

Technology developments and deployment for net zero transition in the energy sector: One perspective

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Net zero goal – various carbon neutrality pathways

Pathways for carbon neutrality

Minimize CO₂ generation

- Energy efficiency (all sectors)
- Renewable energy (RE)
- RE storage
- Circular economy
- Green H₂

Maximize C-neutral feed-stocks

- Biomass
- MSW organics
- ETP sludge
- Other organic waste
- On purpose algae production, etc.

Fixation of carbon

- Chemicals and materials
- Carbon capture and utilization
- Carbon capture and storage
- Nature based solutions

Aim of new **green** technology development is to reduce green premium relative to fossil-based technologies used today

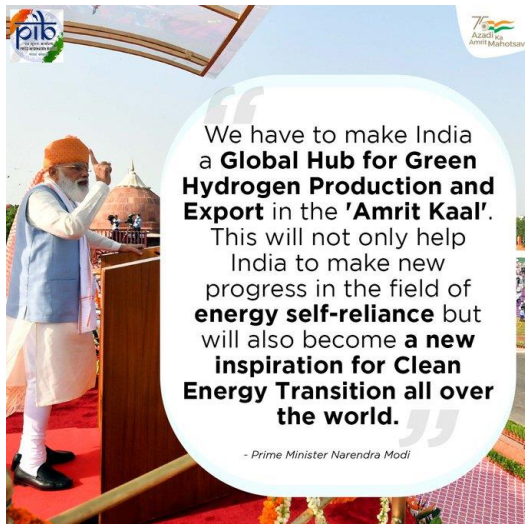
Regions with lower GDP/ capita and overdependence on fossil fuels will need to spend > 10% of GDP/ yr – McKinsey

Multitude of options for collaboration with aim to minimize green premium



'Net Zero' initiatives by the Indian government

Government has set a target of 450 GW power from renewable energy by 2030



We have to make India a **Global Hub for Green Hydrogen Production and Export** in the 'Amrit Kaal'. This will not only help India to make new progress in the field of **energy self-reliance** but will also become a **new inspiration for Clean Energy Transition all over the world.**

- Prime Minister Narendra Modi

Renewable electricity in India

- Capacity target end of 2022 is 175 GW renewable electricity
- PV is 100 GW
- Wind is 60 GW
- Today we are at 115 GW
- Pollution reduces PV output by ~ 25% (IIT study)
- Capacity factor ~ 20%
- **Net intermittent electricity delivered <10%**

National hydrogen mission

- IOCL and GAIL doing **blending hydrogen with CNG**
- India is eyeing **exports of green ammonia** to developed economies



Bio-CNG, Bio-ethanol, Biodiesel

- Bio-CNG plant inaugurated in Indore – biggest in Asia
- 20% bio-ethanol blending established for transport fuels by 2026

C trading scheme being developed

Solar Wind Batteries (SWB)



National solar mission

Promote domestic manufacturing for attaining 280 GW by 2030

- **PLI for solar photovoltaics** production to promote self reliance



Wind energy mission

Raise wind power generation to 60,000 MW by 2022 end



Batteries

2.4 Billion \$ **PLI scheme** launched for large scale indigenous Li-ion battery manufacture



Hydro-electric

India is 5th globally in **hydroelectric power generation**

- Pumped water storage (PHS) has provided surplus power

GOI's initiatives are reducing energy imports and progressing decarbonization



New Reliance for new India

- Reliance will provide **end-to-end** green energy solutions, at an affordable rate
- Established the Reliance New Energy council
- Announced **\$10 bn capex** commitment over 3 years
- Plans to partner with the best technologies across the energy value chain
- Begin work on **4 new Giga factories** at Dhirubhai Ambani Green Energy Giga complex
- Green ecosystem for SMEs – Invest Rs 5.95 Lakh Cr in Gujarat over 10-15 years



