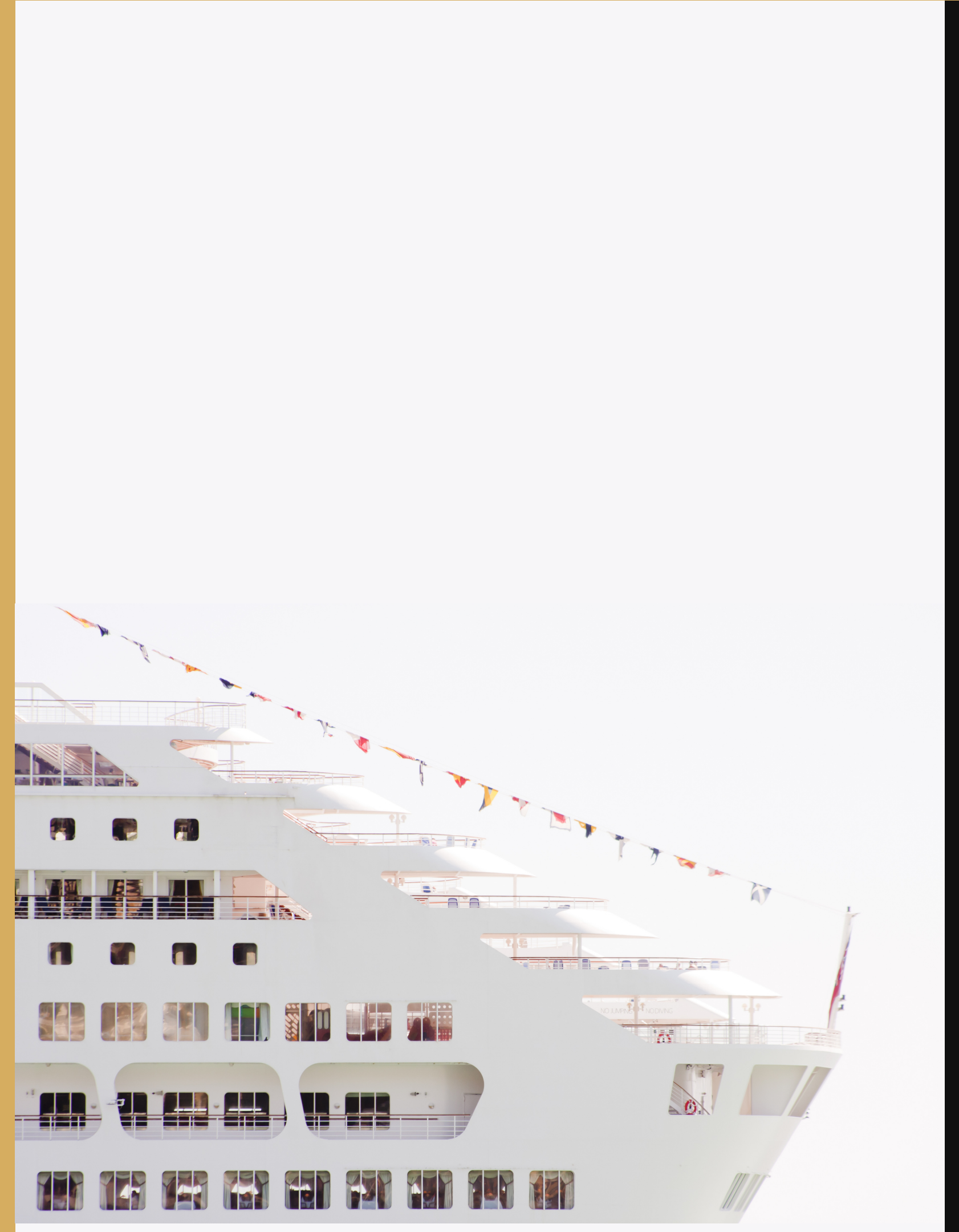


Our reliance on imported CNG will be a colossal forex bleed.

If we restrict crude oil imports to existing levels or lower levels, we will need to import kerosene for aviation and shipping.

A disruptive plan along the lines of that proposed will need an ecosystem approach for global leadership.

