বিজ্ঞান ও প্রযুক্তির মাধ্যমে সুস্থির জীবন ও অস্তিত্ব

A DISCUSSION ON

EXISTENCE, LIFE, SUSTAINABLE LIVING THROUGH SCIENCE AND TECHNOLOGY

25TH SEPETEMBER **TIME - 11 AM**

INNOVATION FOR GLOBAL SUSTAINABILITY 5I
INNOVATION
INSPIRATION
INVOLVEMENT
INFORMATION
INQUIRY
BHATTACHARYYA FOUNDATION

SARBODAY SANGHA
AJAYA, PURBA MEDINIPUR

IIEST, Shibpur
आई आई ई एस टि, शिवपुर
Erstwhile B E College (Estd 1856)

Anandalok Energy Pvt. Ltd.

Next episode:

- Hydrogen
- Demonstration of PV working

To Dear Mita & Soumitra
With Love!

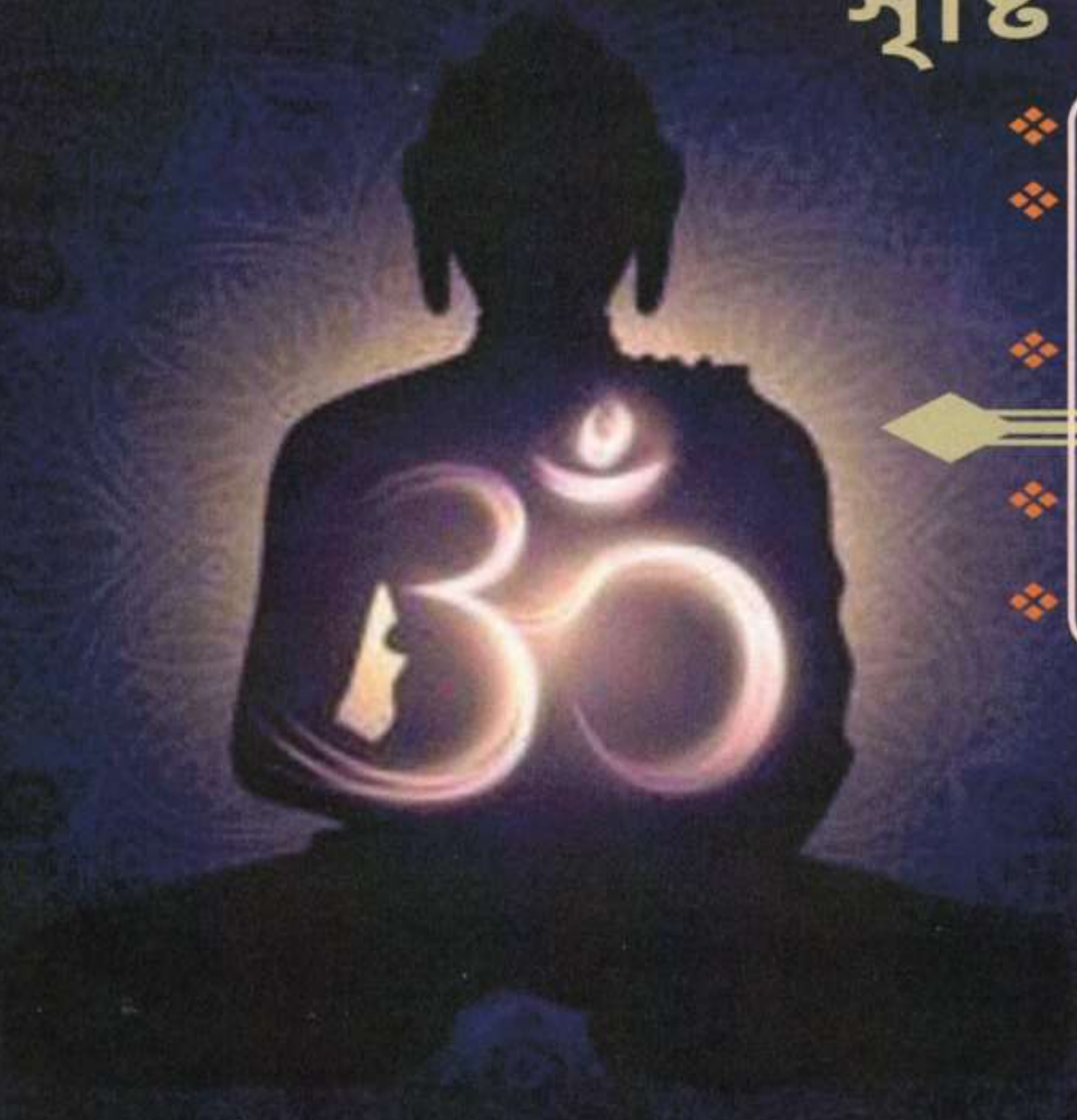
Anupda
18 Glenwood Dr., Essex Jct.
VT 05452
USA

Feb 2023


জীবন- সৃষ্টি ও স্থিতি
চিরন্তন এই পৃথিবী
ভাবনা ও নির্দেশনা: শ্রী অরূপ ভট্টাচার্য
রূপায়ণ: শ্রী সুগত ঘোষ

CREATION & EXISTENCE

সৃষ্টি ও স্থিতি



- অ: অনন্ত ব্রজশক্তি বিরাজ
- উ: উত্তর- দক্ষিণ- পূর্ব- পশ্চিম: সর্বদিকে প্রবাহিত
- ম: মুহুর্তম্ সর্বক্ষণ পরিবর্তনশীল

- ব: বহুরূপী আবদ্ধ শক্তি
- জী: জীবন্ত (চলমান) পদার্থ $E=mC^2$
- **E:** **ENERGY – FLOW in**
- **S:** **SPACE**
  &
- **T:** **TIME**

- **M:** **MATTER:** $E=mC^2$ **(Low Probability)**
- **L:** **LIFE** **(VERY Low Probability)**

TIME SPAN: “ म ”

!! BE HUMBLE SAPIEN !!

Universe: 4.4 E 17 Sec (Formed in 10^{-43} Sec)

Time Dimension: 10^{-43} to 10^{17} Sec

Ξ 10^{60} Sec Ξ 14 Billion Years

Our GALAXY: 13.6 Billion Years old

Our SUN: 4.57 Billion Years old

Our EARTH: 4.5 Billion Years old ≈ 10^{17} Sec Old

Homo-Sapien → 200k years → 6E12 Sec

(Human form of LIFE)

Human form is a very recent life form of Existence

Human Life: 100 Years (Max)

EARTH	HUMAN	A Person's Life
10^{17} Sec	$6X10^{12}$ Sec	$3X10^{7}$ Sec

One HUMAN LIFE IS NEARLY INSIGNIFICANT IN NATURE'S TIME SCALE

SPACE

Defined by ***'Flow of Energy'*** within the confines of

'OUR UNIVERSE ONLY'

Unit: 1 Light Year = 1 E18 cm

Our UNIVERSE is Expanding in TIME

Edge of Space ~ 23 E 12 Light Year Away

= $23X10^{23}$ cm

Diameter of the Earth: ~ 3 E9 cm

Space to Earth Ratio: 8 E21 !!

