

RNEWABLE ENERGY TARGET: 175 GW + COP21



“How realistic is the RE target ? ”

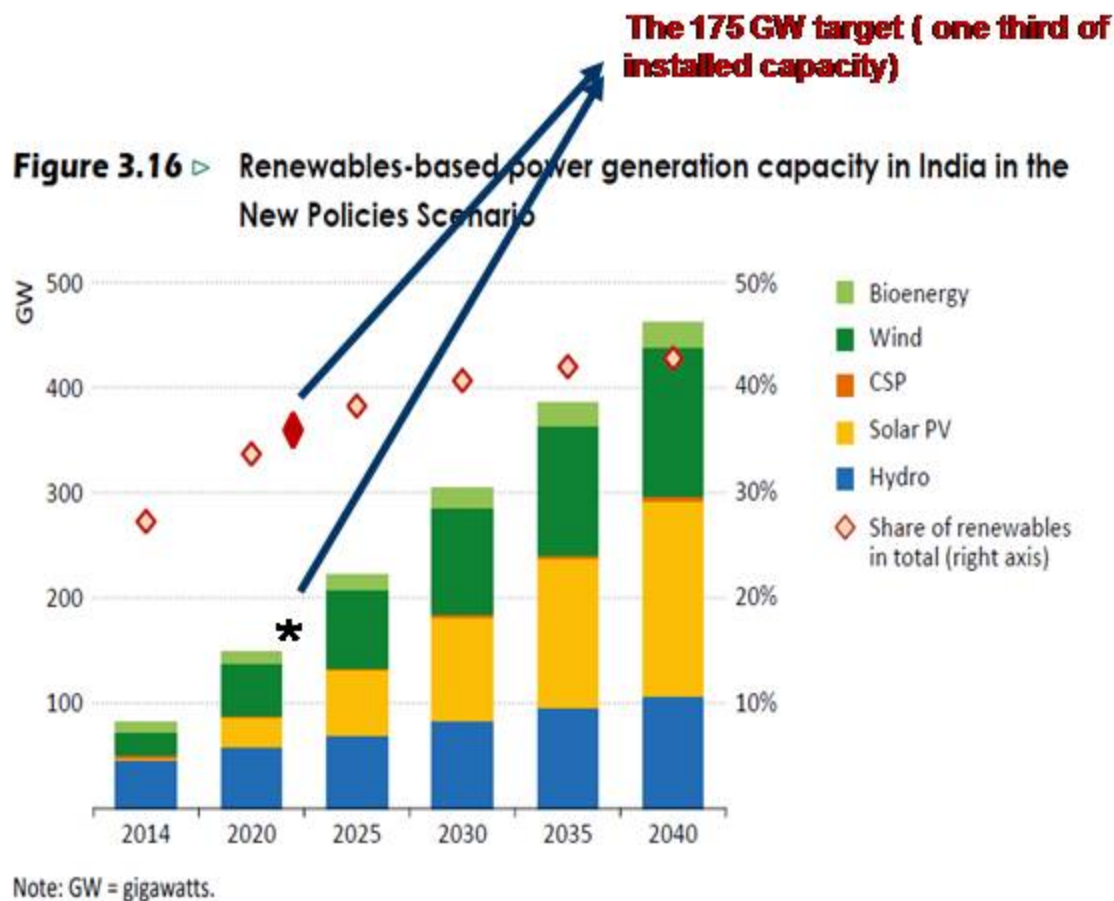
“After the final NO; then comes YES” – Al Gore



Formerly with Atomic Energy Commission

Dr Ramakrishna R Sonde
Executive Vice President, Thermax
Formerly with Atomic Energy Commission & NTPC Ltd.

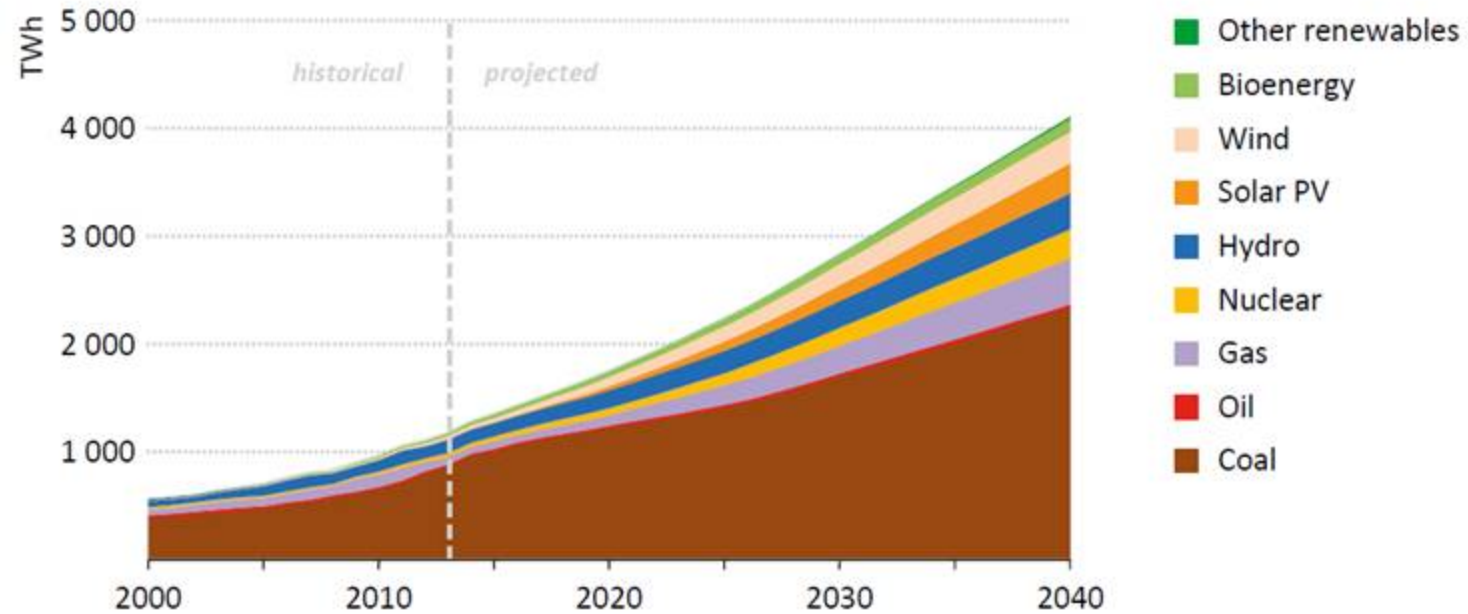
WHAT IS THE EMERGING SCENARIO?



3

The renewable electricity forming a power generation capacity from 28% to 43% from 2016 -2040

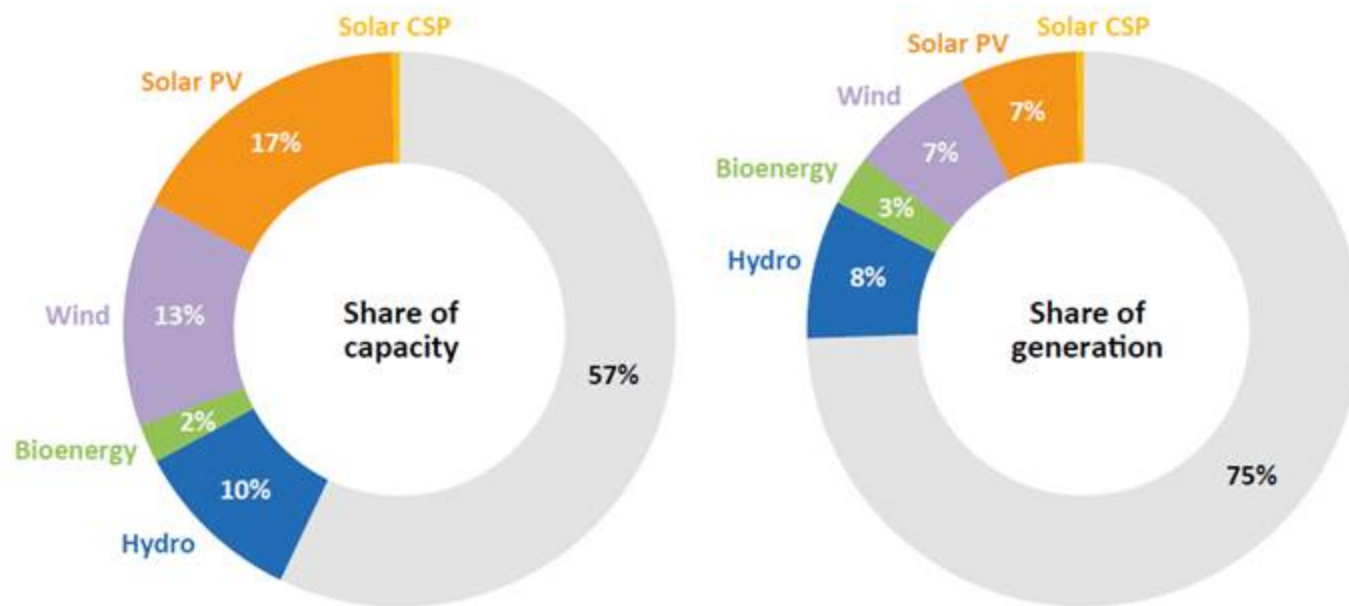
Figure 2.22 ▷ Power generation by source in India in the New Policies Scenario



Business as usual case

A factor of 1: 1.7 to be applied on the installed capacity for renewable electricity to the electricity consumption in a given year