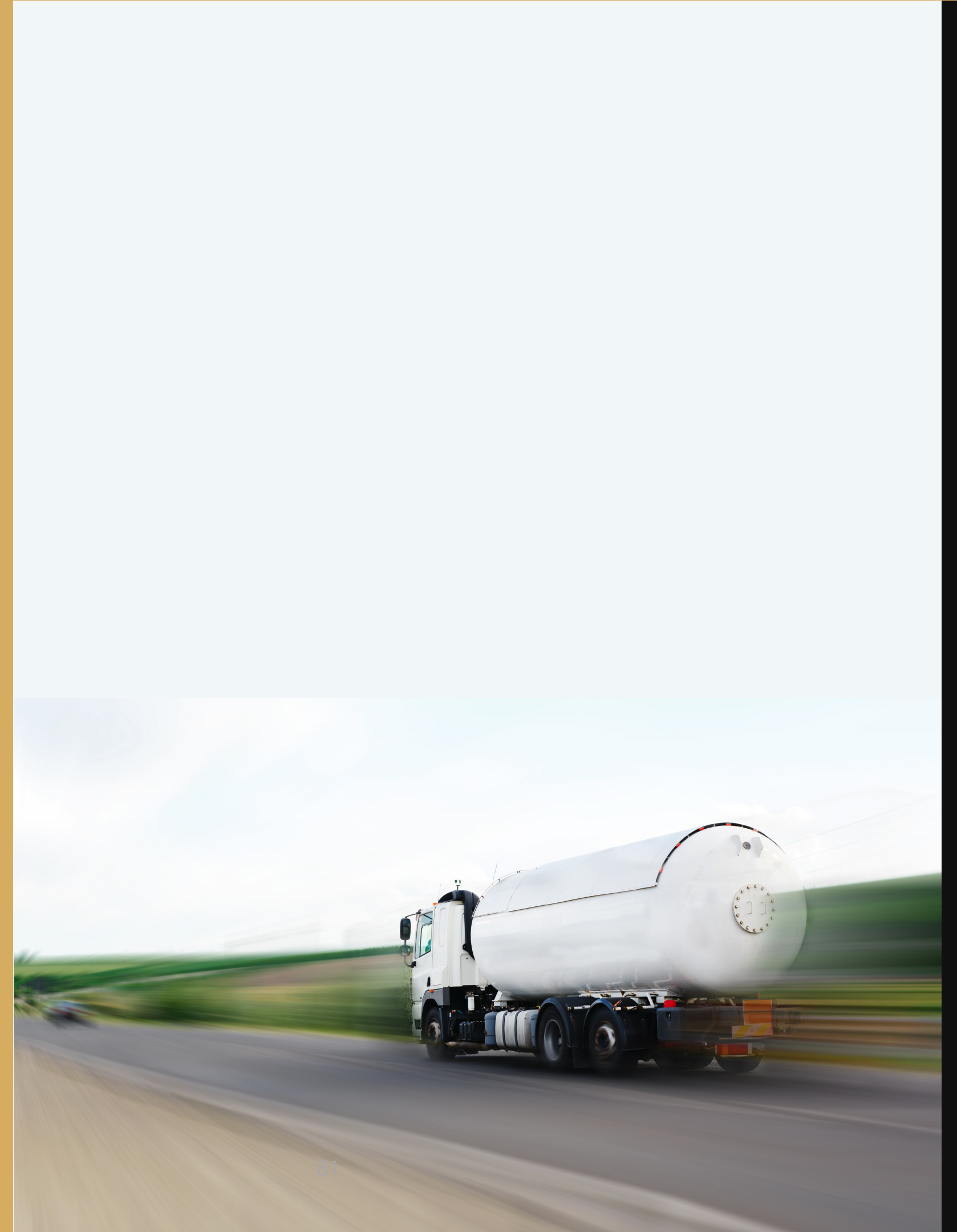
This requires a collaborative framework, suitable public policy, supporting regulations and



In the absence of an initiative such as the proposed one, we will end up relying on imported CNG to meet our need for clean fuel to supplement renewables.

The methane proposed to be produced will be ready for use as a CNG replacement for baseload/ peak load power generation, transportation fuel (for IC and hybrid electric public vehicles) and piped cooking gas.

The thermolyser fuel cell approach can radically improvise on the design for electric vehicles which will now need 90% lower capacity of batteries. This would make electric vehicles viable without subsidy.





Once the project meets all its objectives,

India will be able to reduce its dependence on imported crude /petroleum products for use in power generation, transportation fuel and cooking gas.



In keeping with our approach, we would like to include as many entities as possible in the project on both – the supply side, intermediation side as well as on demand side.

On the supply side, these include underground coal mine concession owners, microorganism developers and equipment suppliers.

On the demand side, all user segments, especially power generators.

On the intermediate side, transmission pipeline companies, retail distributors and local piped gas delivery entities.