OUR BLESSED EARTH WITH FULL OF LIFE

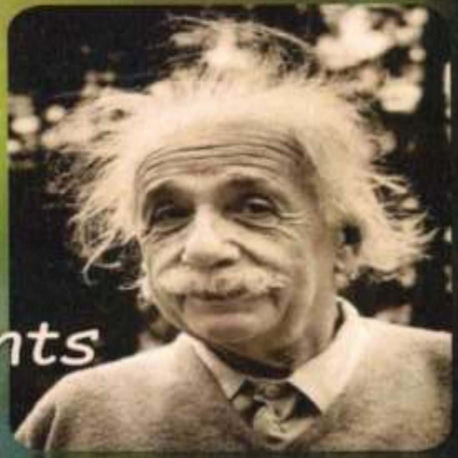
&

BEAUTY IS NOT EVEN

A TINY DOT IN SPACE

MATTER

A form of energy
PRIMARILY FROZEN IN SPACE
With the exception of Radio-Active Matter
(Emitting energy)



$E = mc^2$

Guru: EINSTEIN

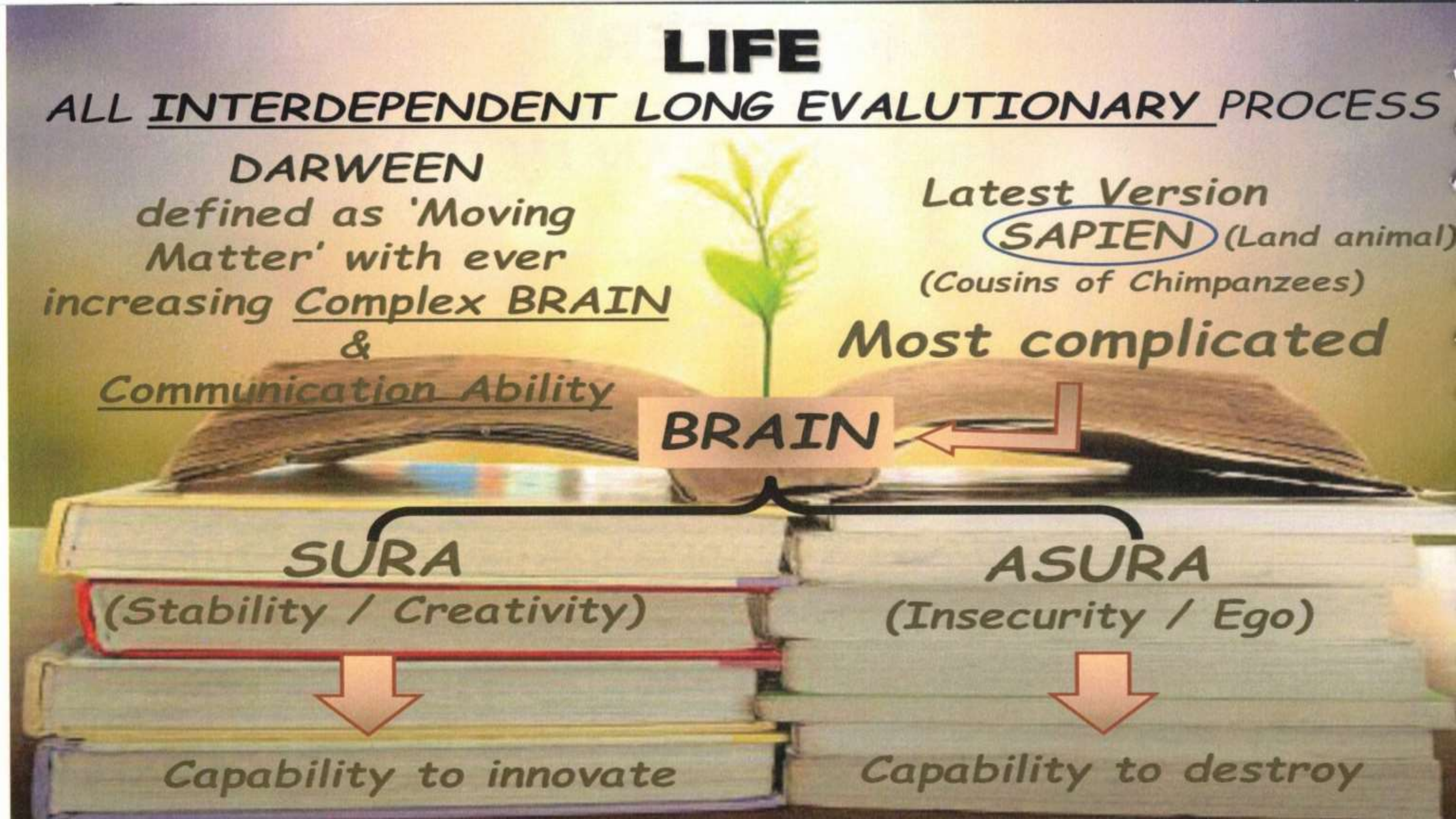
See periodic table of elements

LIFE

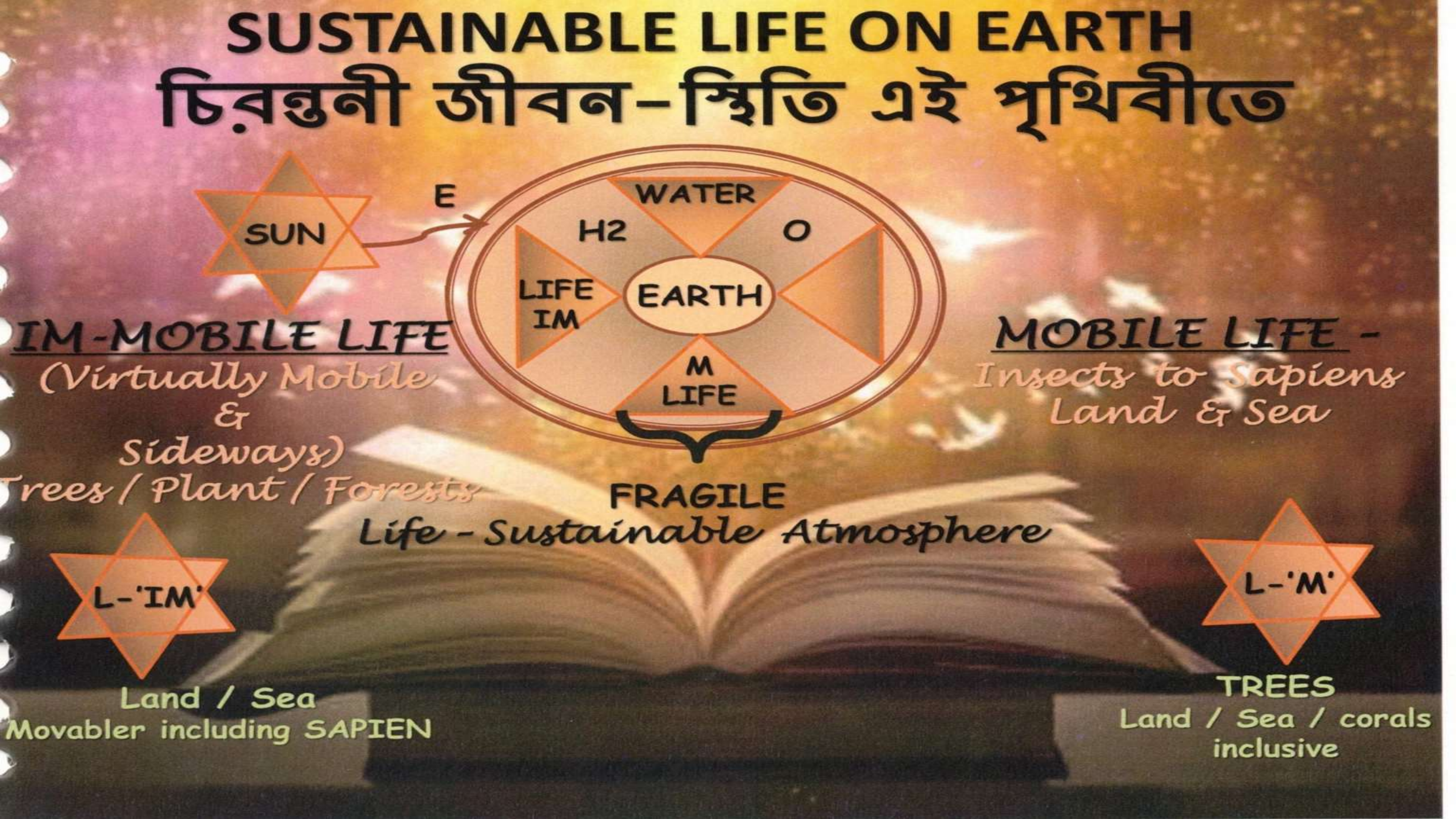
With a very low probability Matter transforms into "LIFE"
In the presence of
WATER → H2 + O