Figure 3.18 ▷ Share of renewable energy capacity and generation in India, 2040

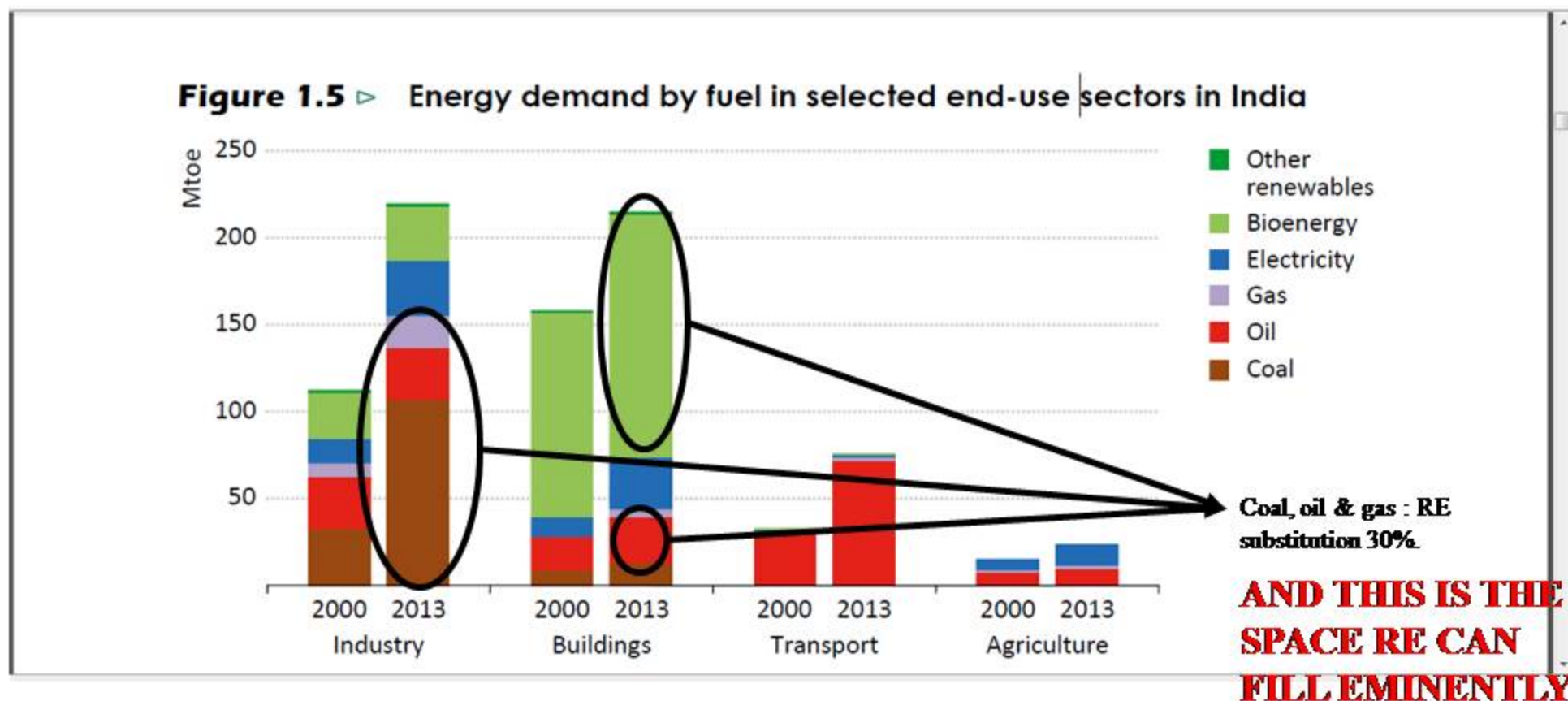


A 175 GW target would mean it would form about 40% of installed electricity capacity and form approximately 25% of the annual consumption. The above scenario in 2040 will not be very different.

Importance of STORAGE is very critical if RE has to penetrate in significant measure

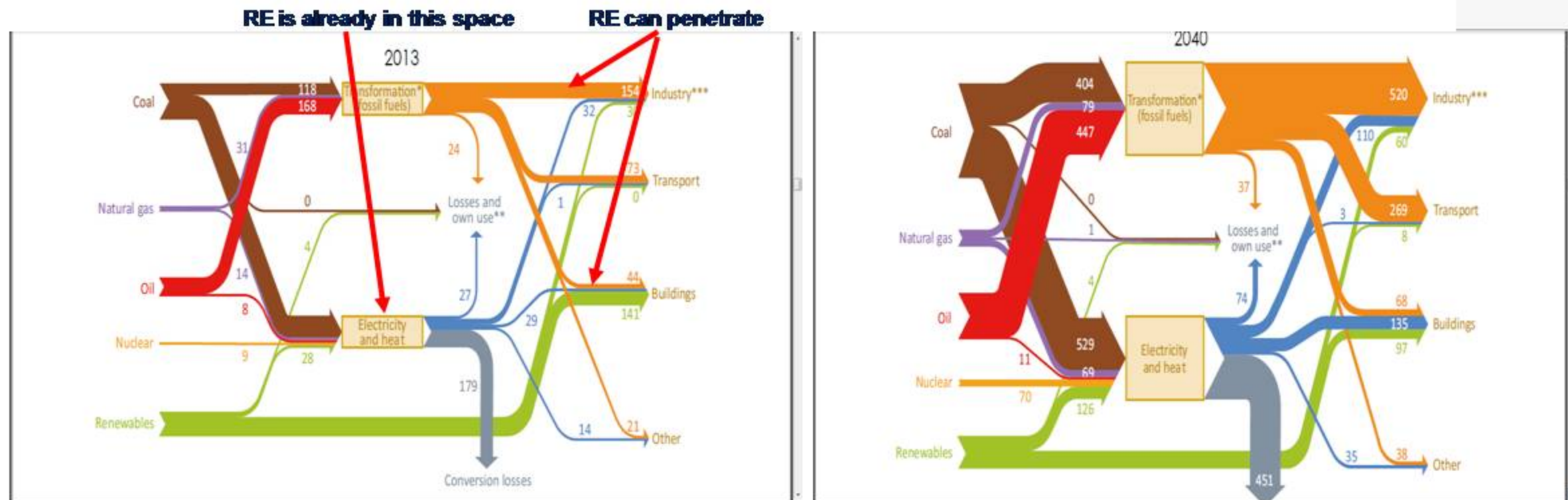
ENERGY IS NOT ELECTRICITY ALONE: MY FAVOURITE LINE

Electricity forms just about 12% of the total consumption when all energy consumption is converted to MTOE – million tonnes of oil equivalent. Hence at 175 GW RE means just about 3-4% in the overall mix.



*If the 30% energy demand in Industry and Buildings are converted to RE – thermal, cooking, cooling energy, lighting etc. – then the overall RE contribution can be in multiple of 175 GW.
AND THIS IS REAL FOR SURE!!!*

Domestic energy flow in different sectors



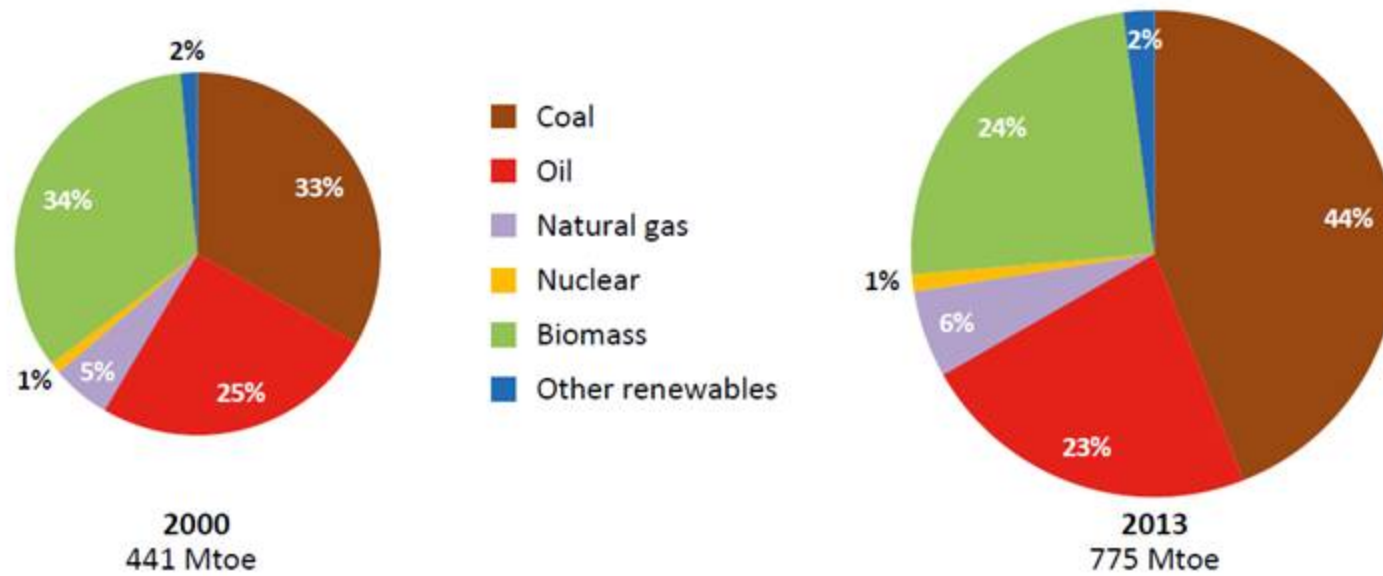
Two scenarios can be projected.

1. Whether the future energy mix will become **electricity centric** viz. all energy demand will happen via electricity? Battery driven cars, electric driven kitchen wares, electricity boilers
2. Hydrogen derived fuels (solar, biomass) using fuel cells and other devices for fuelling the above needs

If we can pick up in the energy flow, RE possibilities (and there are large number of them), 175 GW will appear suddenly doable and exceed – able...

The renewable energy penetration is not showing up even now!!!

Figure 1.4 ▷ Primary energy demand in India by fuel



If current renewable (excludes the biomass for cooking) at 2% to become 20% by 2022 (35% in installed capacity), then the fundamental paradigms will require to be challenged and then radically changed

THERE IS STILL A BIG PARADOX HERE

Use of modern energy in rural house hold cooking shows a dip in RE share from now to 2040.

Table 2.1 ▷ Primary energy demand by fuel in India in the New Policies Scenario (Mtoe)

	2000	2013	2020	2030	2040	Shares		2013-2040	
						2013	2040	Change	CAAGR*
Oil	112	176	229	329	458	23%	24%	282	3.6%
Natural gas	23	45	58	103	149	6%	8%	104	4.6%
Coal	146	341	476	690	934	44%	49%	592	3.8%
Nuclear	4	9	17	43	70	1%	4%	61	7.9%
Renewables	155	204	237	274	297	26%	16%	93	1.4%
Hydropower	6	12	15	22	29	2%	1%	16	3.2%
Bioenergy	149	188	209	217	209	24%	11%	20	0.4%
Other renewables	0	4	13	35	60	0%	3%	56	11.0%
Fossil fuel share	64%	72%	75%	78%	81%	72%	81%	8%	n.a.
Total	441	775	1 018	1 440	1 908	100%	100%	1 133	3.4%

2015

CHALLENGE : HOW DO WE BUILD RENEWABLE ENERGY IN EVERY FORM?

