Liquid Sunshine

for

India

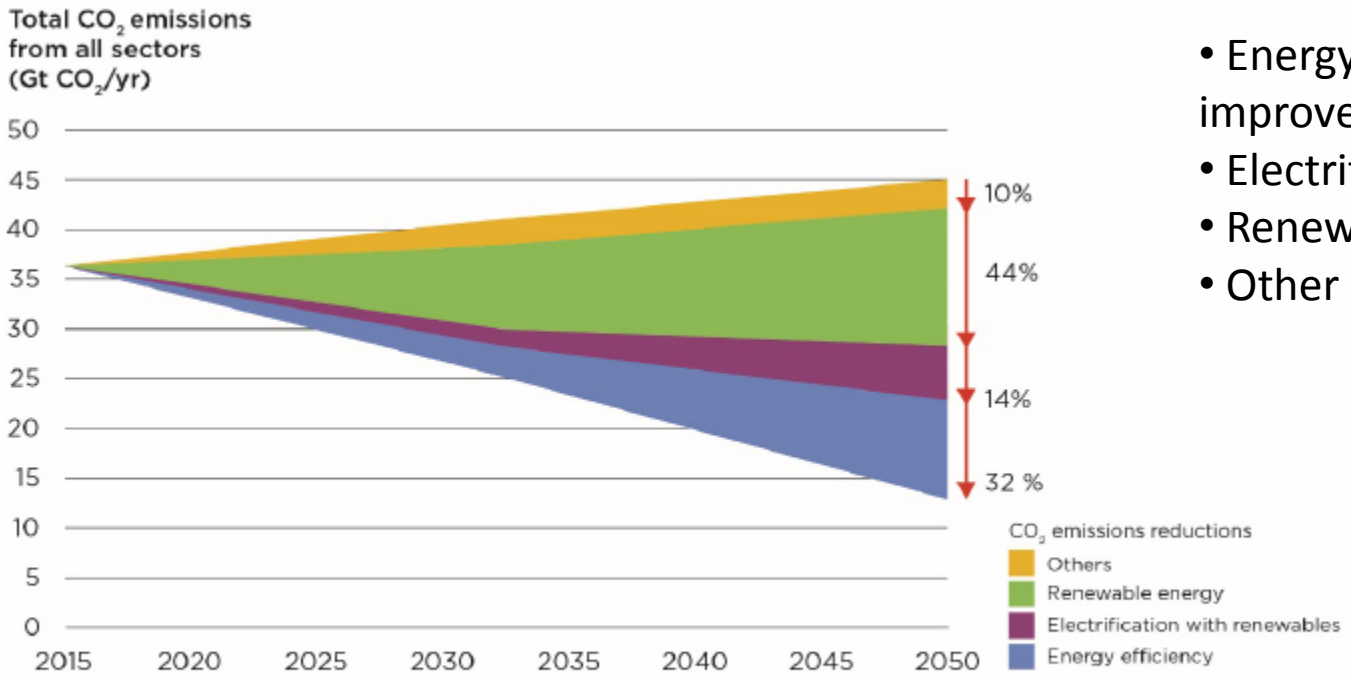
Way to low cost, low GHG sustainable transport

Dr. Anirudh Gautam
Executive Director, SRESTHA

Different Sectors

- Road Transport Sector
  - 2-Wheeler
  - Cars
  - SUVs/ LCVs
  - HCVs
- Gensets Sector
- Railroad Sector
- Marine Sector
  - Inland Waterways
  - Ships (Methanol)

International Efforts to reduce Carbon footprint



- Energy & material efficiency improvements – 32%
- Electrification of drives – 14%
- Renewable energy - 44 %
- Other measures – 10%

Notes: CO_2 emissions include energy-related emissions (fossil fuel, waste, gas flaring) and process emissions from industry. If only fossil fuel emissions were displayed in this figure, CO_2 emissions would start from 33 Gt in 2015 and would reach 40.5 Gt and 9.5 Gt per year in 2050 in the Reference Case and REmap, respectively.

GHG Emission Facts

India	Total	Coal	Oil	Gas	Other	Total	Coal	Oil	Gas	Other
Total sectors (Mt CO_2)	**1,869**	**1,348**	**447**	**72**	**1**	**100%**	**72%**	**24%**	**4%**	**0%**
Power and heat generation *	945	886	25	32	1	51%	47%	1%	2%	0%
Other energy industry own use	43	3	31	10		2%	0%	2%	1%	
Manufacturing industry **	493	410	66	17		26%	22%	4%	1%	
Road transport	206		203	4		11%		11%	0%	
Other transport ***	16		16			1%		1%		
Residential sector	87	14	66	8		5%	1%	4%	0%	
Other buildings ****	78	36	40	2		4%	2%	2%	0%	