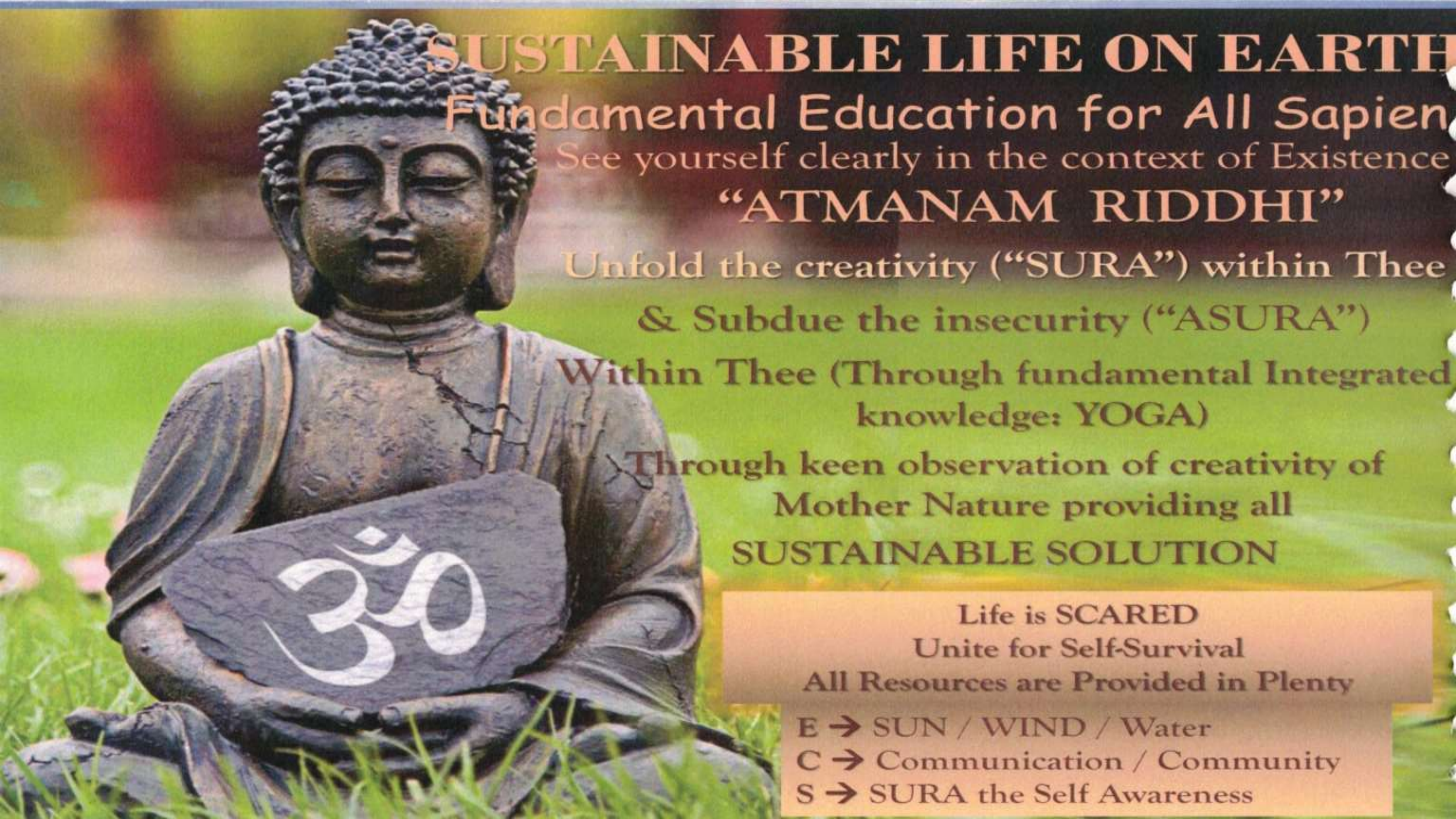
Key to "MOTION"

Nature's Fuel
(Energy Pure)



LIFE
ALL INTERDEPENDENT LONG EVALUTIONARY PROCESS
DARWEEN
defined as 'Moving Matter' with ever increasing Complex BRAIN & Communication Ability
Latest Version
SAPIEN (Land animal)
(Cousins of Chimpanzees)
Most complicated
BRAIN
SURA
(Stability / Creativity)
Capability to innovate
ASURA
(Insecurity / Ego)
Capability to destroy


SUSTAINABLE LIFE ON EARTH
চিরন্তনী জীবন–স্থিতি এই পৃথিবীতে
SUN
E
WATER
H2
O
LIFE
IM
EARTH
M
LIFE
IM-MOBILE LIFE
(Virtually Mobile
&
Sideways)
Trees / Plant / Forests
MOBILE LIFE -
Insects to Sapiens
Land & Sea
FRAGILE
Life - Sustainable Atmosphere
L-'IM'
Land / Sea
Movabler including SAPIEN
L-'M'
TREES
Land / Sea / corals
inclusive