LithiumWerks



Partnerships

- **Batteries:** Ambri, Faradion, Lithium werks, REC
- **Silicon wafer:** Nexwafe (Germany)
- Picked up 40% stake in Sterling and Wilson renewable energy company
- Partner with Denmark's Stiesdal for next gen electrolyzer technology

Stiesdal



“Over the next 12 months our investments across the Green Energy value chain will gradually start going live, scaling up over the next couple of years. This new growth engine holds great promise to outshine all our existing growth engines in just 5-7 years”

— MUKESH AMBANI | CHAIRMAN, RIL

New energy and new materials business may outperform other growth engines in 5-7 years

Green India Initiative – Announced 4 Giga Factories :

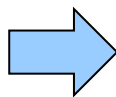
(1) Solar PV, (2) Batteries, (3) Fuel cells (4) Green H₂ through H₂O electrolysis with RE

Reliance Industries will become Net Zero by 2035



Reliance's biomass catalytic gasification for green hydrogen

Biomass/agri residue



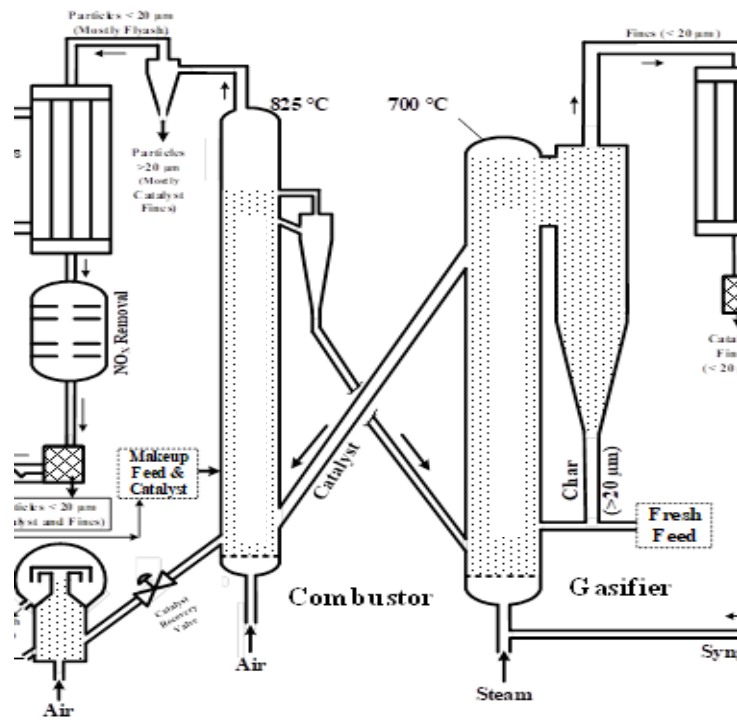
Invented novel migratory solid-solid catalysis

Confident to achieve zero green premium

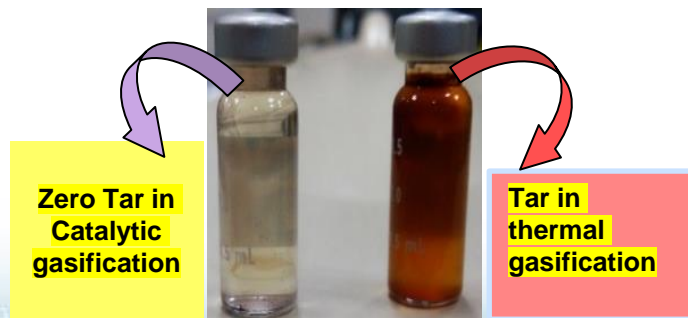
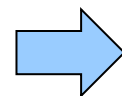
- Gasification of biomass below 750 °C
- Solid-solid catalysis
- **High H₂ % in syngas H₂:CO (> 2.5:1)**
-15-20% higher heating value versus thermal

gasification

- High reliability and scalability
- **40% lower capex and 40% lower opex** than conventional gasification



Green hydrogen



RIL's catalytic biomass gasification for surplus agri-residue will produce green hydrogen