* Includes public power and heat production

** Excludes emissions from non-energy use and feedstock use of fuels

*** Excludes international marine and aviation bunkers

**** Service sector; includes agriculture and forestry

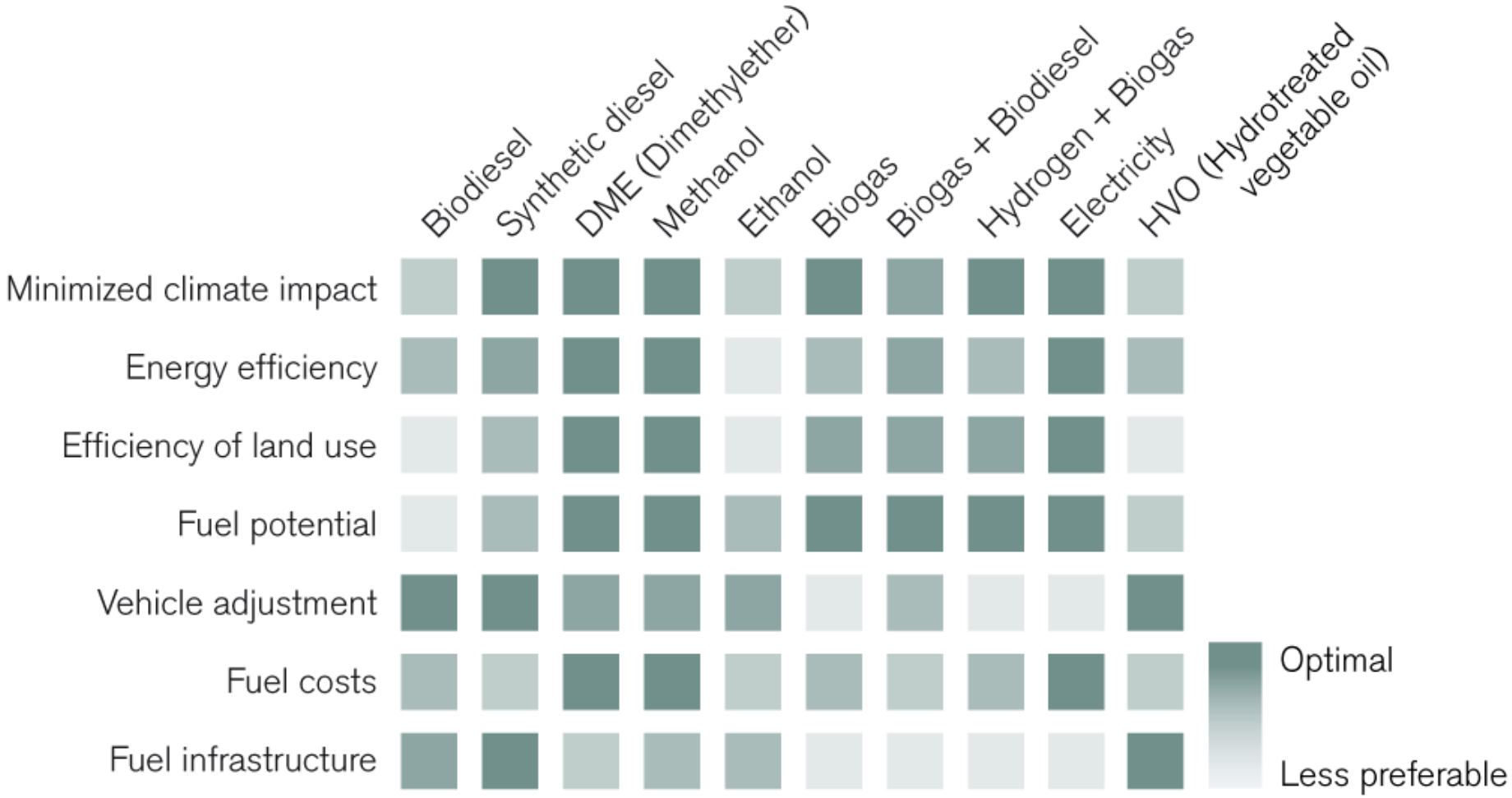
Different Fuelling Options

- Road Transport Sector
  - Electric Vehicles (BEVs)
  - Hybrid (ICE + Battery)
  - FC Hybrid (FC + Battery)
  - ICE with methanol
- Genset Sector
  - Diesel + ICE
  - Natural Gas + GT
  - Methanol + ICE/ GT
- Railroad Sector
  - Diesel
  - Electricity
  - Methanol
- Marine Sector
  - MGO/ HFO/ etc.
  - LNG
  - Methanol

Parameters to choose fuels/ technology

- Economics
- Efficiency
- Environment
- Security (Indigenous/ Imported)
- Safety including toxicity
- Scalability
- Supportability
- Sustainability
- Design capability
- Manufacturing capability