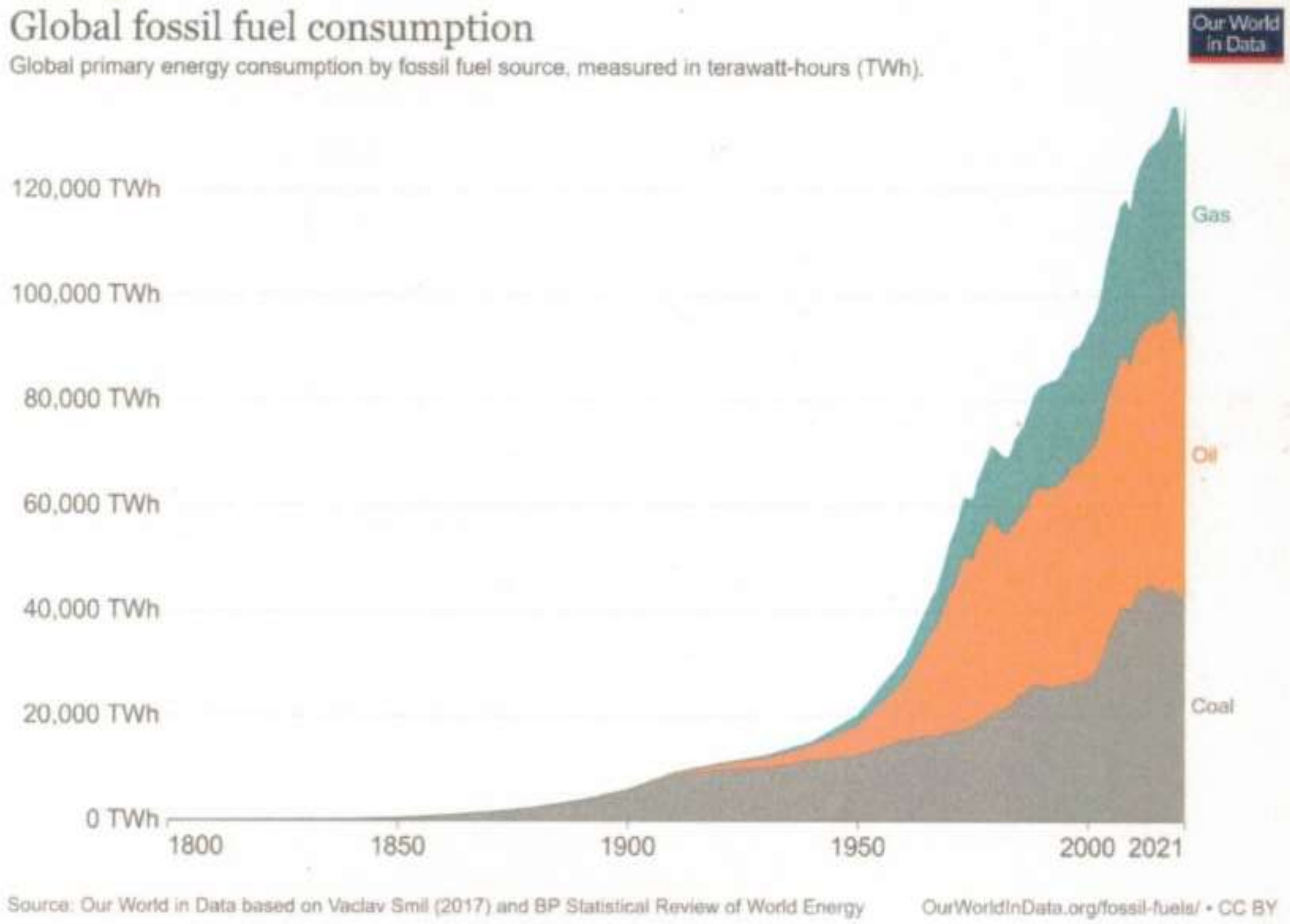

SUSTAINABLE LIFE ON EARTH
Fundamental Education for All Sapien
See yourself clearly in the context of Existence
"ATMANAM RIDDHI"
Unfold the creativity ("SURA") within Thee
& Subdue the insecurity ("ASURA")
Within Thee (Through fundamental Integrated knowledge: YOGA)
Through keen observation of creativity of Mother Nature providing all
SUSTAINABLE SOLUTION
Life is SCARED
Unite for Self-Survival
All Resources are Provided in Plenty
E → SUN / WIND / Water
C → Communication / Community
S → SURA the Self Awareness


প্রণাম


ALL
INDIANS
MUST KNOW

শক্তির ইতিহাস
গত তিন শতাব্দী এবং গত **60** বছর

- অষ্টাদশ শতকে ইংল্যান্ডে শিল্প বিপ্লবের বিকাশের ফলে কয়লার ব্যবহার ব্যাপক বৃদ্ধি পায়। কারণ বাষ্প ইঞ্জিন জল- চাকা থেকে দখল করে নেয়।
- জীবাশ্ম জ্বালানি: কয়লা + তেল + প্রাকৃতিক গ্যাস কেবলমাত্র গত তিন শতাব্দীর জন্য নয়, বিশেষ করে গত 60 বছর ধরে বিশ্বব্যাপী স্থিতিশীলতা-য় চরম সঙ্কট সৃষ্টি করেছে।
- ফলস্বরূপ বৈশ্বিক অর্থনীতিতে সুবিধাভোগী ও অবহেলিত শ্রেণী এর মধ্যে প্রায় 90% বৈষম্য আজও বর্তমান।
- 1700 সালে, বিশ্বের পাঁচ-ছয় ভাগ কয়লা ব্রিটেনে খনন করা হয়।



ভারতের প্রাচীন অবস্থা ও পরিবর্তনের ইতিহাসঃ

ইতিহাসের ঊষালগ্ন থেকে আকবরের শাসনাকাল পর্যন্ত ভারত ছিল পৃথিবীর সবচেয়ে ধনী দেশ

1720: ভারতকে বিশ্বের অন্যতম ধনী দেশ হিসেবে গণ্য করা হত। বিশ্ব জনসংখ্যার 23.4% ধারণকারী দেশ ভারত বিশ্বের জিডিপির 29% এর অংশীদার হিসেবে চিহ্নিত ছিল।

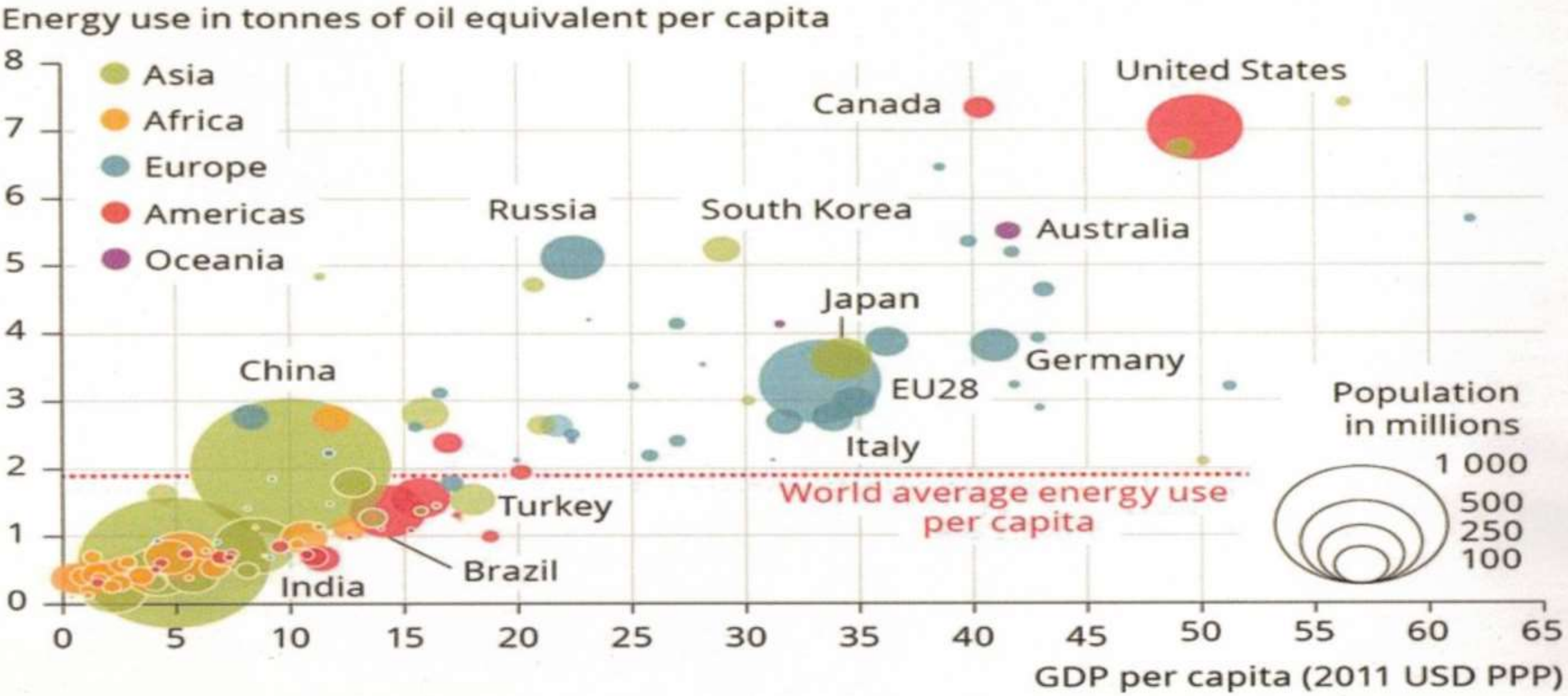
1৪20: ভারতের জিডিপি বিশ্বের জিডিপির 16% এ ও জনসংখ্যা বিশ্বের 22% এ হ্রাস পায়

1920: বিশ্বের মোট জনসংখ্যার 19.9% জনসংখ্যা ধারণের সাথে ভারতের জিডিপি আরও কমে বিশ্ব জিডিপির 6.5%-এ নেমে আসে।