AND THEN THERE ARE THE USUAL QUESTIONS



Power sector is in not healthy shape especially the **DISCOs**

To meet these targets, do we have **1) financing – 100 billion\$ in next six years** 2) **Land 500 million acres** 3) **water 80 billion cubic meters** and, finally 4) **technology, manufacturing skills and all the rest of the necessary eco systems.**

Disruptive developments and innovative processes will answer all the questions,,,,,,,,,,,,,

Climate change will be the one single most important factor which will determine this not only for India, but for the globe as well. The tell-tale signatures of likely destructions and the emerging enthusiasm of new technologies in renewable space is the basis for this prediction

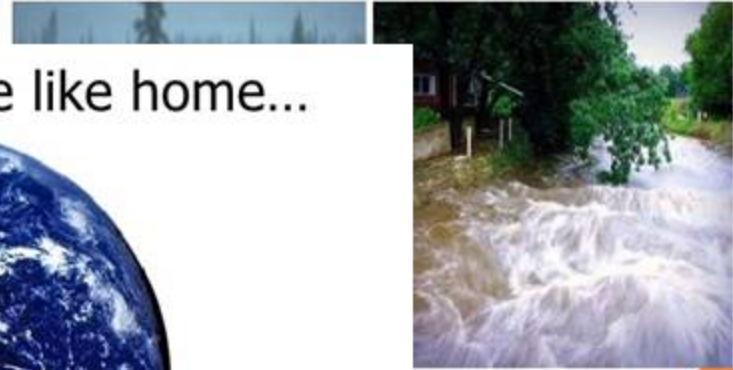
The answer is BIG YES. As Al Gore says “ After the final NO comes the YES”

THIS ONE PICTURE SHOULD BRING UP THE RESOLVE BEYOND ANY DOUBT

RISE IN TEMPERATURE



HEAVY RAINFALL ACROSS THE GLOBE



There's no place like home...

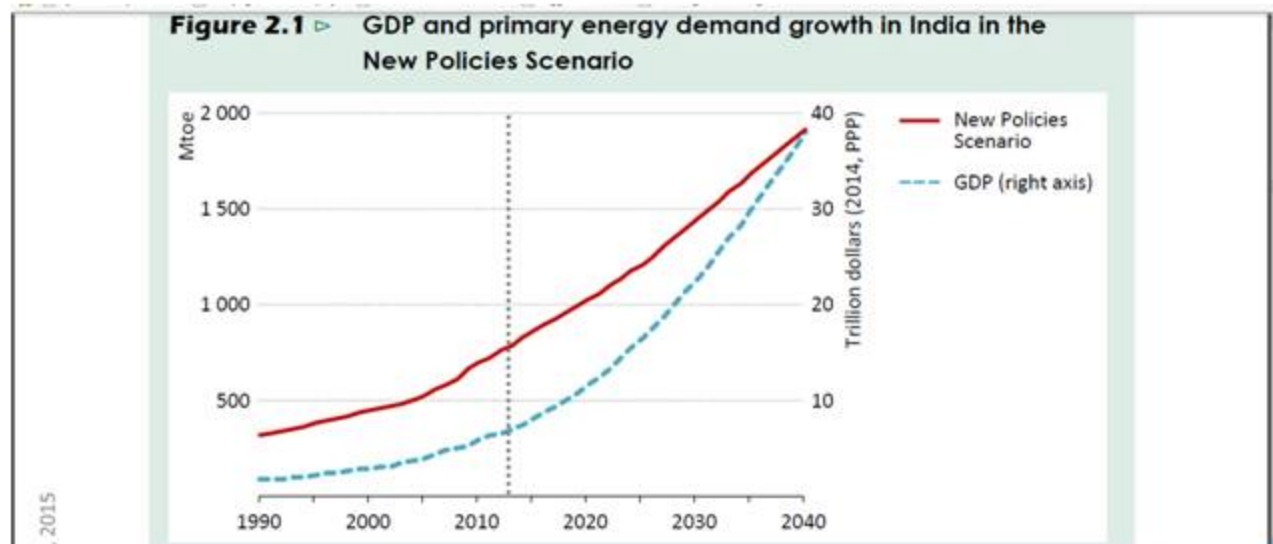


DECLINE IN CROP PRODUCTION



...and there may never be again. Do your part.



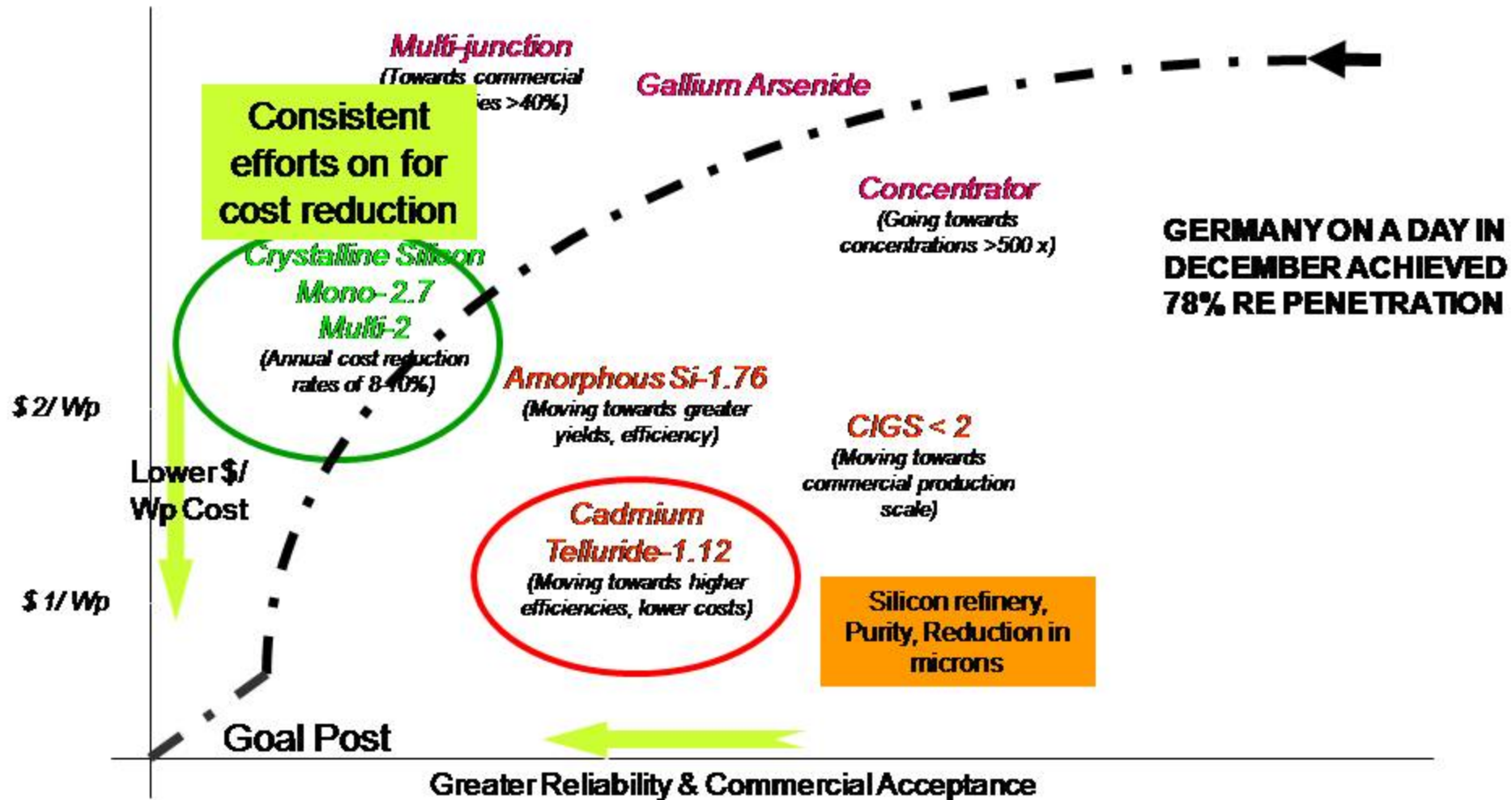


India is going to be strong global economy. Energy needs will rise, investments will happen. INDC under COP 21 will drive this change

I propose following **FOUR** mechanisms other than whatever current strategy set forth for 100 GW solar and rest for other renewable energy systems

- 1. Hybridize solar to the existing coal based power plants both at utility scale as well as captive scale**
- 2. Industrial heating demands to be met by RE hybrid (solar-biomass for ex.)**
- 3. Energy for buildings—AC / cooking – to be shifted to RE – BIG PUSH**
- 4. Kick start METHANOL driven clean fuel replacing diesel for power and transport applications**

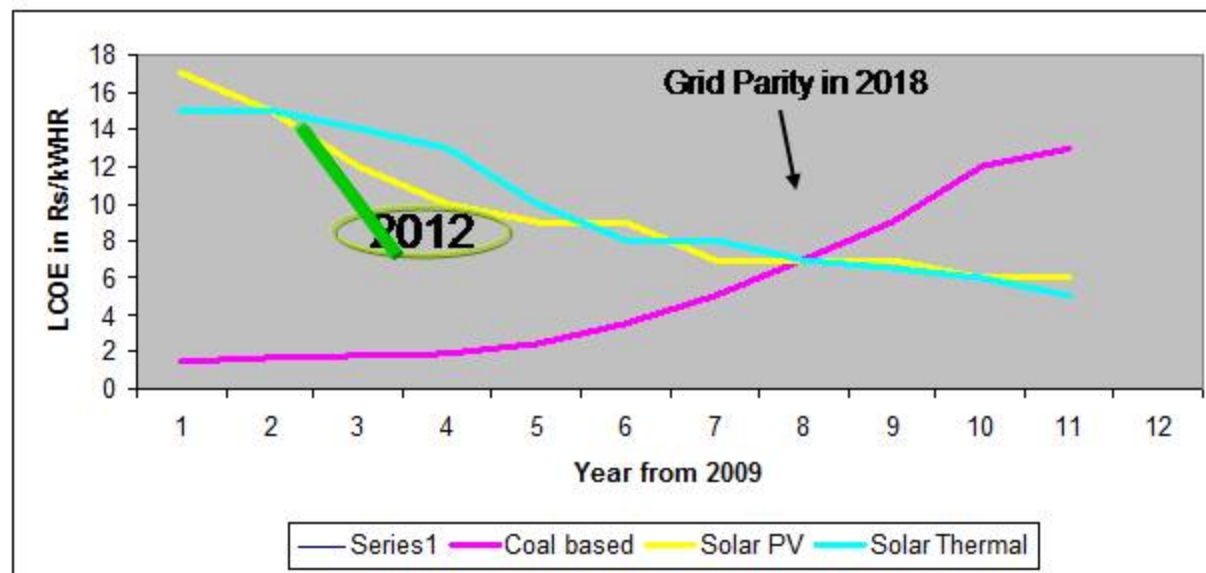
GOOD NEWS: IN JUST FIVE YEARS, PV HAS BREACHED \$1 MARK FROM A \$6 MARK



The developments in energy technologies is nothing but DISRUPTIVE!