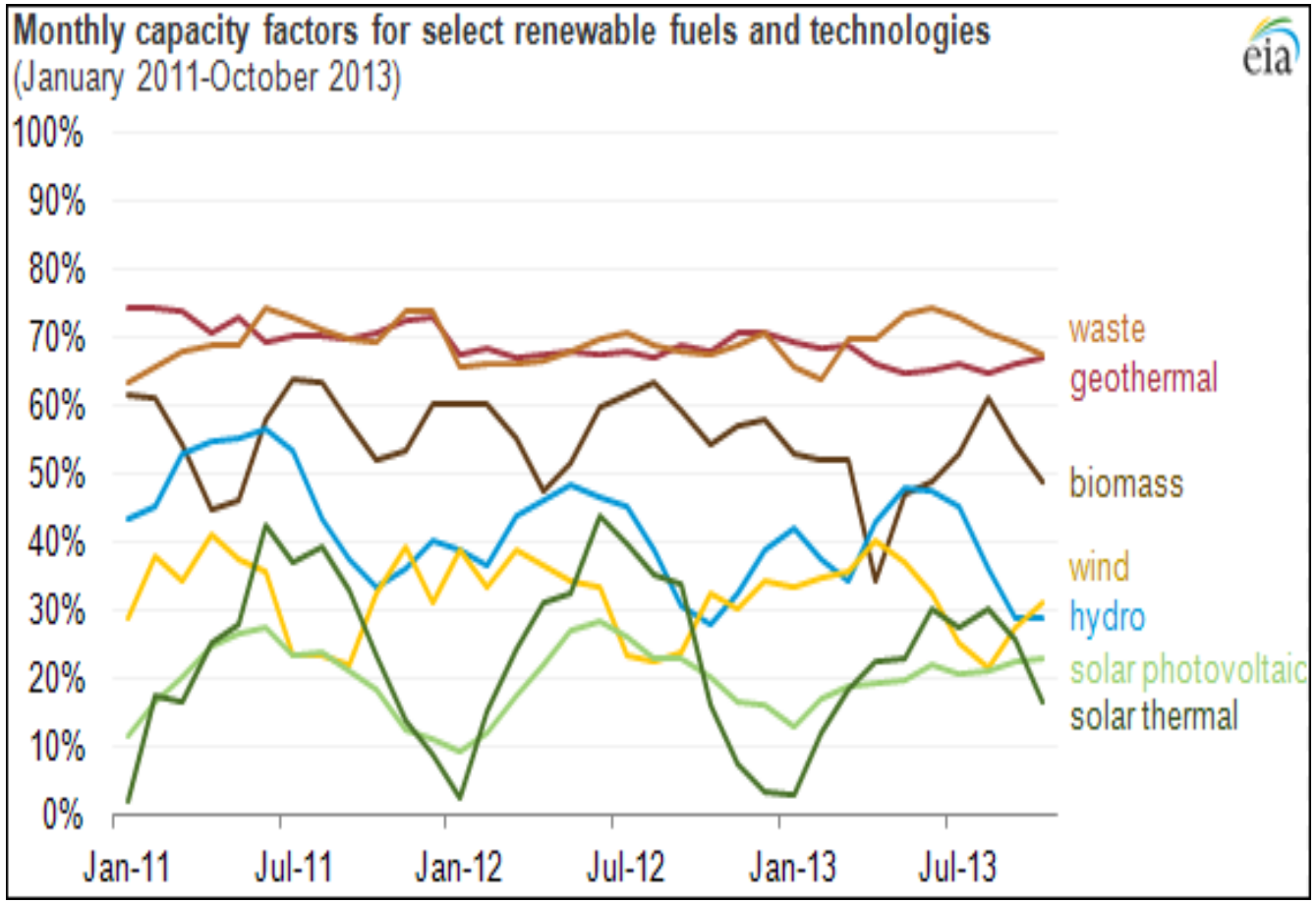
Volvo Matrix



Issues

- Li-Ion battery
  - Raw material (Lithium/ Cobalt) India to forge alliances with Bolivia, other countries of South America
  - R&D capability
  - Manufacturing capability
  - Toxicity
  - TCO
  - Transport as a Service(TaaS)
- Solar PV
  - Raw material availability
  - Toxicity
  - Low cost sustainability
  - Only 10% made in India, India net importer of technology/ goods
  - R&D capability in India
- Concentrated Solar Power
  - Higher cost than Solar PV
  - Power generation technology – Stirling engine?

Renewables and their limitations

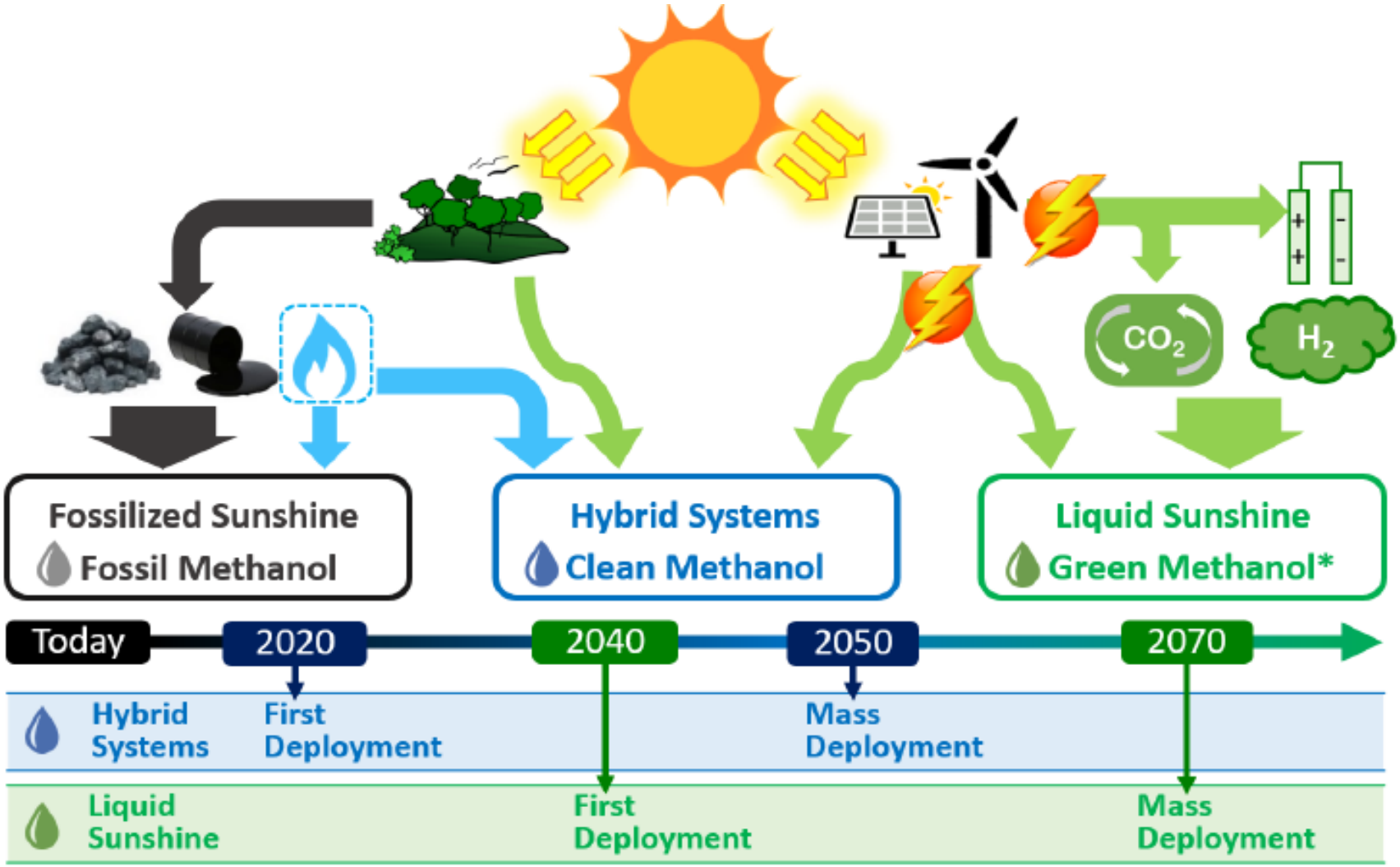


- Low capacity factor of renewables
- Capacity of 200 GW of Solar and Wind can generate peak 50 GW
- Energy storage required
- Electrofuels like methanol best way to store renewable energy