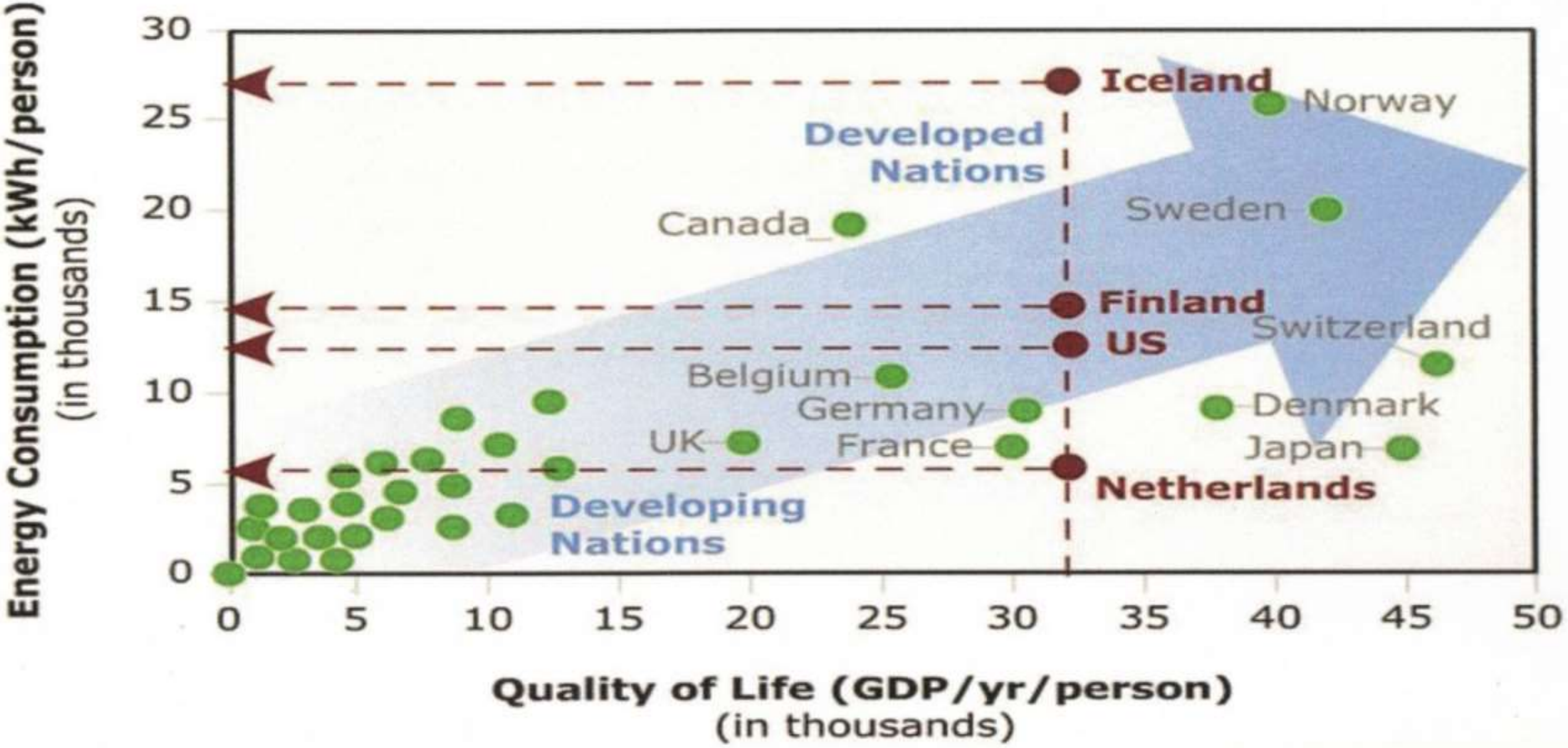
2020: ভারতের জিডিপি বিশ্ব জিডিপির মাত্র 3.62% এবং ভারত এখন একটি "তৃতীয়-বিশ্বের দেশ যখন বিশ্বের জনসংখ্যার 22.9% ভারতে বর্তমান"

SOURCE: International Monetary Fund: World Economic Outlook Database April 2019; United Nations: National Accounts Main Aggregates Database

"FOR THE NATION THAT CONTROLS THE ENERGY CONTROLS THE GLOBE"



শক্তির ব্যাবহার ও জীবন যাত্রার মান



হৃত গৌরব পুনরুদ্ধারের প্রধান রাস্তা
শক্তি ক্ষেত্রে স্বাবলম্বন

Self sufficiency in
energy harvesting

শক্তি মানচিত্রে ভারতের অবস্থানঃ

- ভারতের (জনসংখ্যা **1366** মিলিয়ন) মোট শক্তির প্রয়োজন **210 GW** চেয়ে কম. *(April,2022 The Hindu)*। যা মে-জুন মাসে বেড়ে হবে, প্রায় 215-220 GW।

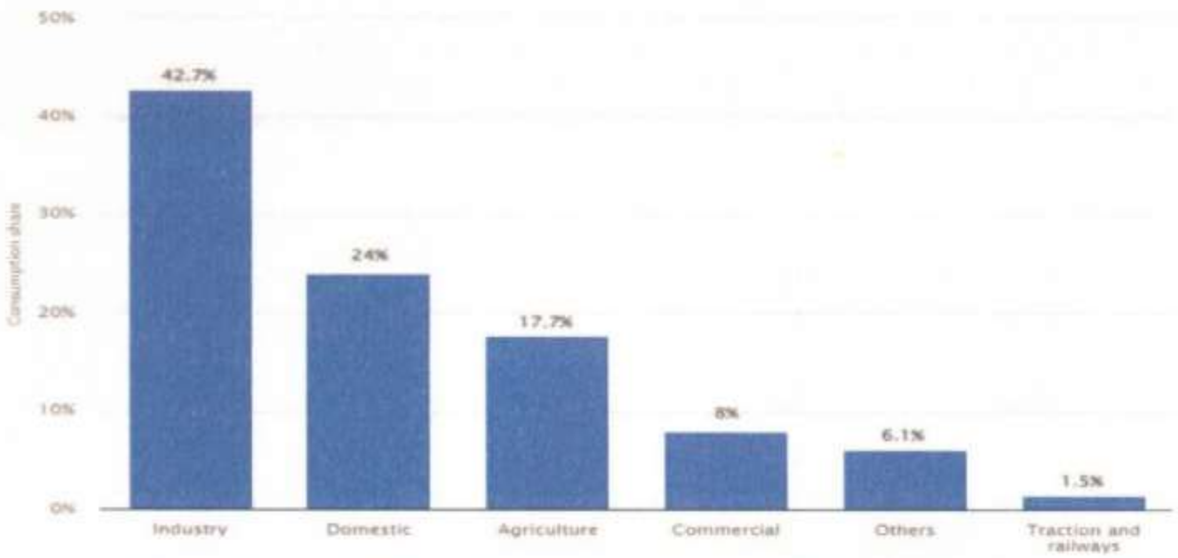
(Source: MNRE)

- ~60% শক্তির প্রয়োজন **Fossil Fuel** (জীবাশ্ম জ্বালানী) দ্বারা সরবরাহ করা হয় (বৈদেশিক নির্ভরতা সহ)

(Source: Ministry of Power)