GRID PARITY IS NO MORE AN ISSUE

The solar power has reached parity with the grid power. Today solar power is cheaper than fossil power when environmental factors are considered!!



Power from Solar can be free if we extrapolate in not too distant future ...

Will we reach a stage when the electricity will be available free?

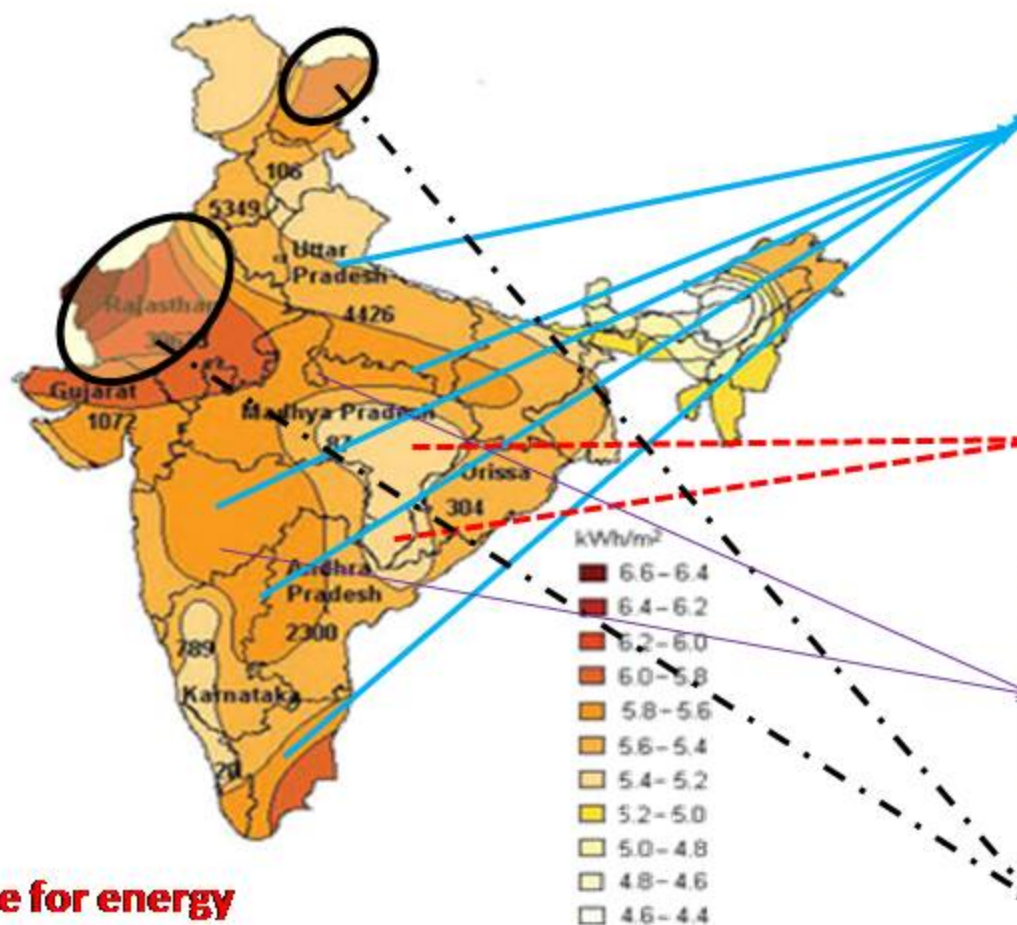
Answer is resounding YES

And if so, how will it happen? We are seeing disruptive developments at breathtaking speed, the need is a tectonic shift in our approach on development to deployment cycle.....

FIVE PRONGED STRATEGY

- 1. RE at stand alone level both as IPP as well as Roof top – the current thrust**
- 2. Hybridize at Coal / Gas power plant – low hanging fruit (~ 12 GW)**
- 3. Integrate industrial energy (heating) level – challenging integration issues (~100 GW @ 10% penetration)**
- 4. Building level integration for Air conditioners – New models necessary (~20 GW @ 10% penetration)**
- 5. Methanol route for transport and small power (DG substitute) level – New paradigm in RE space (~transport sector 500 GW eq.)**

PLEASE NOTE GW: TOTAL ENERGY (FROM MTOE TO GW)



Strategy 1: Current 175 GW policy Add to that Small sized (distributed generation plants) in large numbers with & w/o grid connectivity

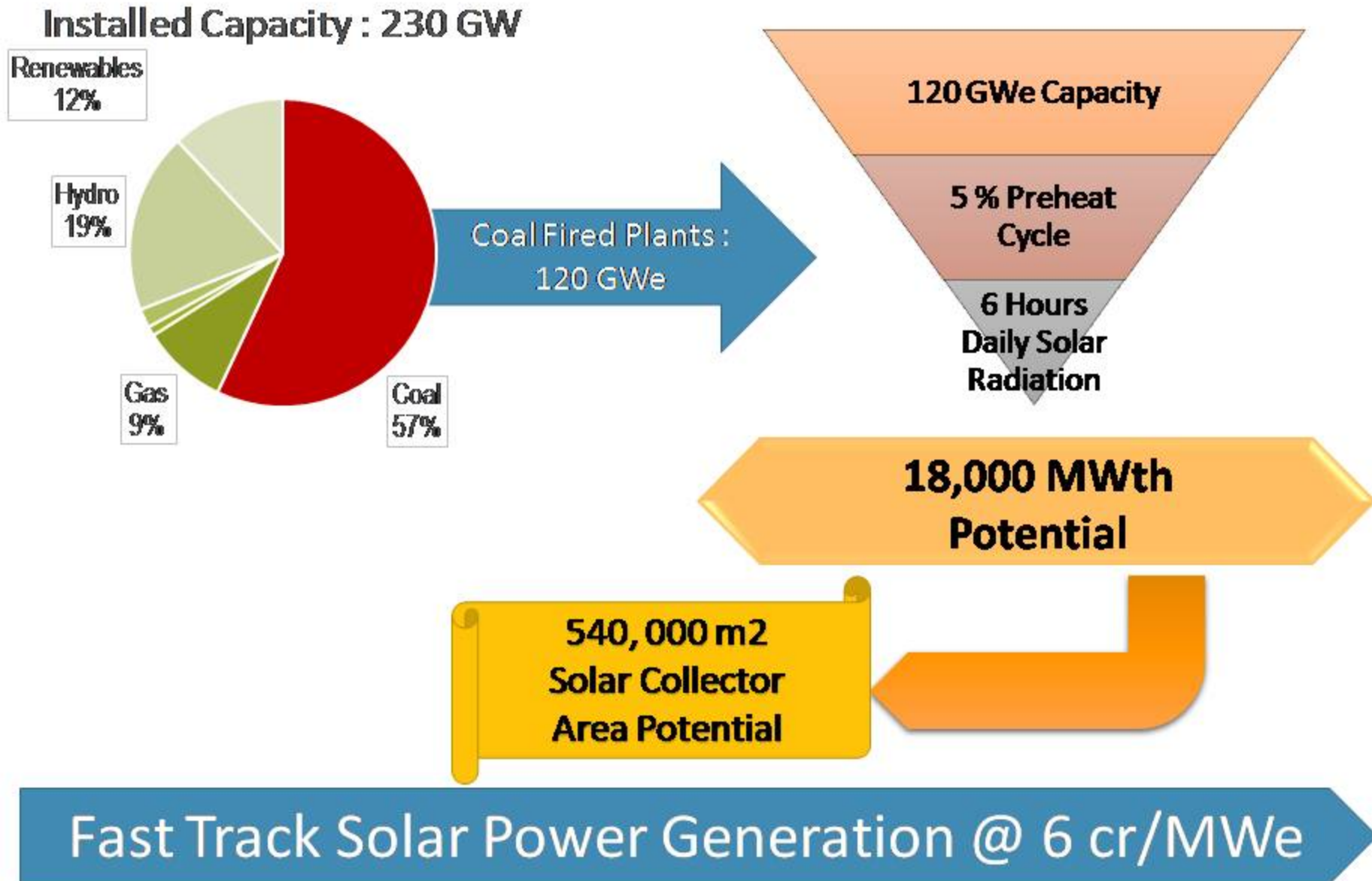
Strategy 2: Hybrid solar with Thermal Power Plants

Strategy 3: Industrial Process heat & cooling

Strategy 4: Large sized CSP plants with STORAGE for grid – dispatch able systems

Methanol route for energy security plus climate change

Hybrid Solar with Coal Power Cycle



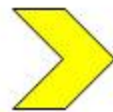
Use of high efficiency Power cycle

Use of existing Balance of plant

Use high efficiency solar at lower temp.