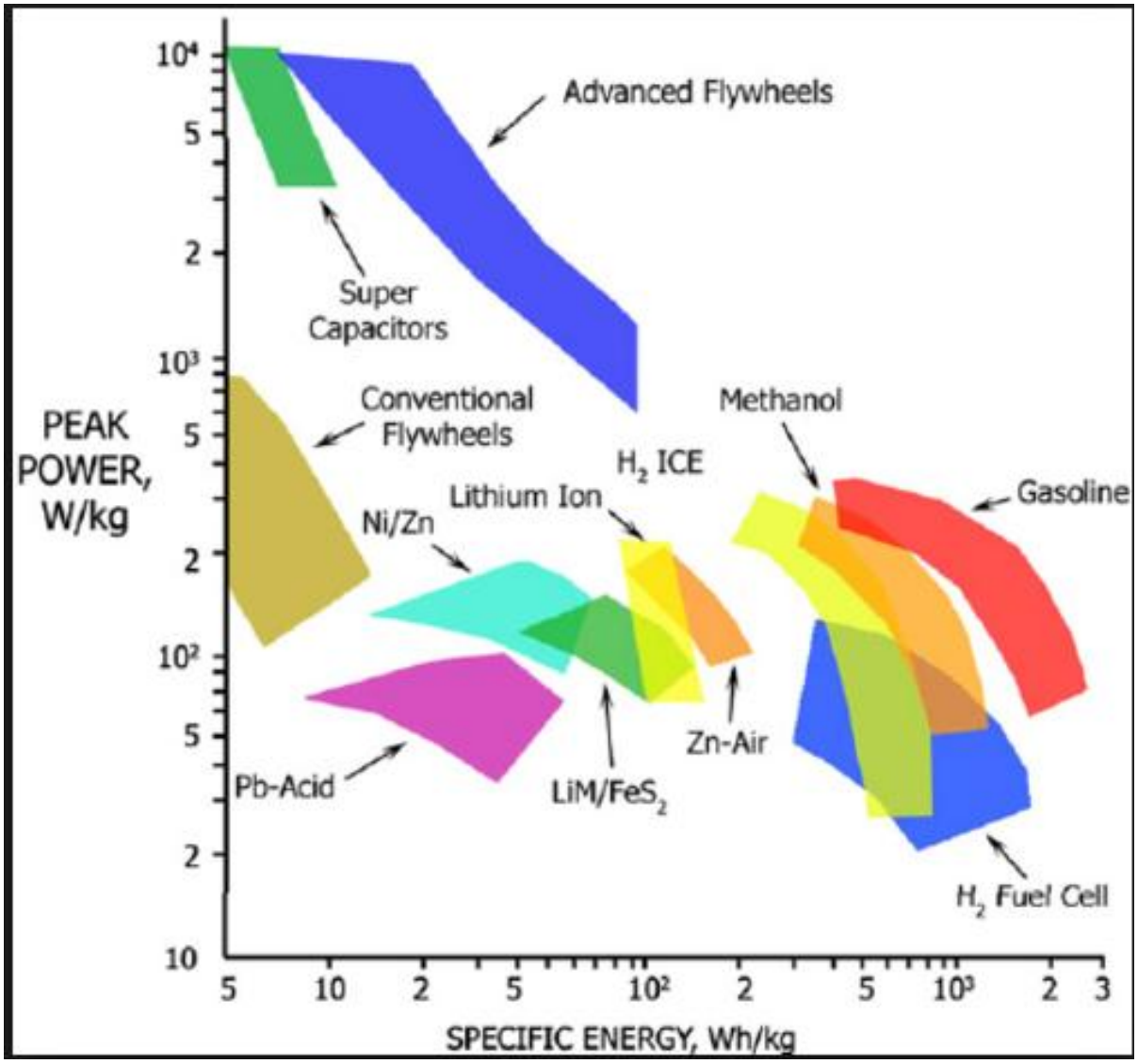
Renewable – installed capacity and actual generation

Renewable	Installed capacity as % of the total installed capacity	Generated power as % of the total generated power
Solar + wind + biomass + bagasse + small hydro	14%	6.90%
Hydro*	14%	11.10%

Methanol – Liquid Sunshine fuel



Ragone Plot comparing different energy devices/fuels



Methanol – Experience in other countries

China

- 114.5 billion tons coal reserves (12.8% of Global)
- Coal to methanol playing dominant role
- Clean Carbon Energy – "To echo the key points and tasks of fundamental research program in 13th 5YP, emphasizing the clean conversion of carbon based energy under energy saving and new energy aspects, researching on promotion and application of effective utilization of methanol fuel in ICE in clean and effective coal.
- 2 million vehicles, cars, trucks, buses plying on methanol