Reliance's RCAT-HTL provides the best economics for waste biomass processing

	Bio-CNG	2G Bio-Ethanol	Biomass incineration to electricity	RCAT-HTL	Bio-oil = Green oil	
					Electricity / heat	Transportation fuels (SAF)
Products	BioCNG, 80% residue	EtOH, Gas, 60% residue	Electricity 40% residue	Bio-oil 5% residue	 RCAT-HTL bio-oil benefits	
Thermal efficiency	48% (18% to electricity)	34%	18%	70% for MSW, Algae 50% for rice straw and ETP sludge	<ul style="list-style-type: none"> Economically most attractive – Bio-oil at ~ \$50/ bbl Feed flexibility; Easy integration of bio-oil into refineries For a resource poor country, we have to be more resource efficient to produce maximum energy 	
Main product (in kg) / MT of feed	169	190	NA	500		
Capex, M\$	36	100	5	66		
Subsidy (cents/MJ)	0.5	3	1.6	- 0.5		
Challenges	Microbes cannot handle plastics contamination	Lignin disposal, low conversion, water disposal	Pollutants, Inefficient for unsegregated waste	High feed flexibility, energy dense drop-in-biofuel	Basis : Feed - 500 TPD dry paddy straw; 4 year payout on all projects Economics of RCAT_HTL assumes tipping fee of 10 \$/ton	

Bio-oil from RCAT-HTL no green premium



Organic waste to bio-oil, cheapest long duration GWhr stored energy to electricity

Region	Countries	MSW Collection %	Moisture in MSW	Tipping Fees, USD/ton	Typical LCOS (\$/KWh)
High Income countries	US, Canada, Australia, Western EU, Nordics, Japan	96%	21%	\$ 50-85/ ton	-0.06 to -0.18
Upper-middle income countries	China, Russia, South Africa, Brazil	82%	35%	\$ 15-40/ ton	-0.03 to +0.05
Lower-middle income countries	India, Pakistan, Bangladesh, Sri Lanka, Nigeria	51%	35%	\$ 9 – 20/ ton	+0.05 to +0.08
Low-income countries	Sub- Saharan Africa	39%	36%	Open dumping	NA

- World-wide ~ 5,000- 6,000 million ton/yr organic waste generation
- **Negative LCOS means at higher tipping fees it is far more profitable**
- India is also on the path to eliminate landfills and improving waste management

Higher tipping fees to eliminate landfills in developed countries leads to higher profitability of RCAT-HTL derived bio-oil as renewable stored energy