Land , infrastructure , fast track

**Get 22 %
efficiency at 200
Deg C**



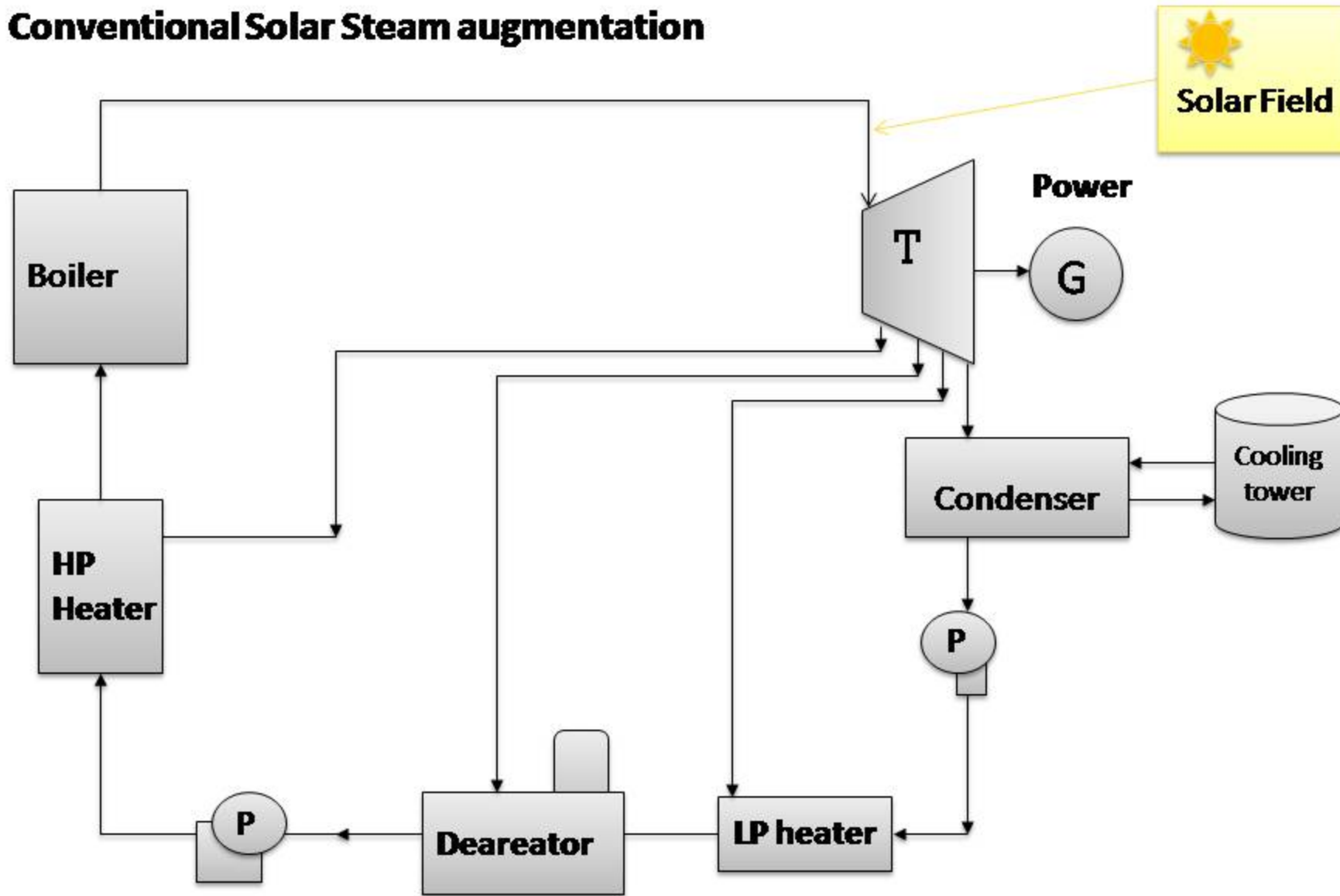
**Get away from
Supplier
controlled
technologies**



**Smart
Hybridisation
Of TPP**

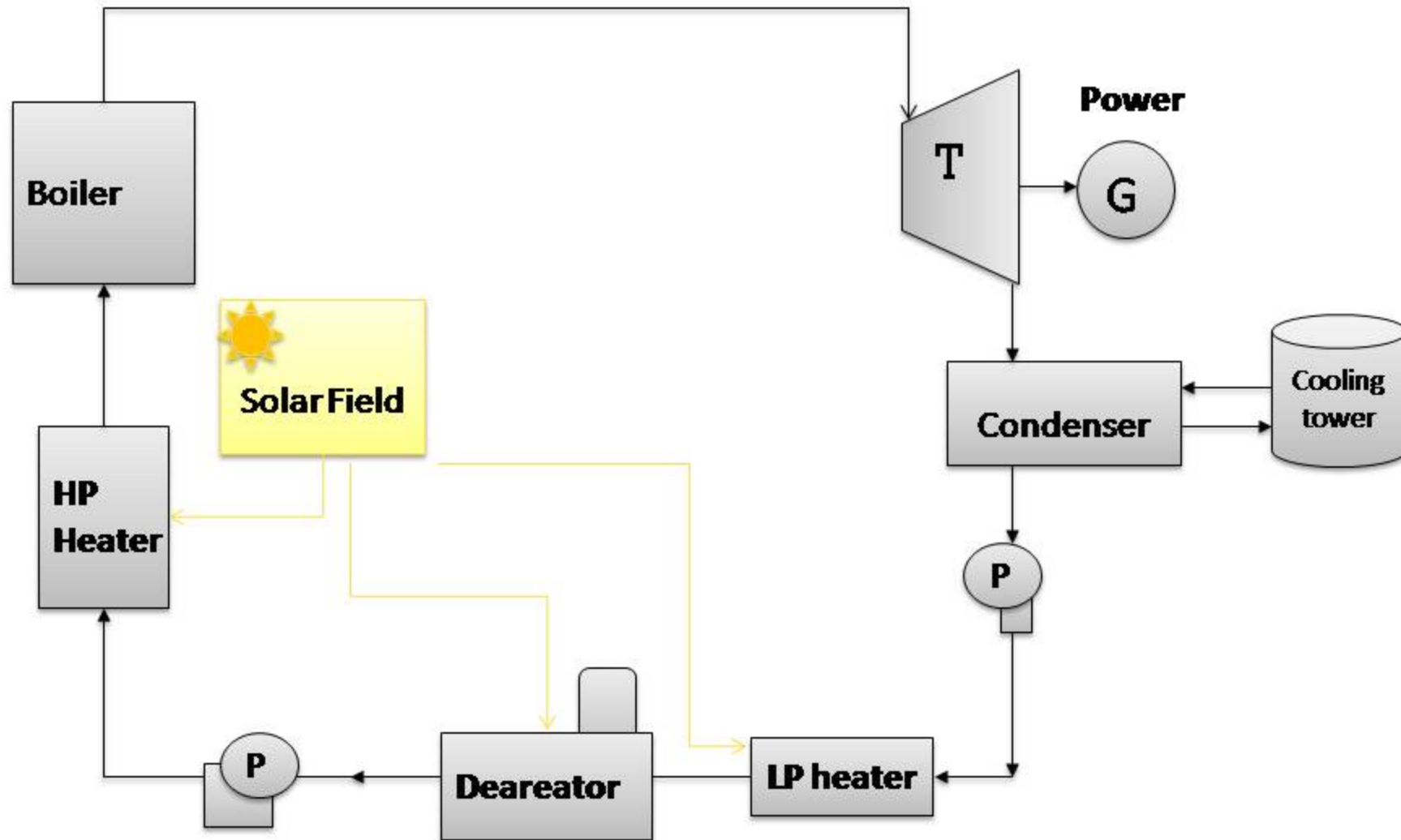
Hybridization : 500 MW

Conventional Solar Steam augmentation

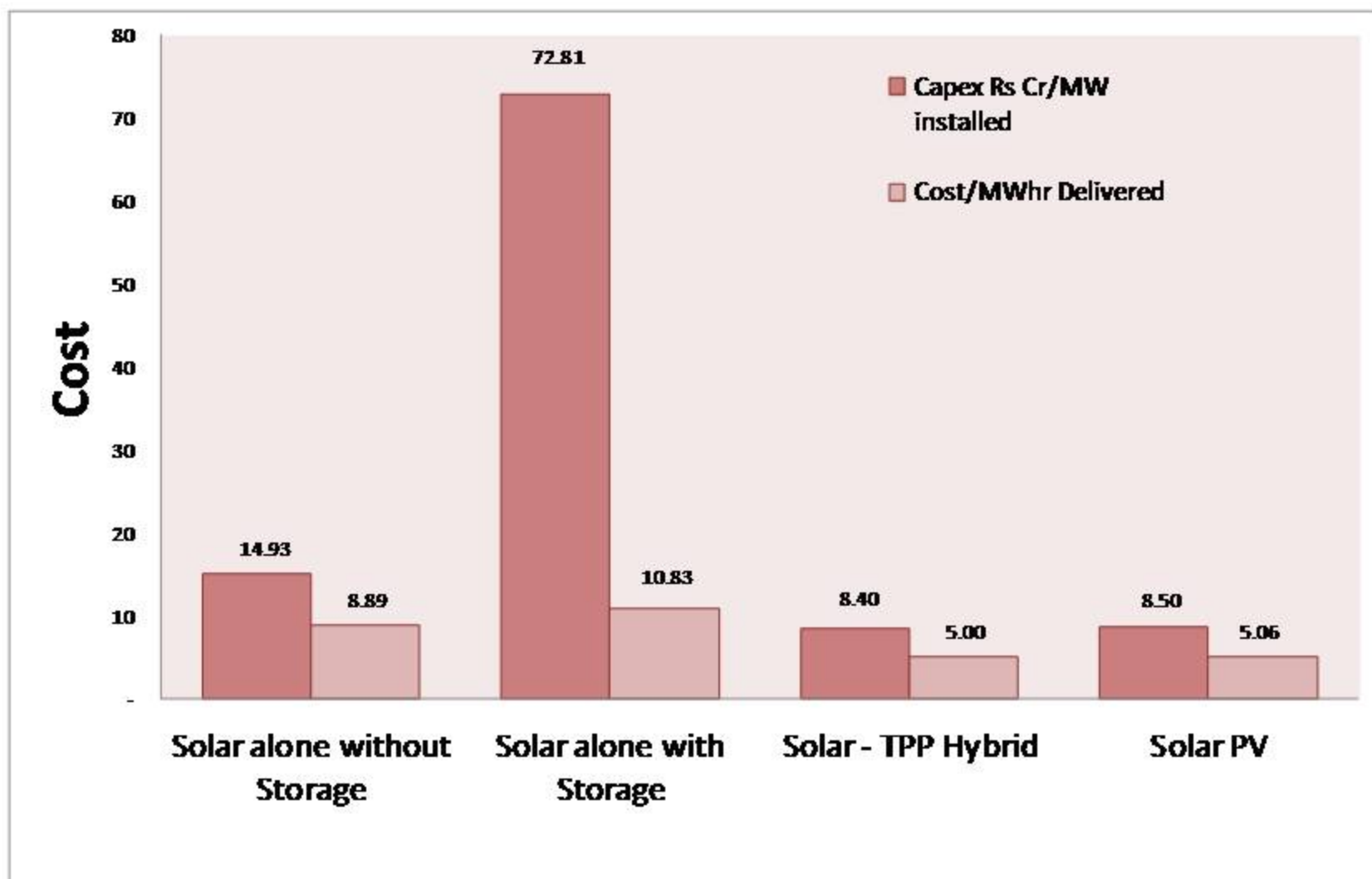


Smart Hybridization : 500 MW

Replacing all Turbine extraction with Solar



Smart Hybridization most cost effective Solar



The assumption is that we have coal plants where the average yearly DNI is > 1800 kWhr/m²