India Coal reserves – 300 bn tons

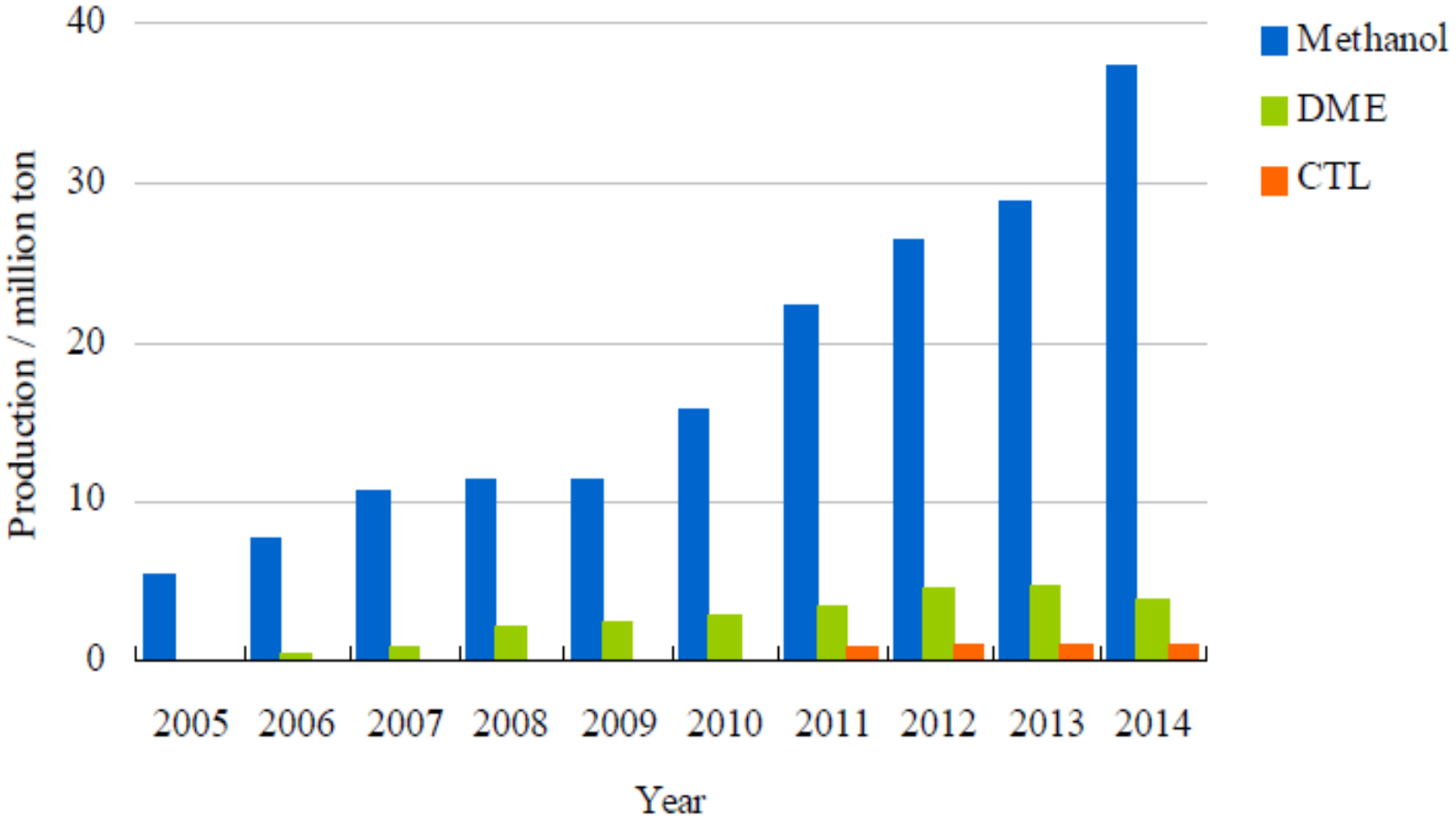
As a result of exploration carried out up to the maximum depth of 1200m by the GSI, CMPDI, SCCL and MECL etc, a cumulative total of 301.56 Billion tonnes of Geological Resources of Coal have so far been estimated in the country as on 1.4.2014. The details of state-wise geological resources of Coal are given as under:

(Million tonnes)

State	Proved	Indicated	Inferred	Total
West Bengal	13403	13022	4893	31318
Jharkhand	41377	32780	6559	80716
Bihar	0	0	160	160
Madhya Pradesh	10411	12382	2879	25673
Chhattisgarh	16052	33253	3228	52533
Uttar Pradesh	884	178	0	1062
Maharashtra	5667	3186	2110	10964
Odisha	27791	37873	9408	75073
Andhra Pradesh	9729	9670	3068	22468
Assam	465	47	3	515
Sikkim	0	58	43	101
Arunachal Pradesh	31	40	19	90
Meghalaya	89	17	471	576
Nagaland	9	0	307	315
Total	125909	142506	33149	301564

China – Methanol vehicles

Production of Methanol in China



Sweden

VärmlandsMetanol AB

- Convert 1000 tons of wood biomass per day
- 4 Lakh liters of biomethanol per day

Iceland

- George Olah Renewable Methanol Plant in Svartsengi
- Worlds largest CO_2 to Methanol plant
- Uses hydro and geothermal energy to split water and uses hydrogen to produce methanol from atmospheric CO_2
- Capacity – 5 million litres of methanol per year
- Recycles 5.5 thousand tons of CO_2 per year