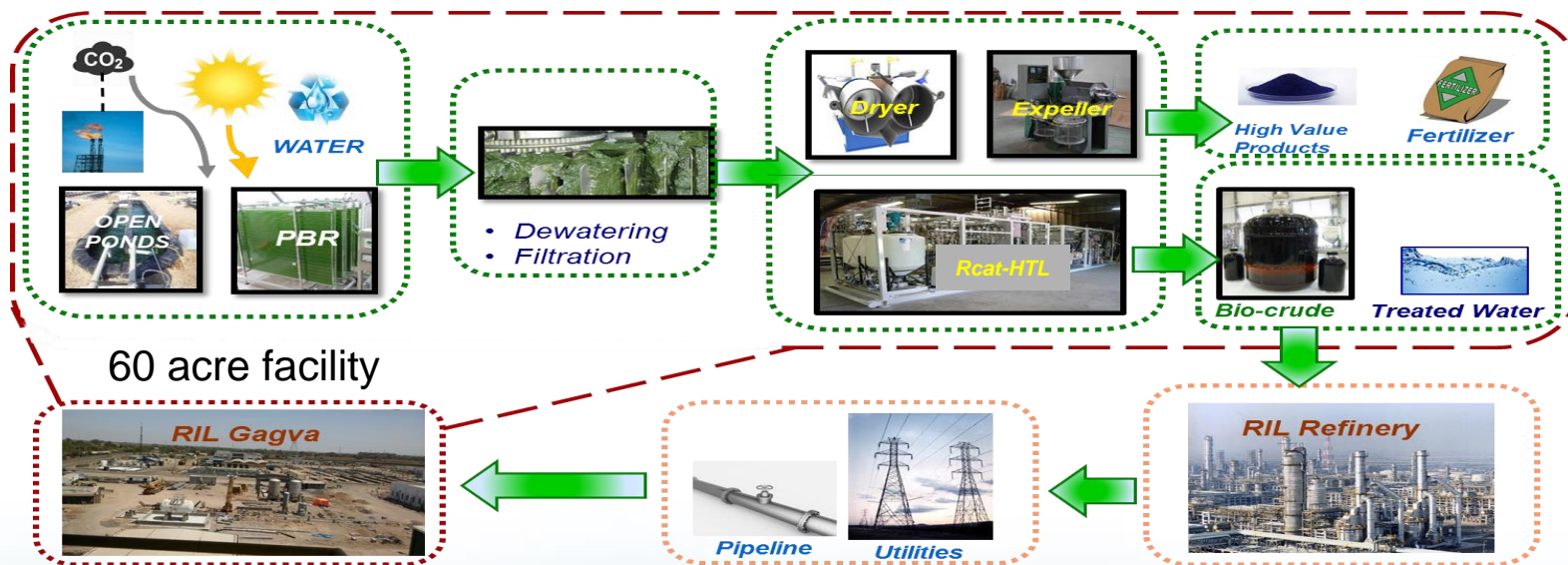


Reliance proprietary algae to bio-oil (A2O) technology – ultimate in sustainability

Every gallon of algal bio-oil produced consumes 15 kg of CO₂



We are significantly ahead of others in this most challenging development



We can commercialize @ ~\$120/ Bbl crude w/o subsidy, or at \$60 Bbl with subsidies in the US/ EU

RIL best global biomass productivity and carbon conversion efficiency to bio-oil



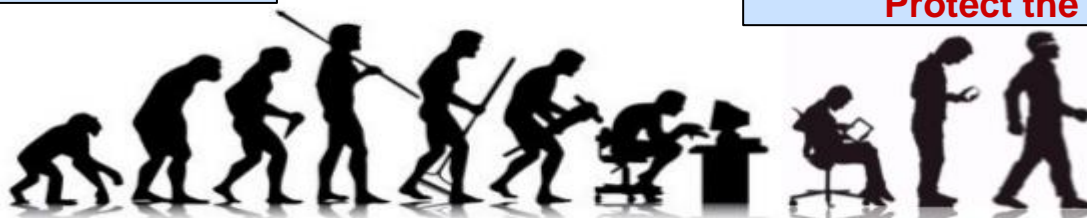
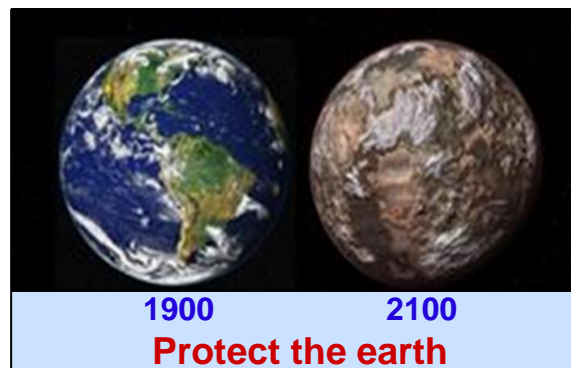
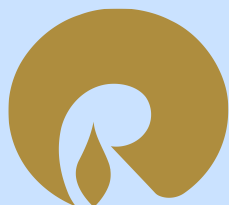
Summing up...

Discover, Develop, Deploy & Deliver Value

Invention Led Growth



THANK YOU



Progress of Mankind from rudimentary tools to RE/ Synbio/ AI/ BMI – Era of Cognification

I would prize every invention of science made for the benefit of all – Mahatma Gandhi