1

2

3

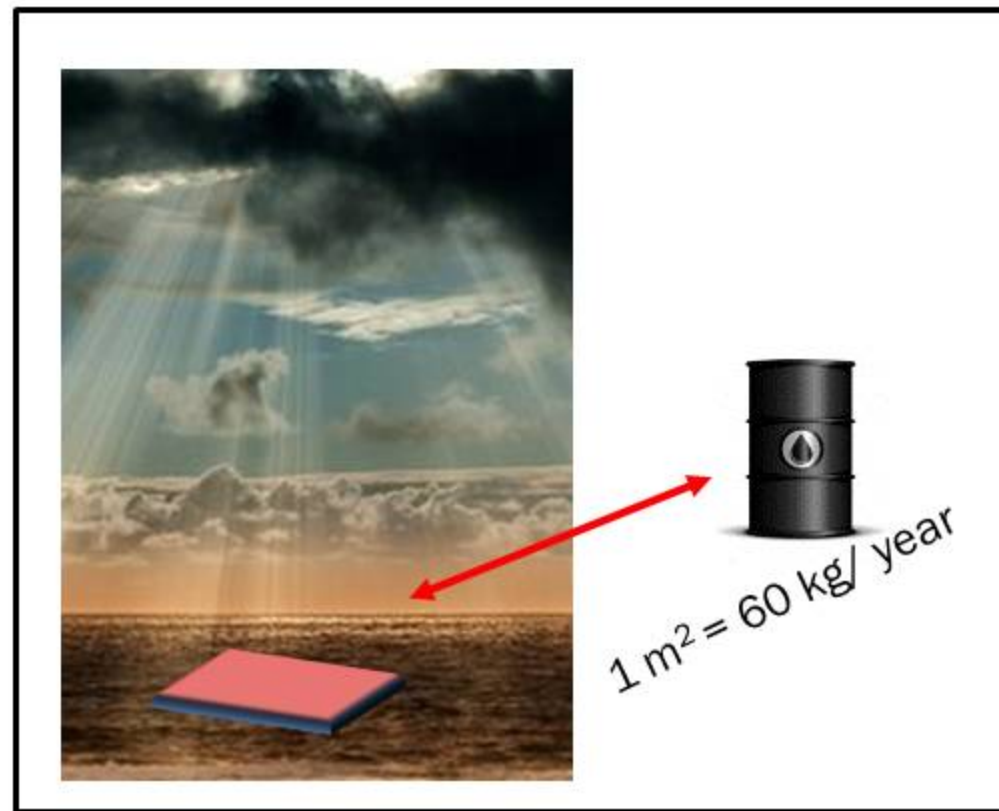
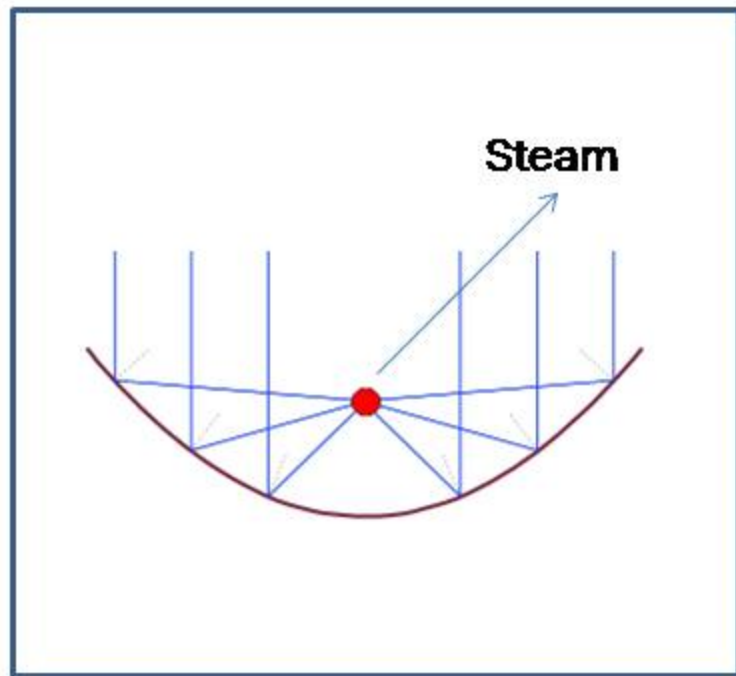
4



Solar / biomass at industrial heating level

RENEWABLES IN INDUSTRIAL HEATING: THE MISSING PIECE IN THE PIE

India consumes about 1.2 million barrels per day (25%) of crude oil for industrial heating which alone means 250 GW of equivalent energy. Cutting across all segments from chemical, food and beverages, automobile, metal processing and big complexes.



1 m² of solar collector can save oil of 60 kg's every year at an efficiency of 60% +

50°C

210°C

SolPac™ E45
Evacuated Tube Collector



- Evacuated Tube collector based on the Thermos flask principle
- Seamless Integration — Doesn't affect performance of existing system
- Mounted on Flat or Inclined Roof as well as Ground
- Easy installation due to modularity & pre-assembled components

SolPac™ NI30
Non-Imaging Collector



- Non-Imaging collector which can serve applications in industrial as well as commercial segments
- This product can give temperatures up to 120°C
- It does not require tracking mechanism thus reducing costs and can be easily mounted on flat as well as inclined roof

SolPac™ D160
Parabolic Dish



- Thermax has re-engineered conventional dish technology for medium temperature process heating & cooling applications
- This product can give temperatures up to 150°C
- This dish comes with a automatic dual axis tracking mechanism and completely boltable structure

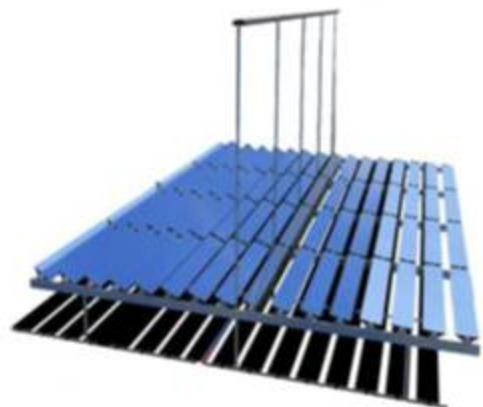
SolPac™ P60
Parabolic Trough



- Thermax has developed Parabolic Trough in-house
- Complete indigenization resulted in significant cost reduction
- This product can give temperatures up to 210°C
- Modular design allows for easy scalability & economies of scale

210 °C

Compact Linear Fresnel Reflector



- Can reach high temperatures up to 280°C
- Uses almost Flat Glass reflectors hence reliable
- Fixed Receiver
- 9 Modules with Peak capacity of 500kWth being set up at Mannaguru (India)

500 °C

Dual Axis parabolic dish For Thermo Electric Generators



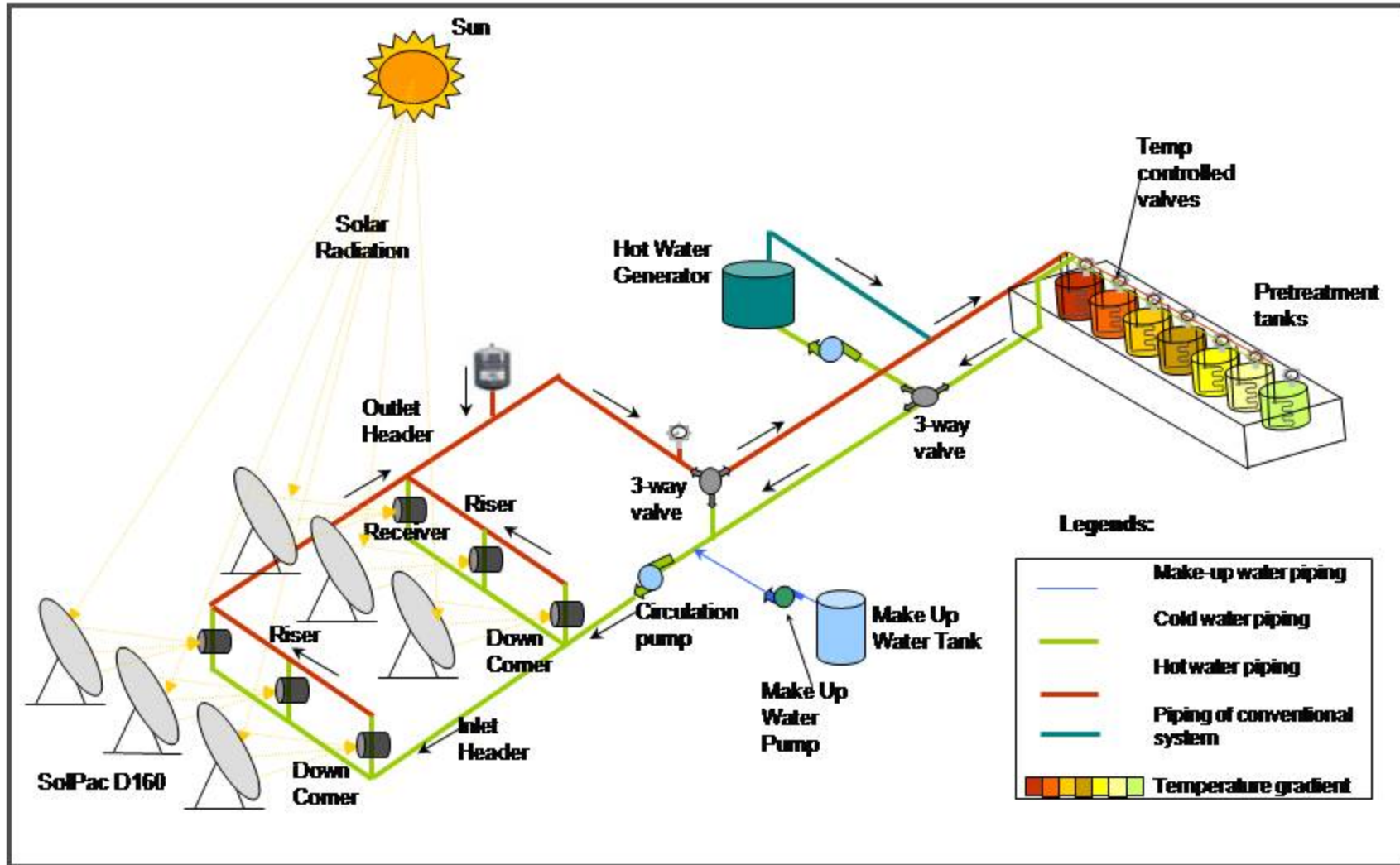
- Thermax has re-engineered conventional dish technology for combined heat and power generation
- This product can give temperatures up to 400°C
- The Dish works with a TEG receiver to deliver electric power as well as Thermal heat to run a VAM
- 2 Dishes with a VAM topping cycle installed at CSIRO Australia