Ghazipur Landfill Delhi

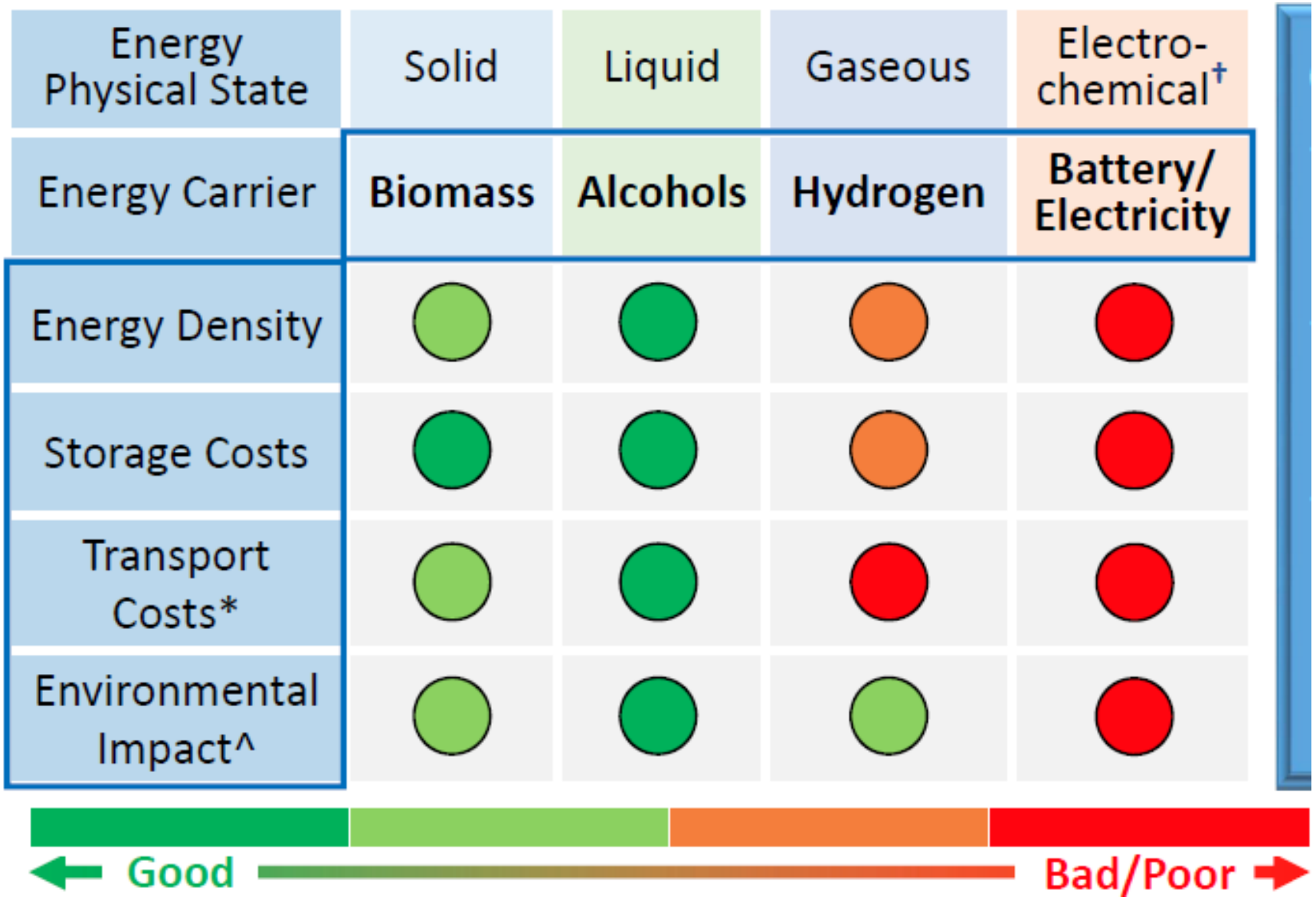
MSW to Methanol – Edmonton Canada Plant

Enerkem Alberta Biofuels

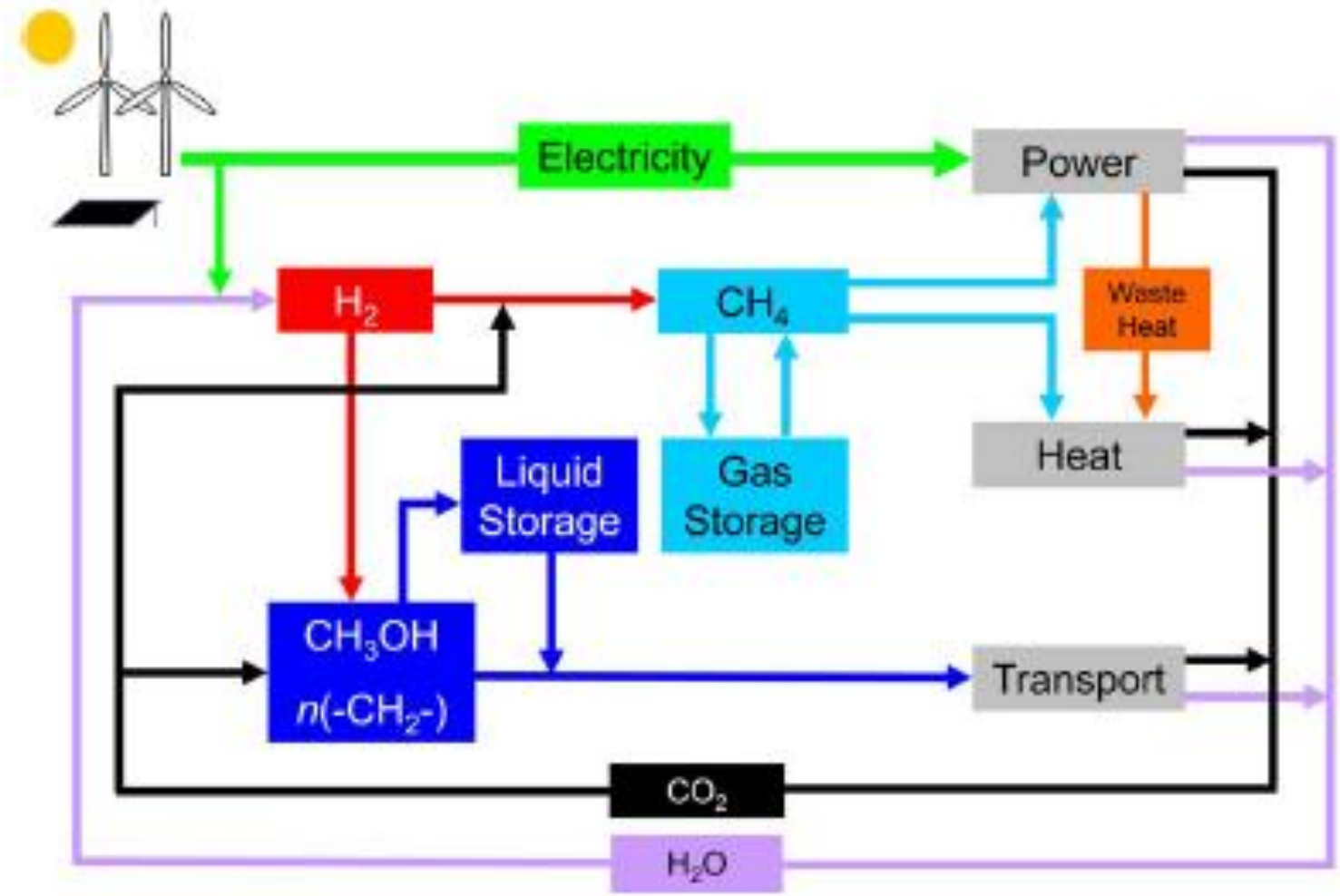
A global game-changing facility!