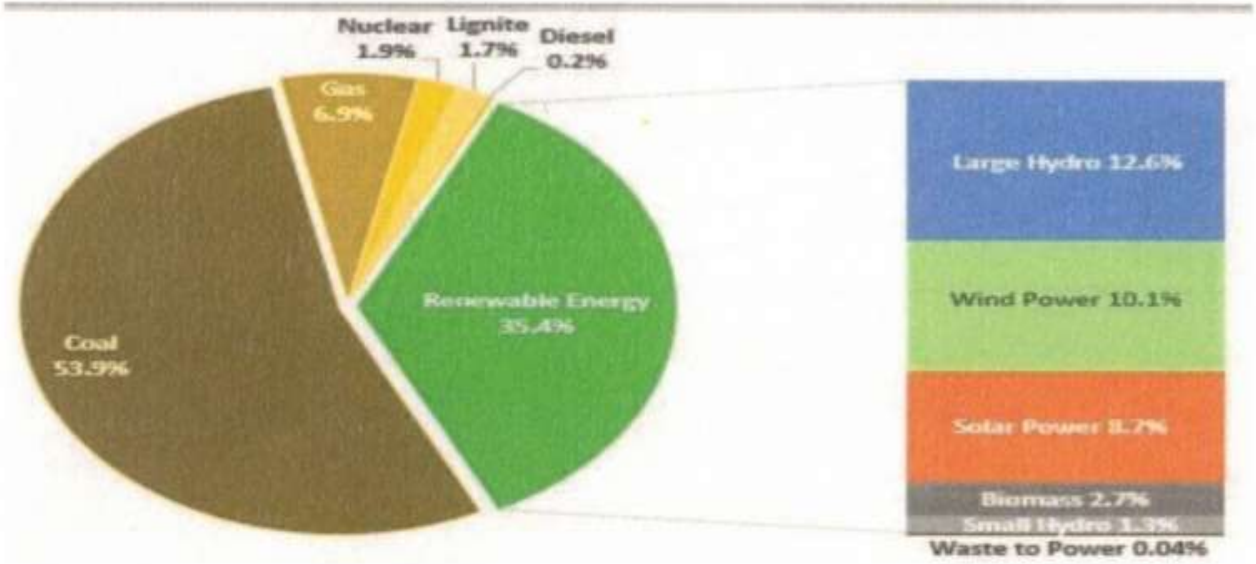
- ফলস্বরুপ মারাত্মক দূষণ, অনিয়মিত বর্ষা, জলবায়ু পরিবরতন, স্বাস্থ্য সমস্যা এবং উত্পাদনশীলতা ক্ষতি ।

- ভারত এখনও একটি তৃতীয় বিশ্বের দেশের পর্যায়ে রয়েছে।



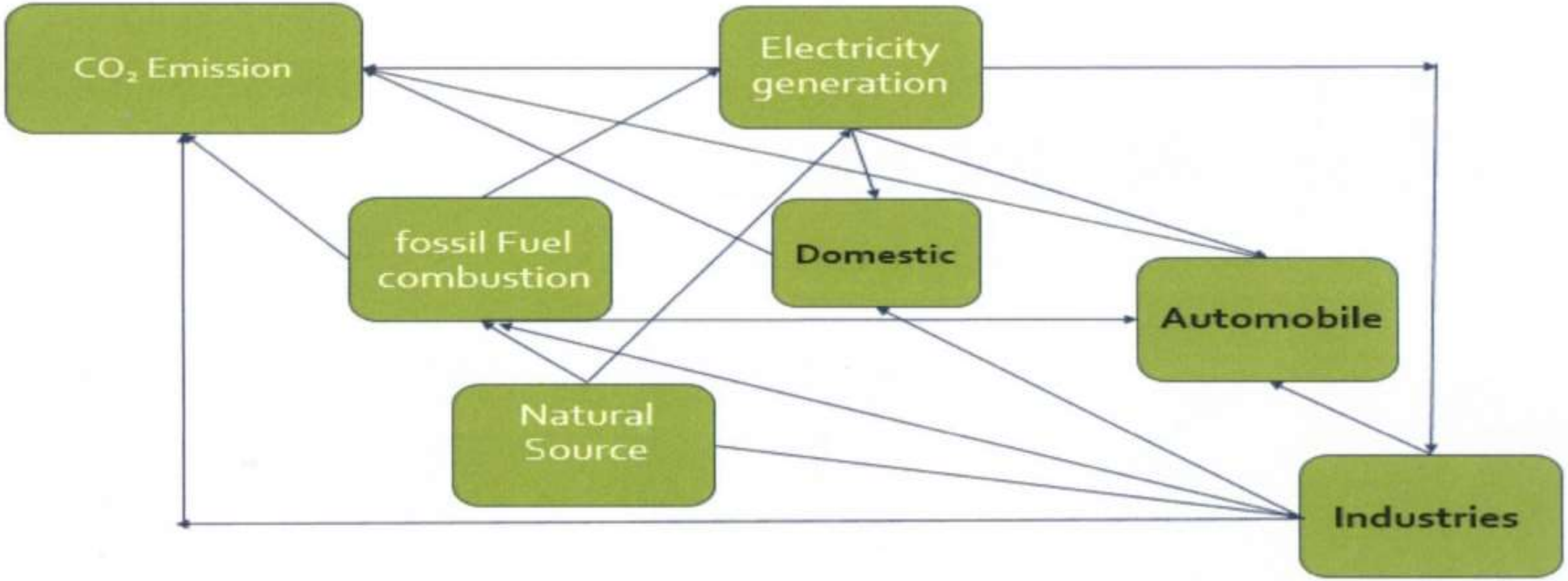
বিভিন্ন খাতে শক্তির খরচ

India - Cumulative Installed Power Capacity Mix (%)