1 MWe Solar Tower Parabolic Trough



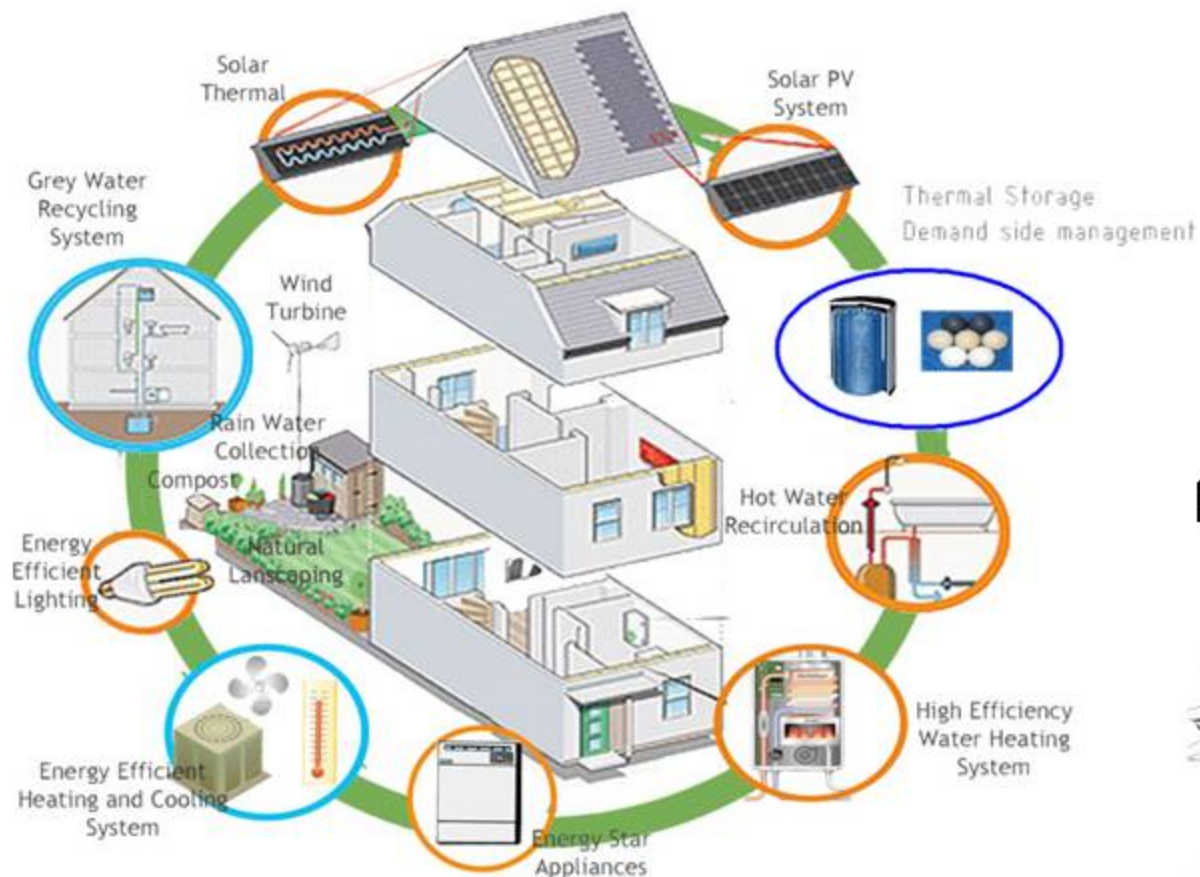
- Development of heliostat technology under SERIUS
- Modular design allows for easy scalability & economies of scale

One Typical Solution of Solar Boiler for Automobile 7 Tank Process



Solar for ROOM AIR CONDITIONER and Waste to cooking gas systems

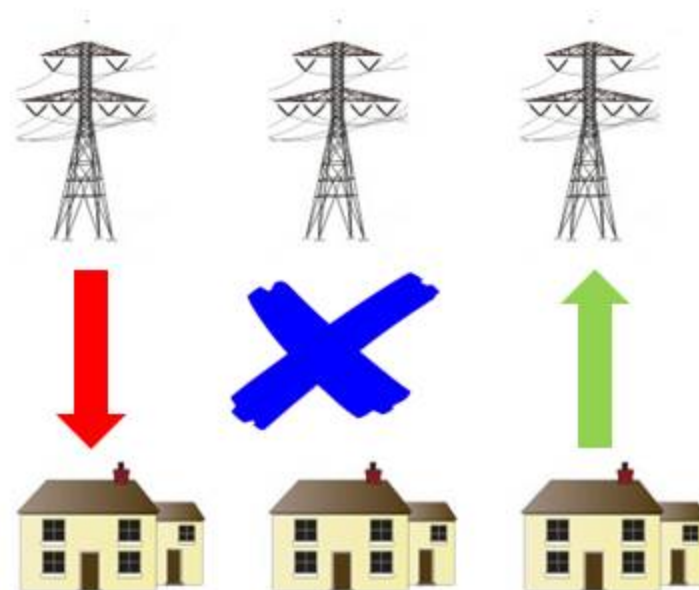
Grid independent to net energy buildings/ communities

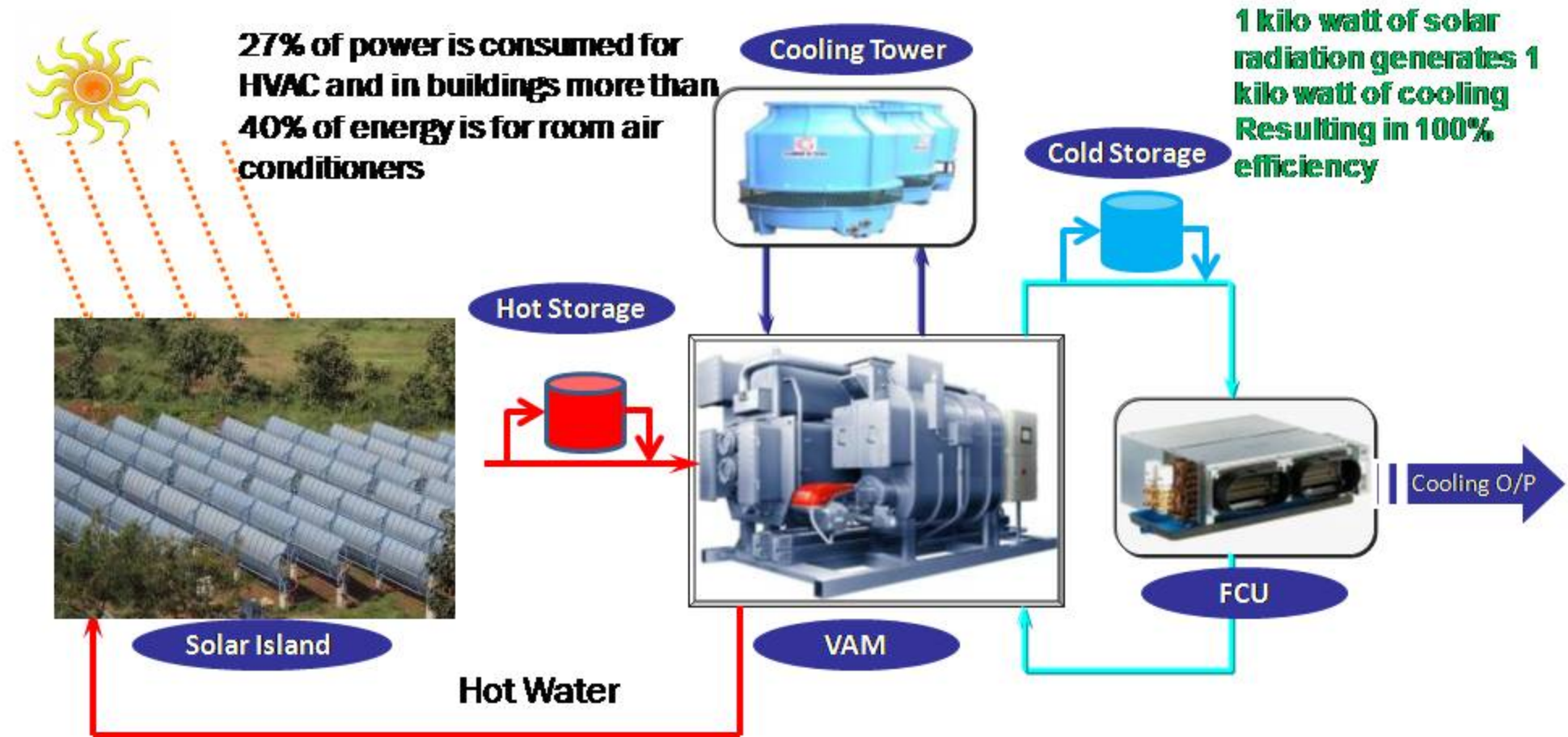


Fuel cells, Anaerobic digestion, Solar, Absorption heat pump

Series of new technologies Address big loads and RE based AC will have a large impact.

Net zero energy building





Solar thermal or direct PV driven AC will be the biggest game changer. Energy efficiency lightings (LEDs) are fine but if major shift has to happen on RE integration, then we need to innovatively build Solar to AC systems, package then like the current starred products both at domestic and commercial scale

Comfort Cooling at Solar Energy Centre, Gurgaon



Globally unique solar cooling solution using solar energy with a Triple Effect Vapour Absorption Chiller

Indigenous development of Parabolic Trough & Vapour Absorption Machine

Caters to cooling requirements of 13 office rooms in Solar Energy Centre

Co-efficient of Performance (COP) of 1.8 - highest among the vapor absorption technology

100 kW Solar Thermal Cooling project comprising of 284 sq. m. collector area generating 60000 kcal of heat to provide pressurized hot water at 210° C

Hydrogen economy via MeOH route

1. Methanol as one carbon fuel with excellent characteristics can become a low carbon fuel
2. Methanol can be produced from bio mass, industrial waste and also solar to fuel route
3. Fuel cells with efficiency (w/o heat integration) $>48\%$ and (with heat integration) $>75\%$ use methanol in final delivery of energy at user point

AGRO RESIDUE TO SYNTHESIS GAS TO METHANOL

Unique feature is very high calorific value gas and no water for gas clean up



THERMAX – ECN HOLLAND BIOMASS TO CO-GENERATION TECHNOLOGY

Efficiency advantage: DIRECT (ELETROCHEMICAL) CONVERSION TO ELECTRICITY

Specific Fuel Consumption

Small capacity (up to 25 kW) : ICE ~ 0.35-0.4 lit/kWh vs. FC ~ 0.2- 0.25 lit/kWh

25-50% savings in fuel consumption

Large capacity (> 100 kW) : ICE ~ 0.24 lit/kWh vs. FC ~ 0.2 lit/kWh

10-15% savings in fuel consumption

Emission advantage:

For Hydrogen : Zero Emission

For reformed HC's : No CO, NO_x, SO_x due to inherent operating conditions of reformer

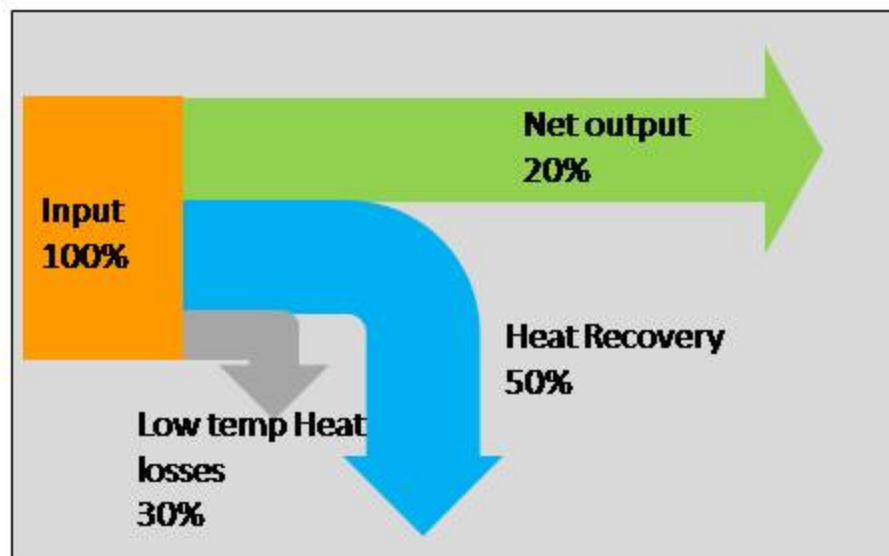
Clean fuel advantage:

Low carbon HC fuels like methanol / Ethanol / CNG

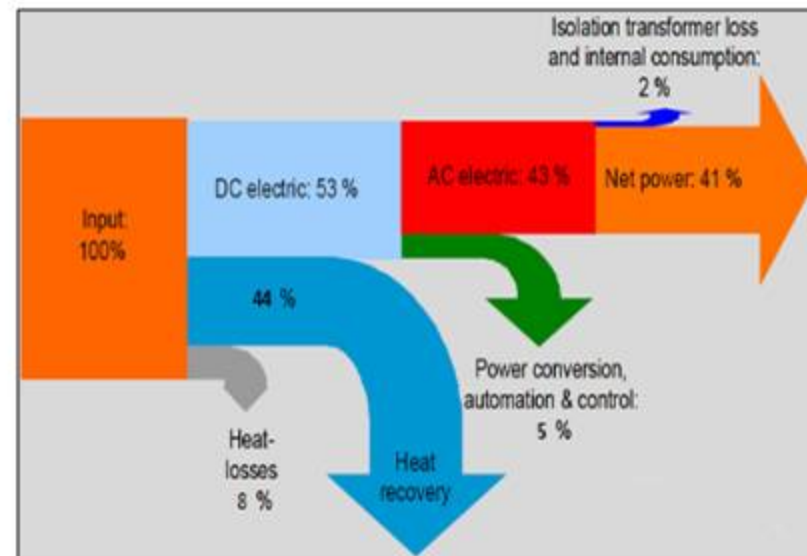
Ultimately converging to hydrogen in future

Small kW Power generation systems

IC Engines



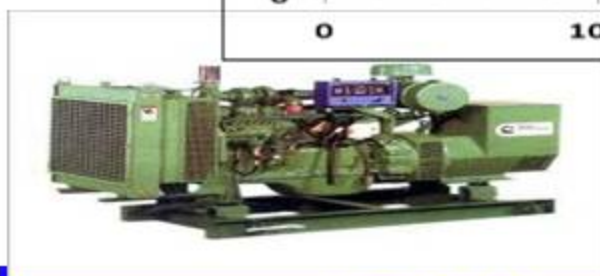
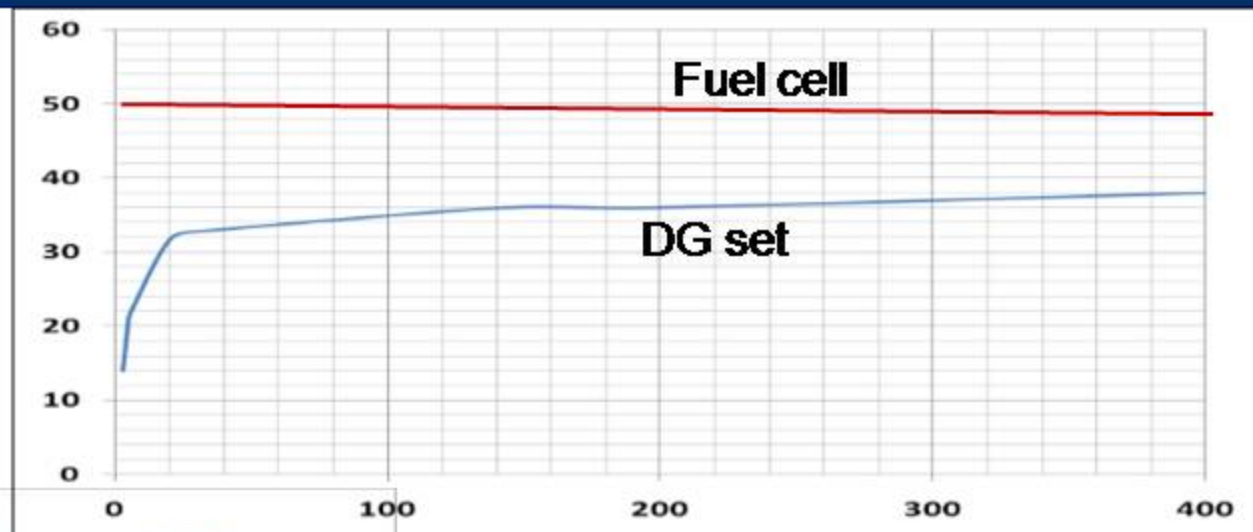
Fuel Cells



Fuel Cells seem to be better option with electric efficiency ~ 40% & CHP potential of 85%

Moreover, better integration for waste heat recovery since waste heat is extracted directly in the form of hot water

New Power Generation Technology: Fuel Cells



DG SETS

- 150 year old matured technology
- Highly optimized cost
- Efficiency still limited by Carnot cycle
- Emissions are high



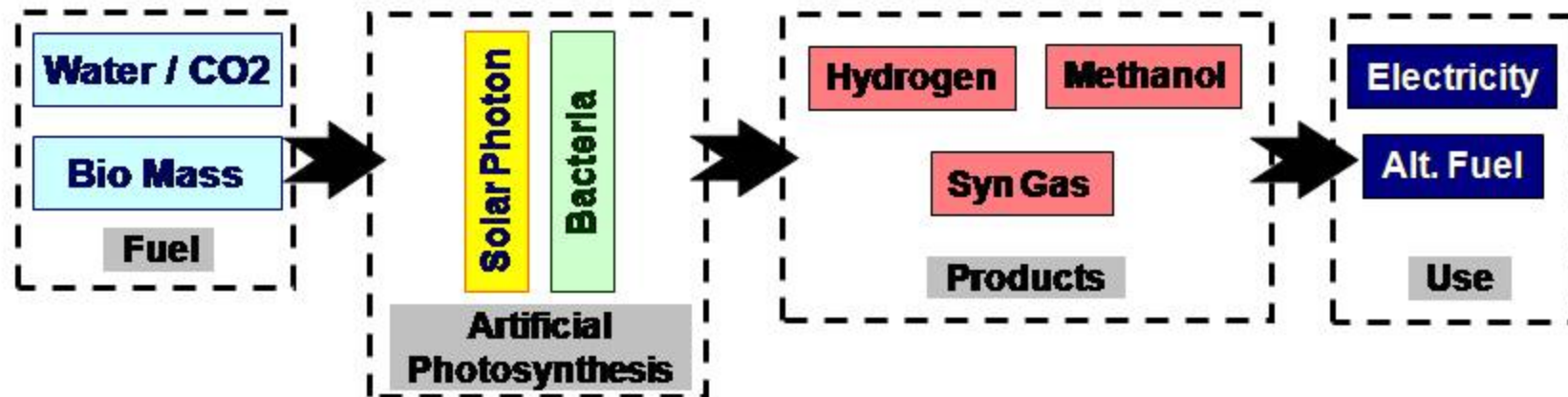
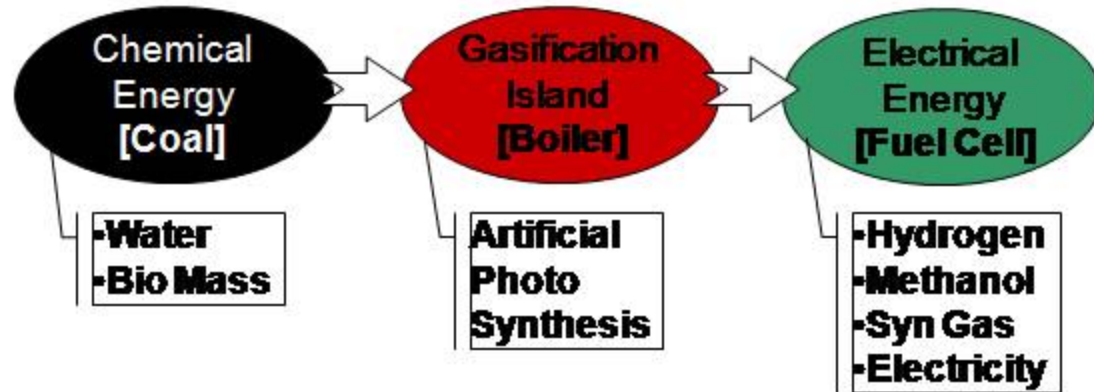
FUEL CELLS

- Disruptive technology
- High initial cost
- Almost double efficient compared to DG sets
- No emissions

Future energy scenario: cutting edge science

Frontier technology, Solar To Fuel And Electricity

Interfacing biology with physical sciences at nano-scale will be what ultimately will provide an abundant and perpetual source of fuel and power – perhaps at par with fusion. Fusion mimics solar while this would mimic nature (photo synthesis)



Thank You!

A large, glowing orange sphere with a textured, almost crystalline surface, set against a dark background. The sphere has a bright white highlight on its right side, giving it a three-dimensional appearance. The overall color palette is dominated by warm oranges and reds.

We must learn to happily progress
together or miserably perish together.
Man can live individually but can
survive only collectively *Atharva Veda*