The Enerkem Alberta Biofuels facility is helping the City of Edmonton increase its waste diversion from 50% to 90%.

Comparison of different fuels- India/ China



Integrated power, heat and transport system with renewable and synthetic fuels



Variability Challenge & Storage of Energy – Enter Electrofuels

- One way to solve the variability challenge is through grid-scale energy storage
- Electrochemical batteries still face technical and economic challenges to achieve grid-scale storage
- Pumped hydro storage and compressed air energy storage can provide long duration, large capacity storage but deployment of those systems are dependent on finding the right geography or geology.
- Storing excess energy in chemical bonds in the form of hydrogen, methane, or ammonia is an effective way to achieve long-term, grid-scale storage
- Instead of storing a surplus of electricity in batteries to be used later, we can convert that electricity into energy-dense liquids and gases
- Doing so has the potential to be simpler and cheaper while also helping to decarbonize the transportation sector
- Fabricators of the electrofuels can get paid twice: once for stabilizing the electric grid, and again when they sell the fuels.

Electro-fuels

- Production of synthetic fuels is an opportunity to make our energy system cleaner and more reliable.
- Process would solve several problems at once: stabilizing intermittent electricity supply while creating renewable fuels for use in power generation, transportation, and industry.
- The large-scale introduction of wind and solar power now makes the production of renewable fuels at least technically feasible
- Policymakers should start to give electrofuels the attention they deserve. There are many tax credits or subsidies for renewable or low-carbon sources of electricity such as wind, solar, geothermal, and nuclear, but electrofuels are not yet prominent in the discussion
- States like California have mandates for energy storage, stakeholders often ignore the option of electrofuels despite the potential for them to be a more useful and affordable competitor to batteries.
- It may be some time before it becomes common for drivers to get behind the wheel of a hydrogenpowered car, as President Bush called for. But electrofuels may provide a unique solution to a number of challenges. And it’s time our markets and policies recognize that possibility.

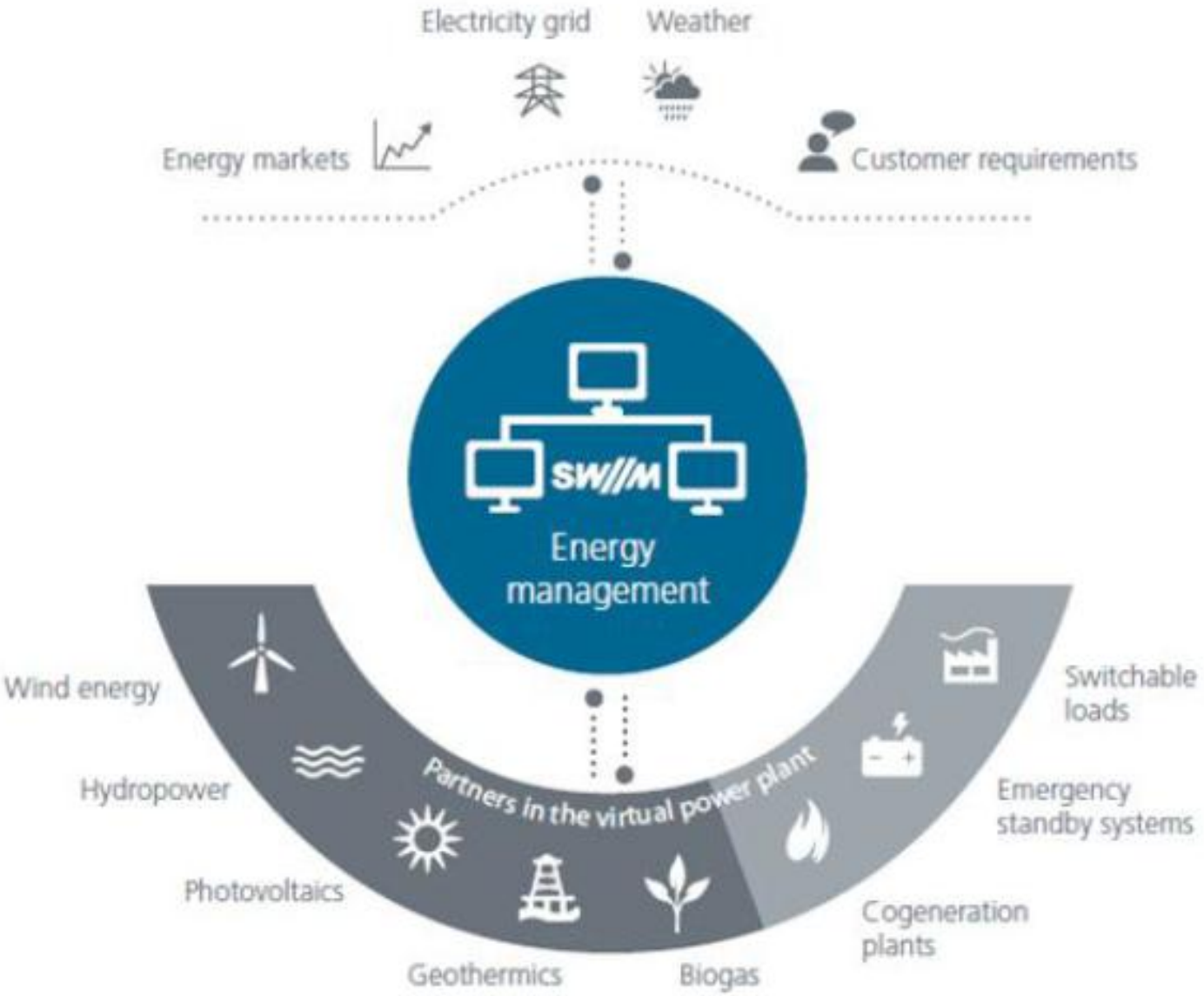
Rise of Electrofuels – Latest issue of ASME magazine