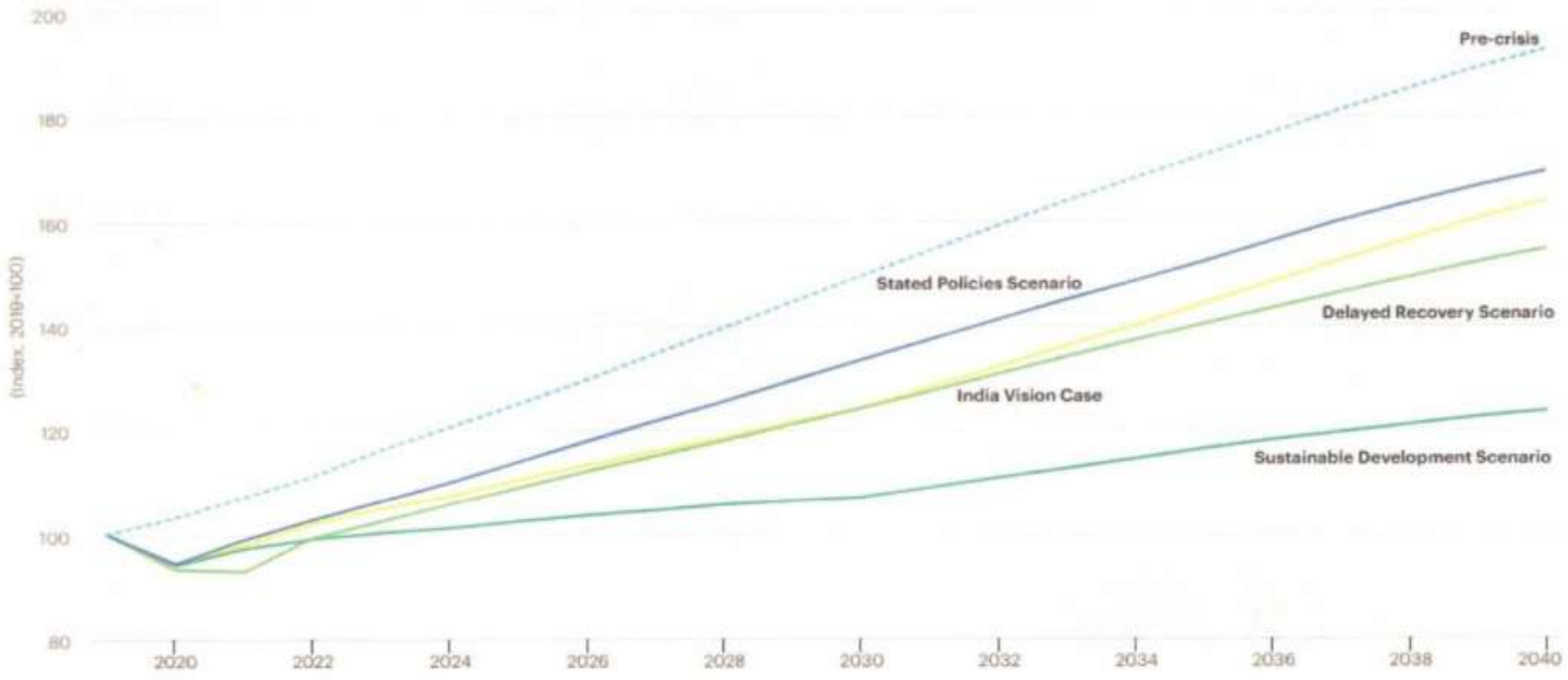
বিভিন্ন খাতে শক্তির উৎপাদন

শক্তি উৎপাদনের বিভিন্ন স্তরের আন্তঃসম্পর্ক, জীবাশ্ম জ্বালানীর বিস্তার



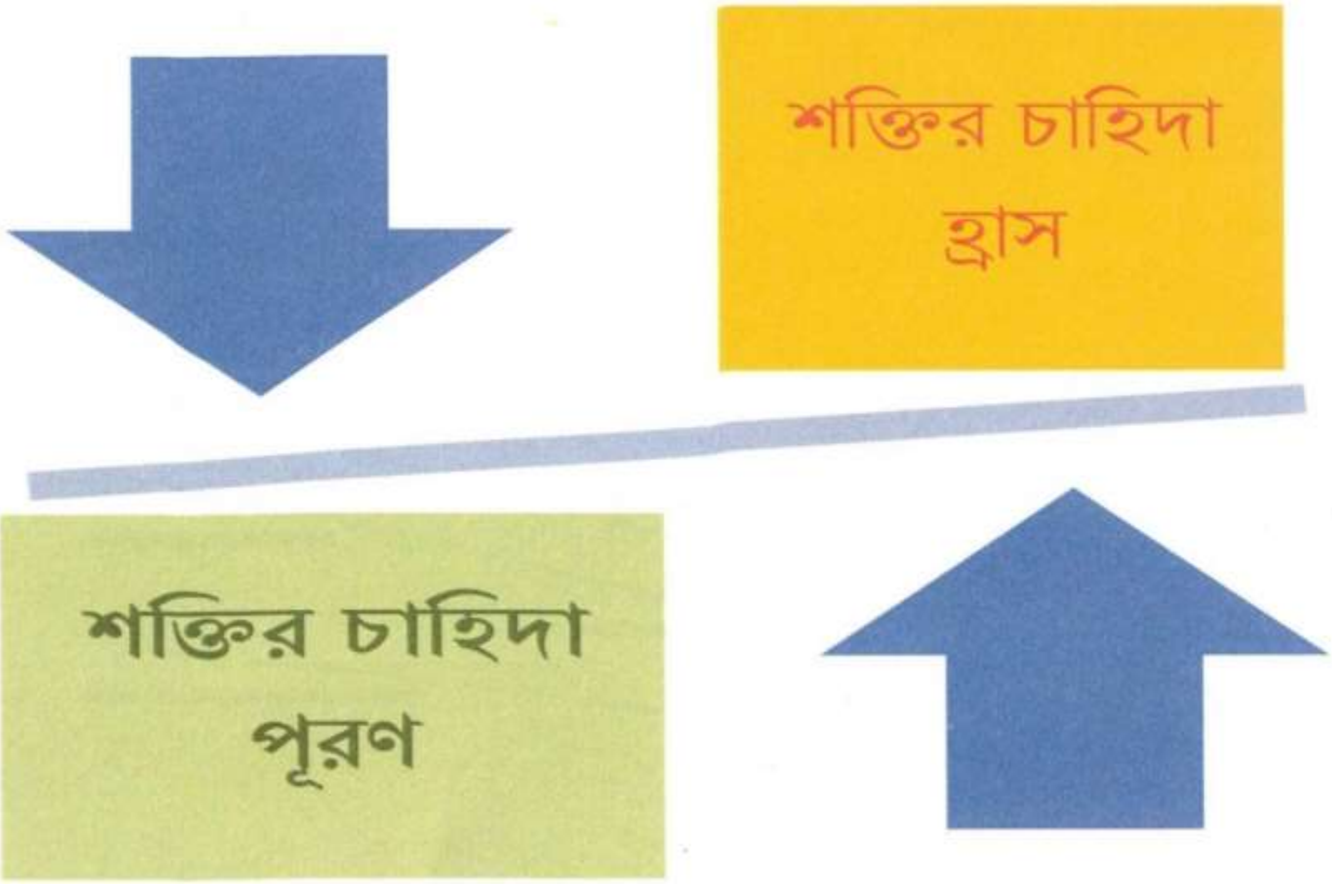
স্থিতীশীল উপায় অবলম্বনঃ

the international energy outlook প্রকাশিত গবেষণাগুলি বিভিন্ন উন্নয়ন কৌশলের উপর নির্ভর করে বিভিন্ন চাহিদা বক্ররেখা দেখায়।

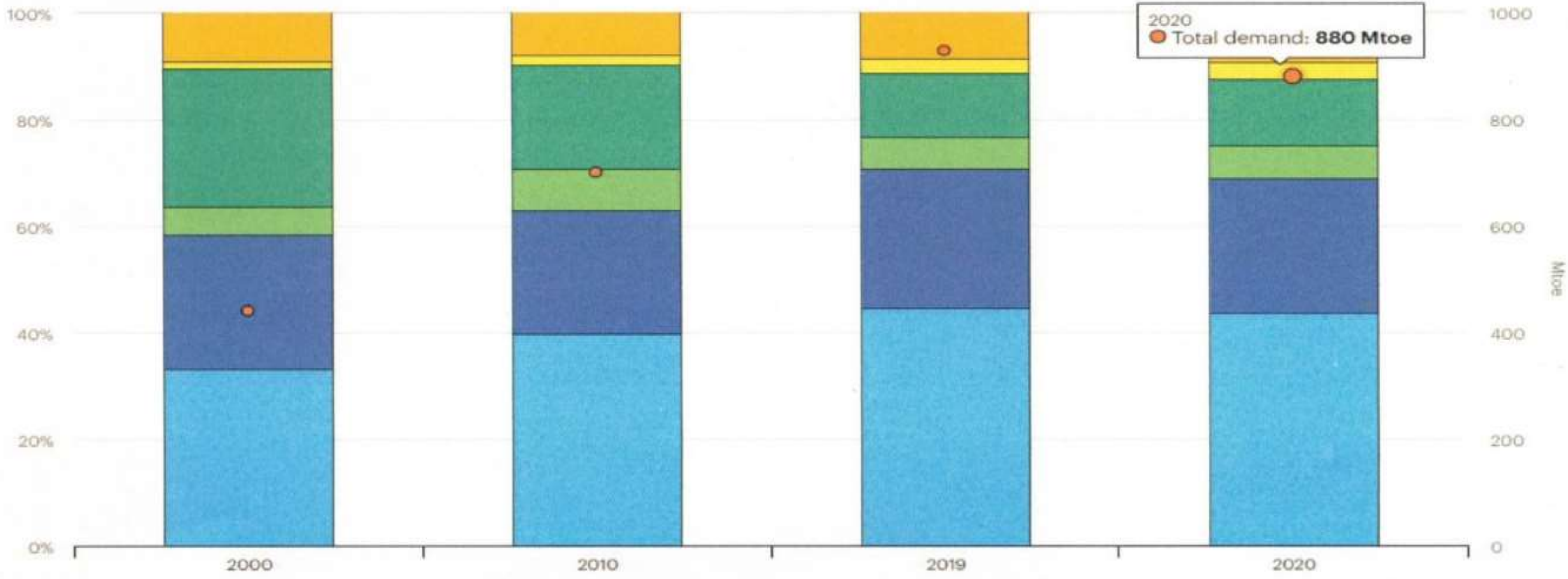


Post covid energy demand curve show a demand growth index ~193
Same falls to ~ 123 for sustainable approach