Solar PV manufacture Industry to create jobs

- Manufacture of materials (silicon, wafers, metal pastes, plastic films, solar glass)
- Manufacture of intermediate and final products, including solar cells, modules, inverters, Supporting structures, cables and coated glass
- Construction of manufacturing plants
- Installation (especially trade)

But at present Jobs in Installation only…

Virtual Power Plant

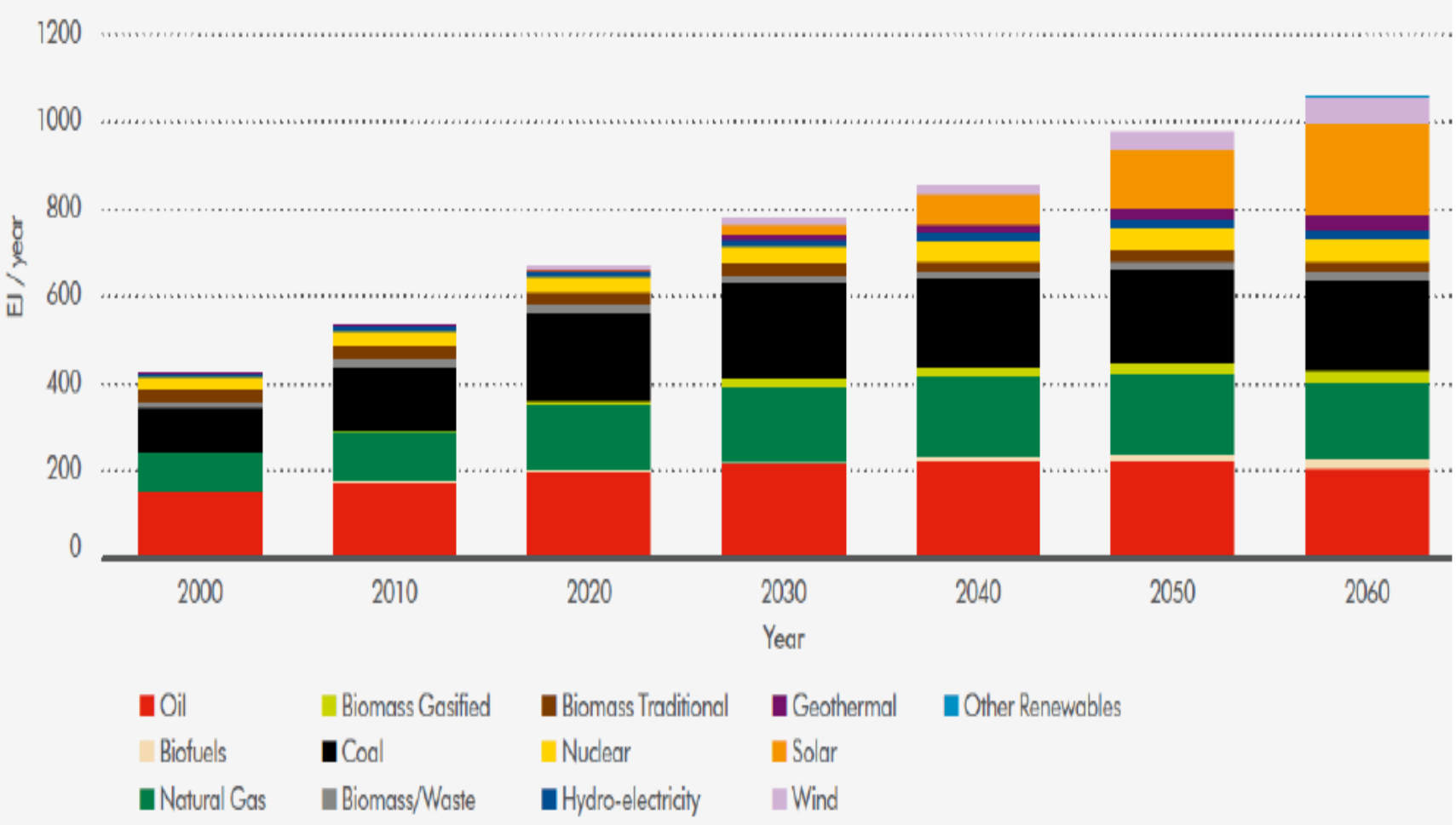


Can PV replace fossil fuels? German Solar PV report

Are PV systems capable of replacing fossil fuel and nuclear power plants?

- No, not in the near future.
- PV and wind power may currently be capable of reducing the use of fossil fuels, imported energy consumption and CO_2 emissions but until considerable storage capacities for electricity or hydroelectric storage facilities are available in the grid, they are not capable of replacing the capacities generated by fossil fuel and nuclear power plants. Calm, dull winter days, when power consumption is at a maximum and no solar or wind power is available, present the most critical test
- Electro-fuels provide a unique answer

Primary energy sources of various sources of power Shell - 2016



Conclusion

- Electro-fuels is an excellent method to store renewable energy
- Indian Coal can be used to produce methanol (electro-fuel) in a very clean manner
- Methanol/ DME can replace gasoline/ diesel on the Indian IC vehicles with consequent
  - Economy
  - Environmental benefit (Euro 6)
  - Much lower GHG emissions
  - Efficiency
  - Energy security
- India to make a fuel switch to methanol on all sectors, i.e. Road, Rail, Marine, Off-road, Gensets etc.
- MSW and Renewables can in the long term meet the energy demands of the transport sector through methanol
- Fuel cell battery hybrids with methanol on-board reforming is the future of transport

On to Methanol Economy

ThankYou