স্থিতীশীল উন্নতি **Balance**



কোভিড পরবর্তী ভারতে শক্তির চাহিদা বৃদ্ধি ও জীবাশ্ম জ্বালানীর ব্যাবহার

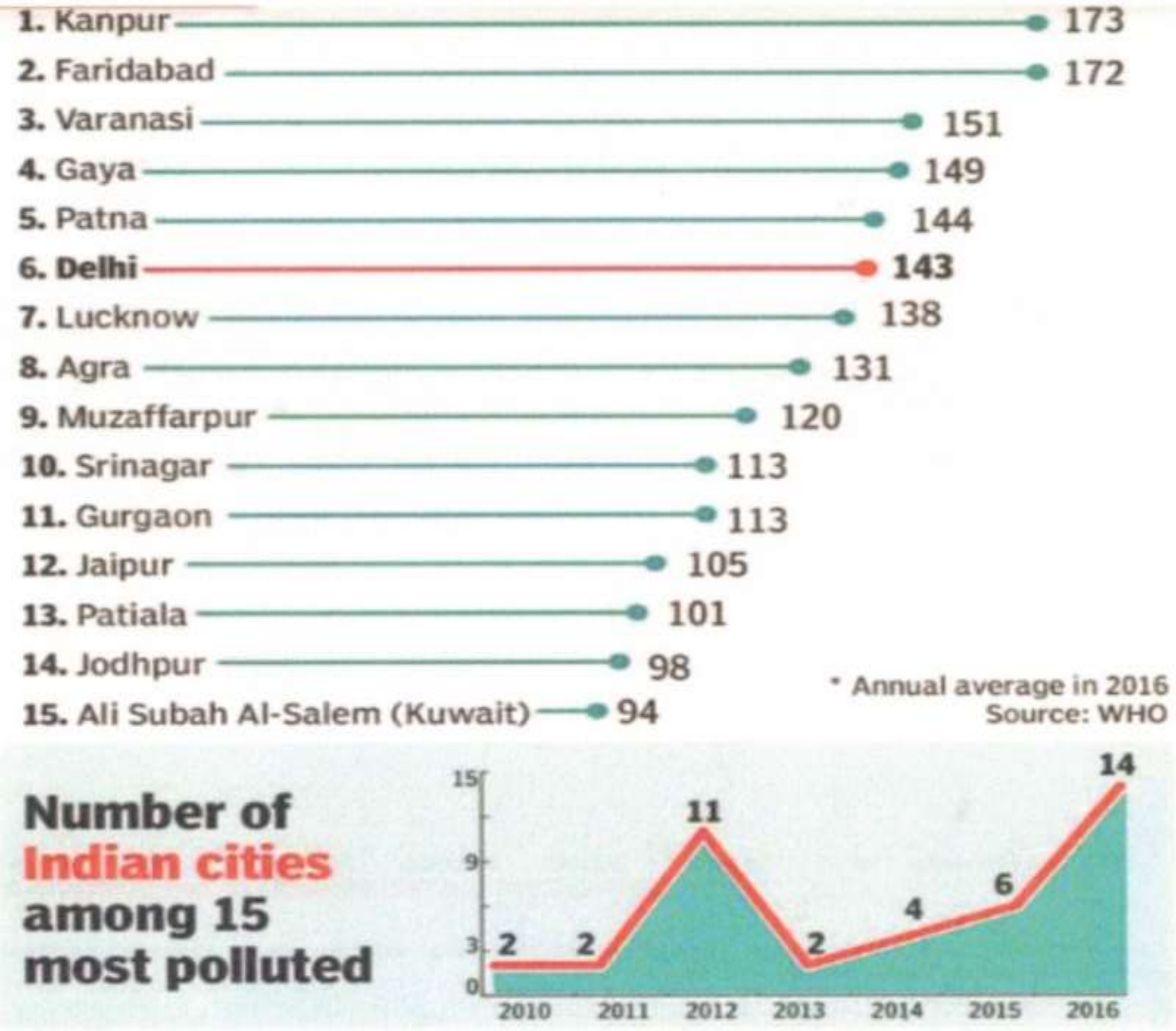



জীবাশ্ম জ্বালানীর
অতিরিক্ত ব্যাবহার
ও ফলাফল

বর্তমান ভারতে পরিবেশ দূষণ ও স্বাস্থ্য সঙ্কট

WHO-এর মতে, অগ্রহণযোগ্য বায়ুর গুণমান সহ বিশ্বের
15টি সবচেয়ে খারাপ মেগাপোলিসের মধ্যে 14টি
ভারতের অন্তর্গত

Zurich,
Switzerland
(0.46 µg/m3)

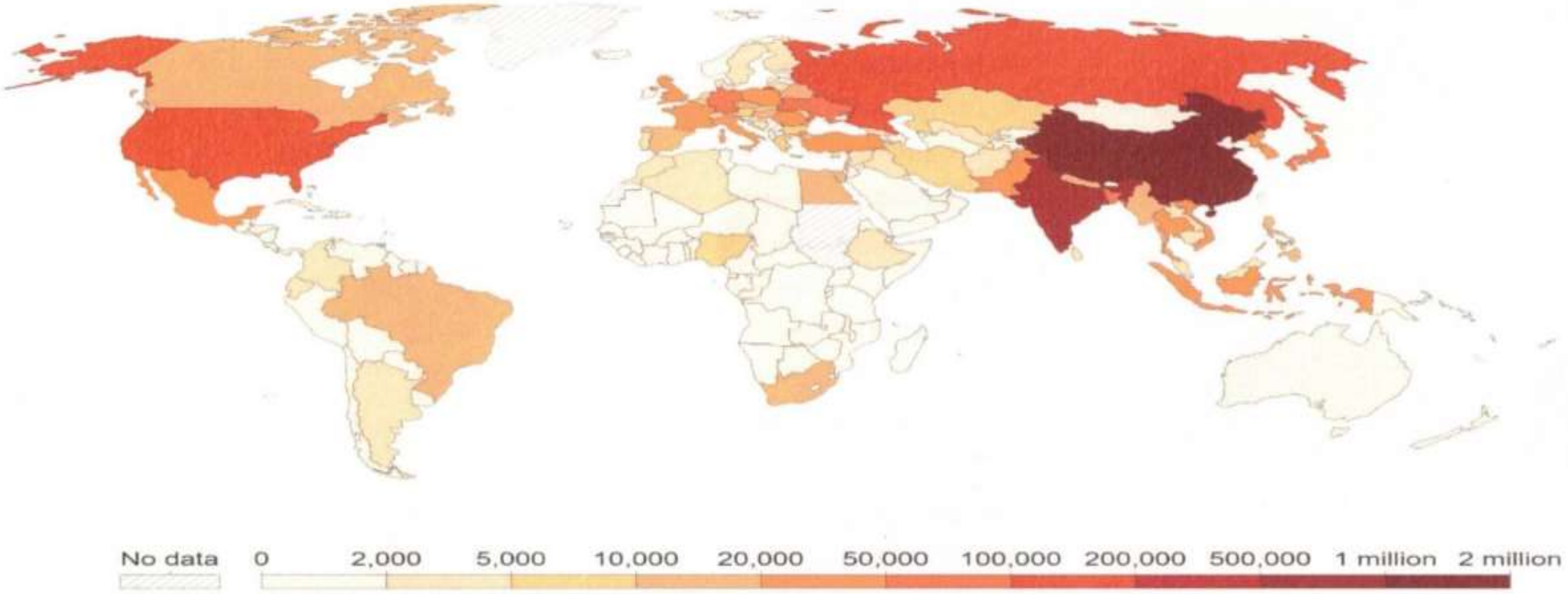


বায়ু দূষণের প্রভাবঃ

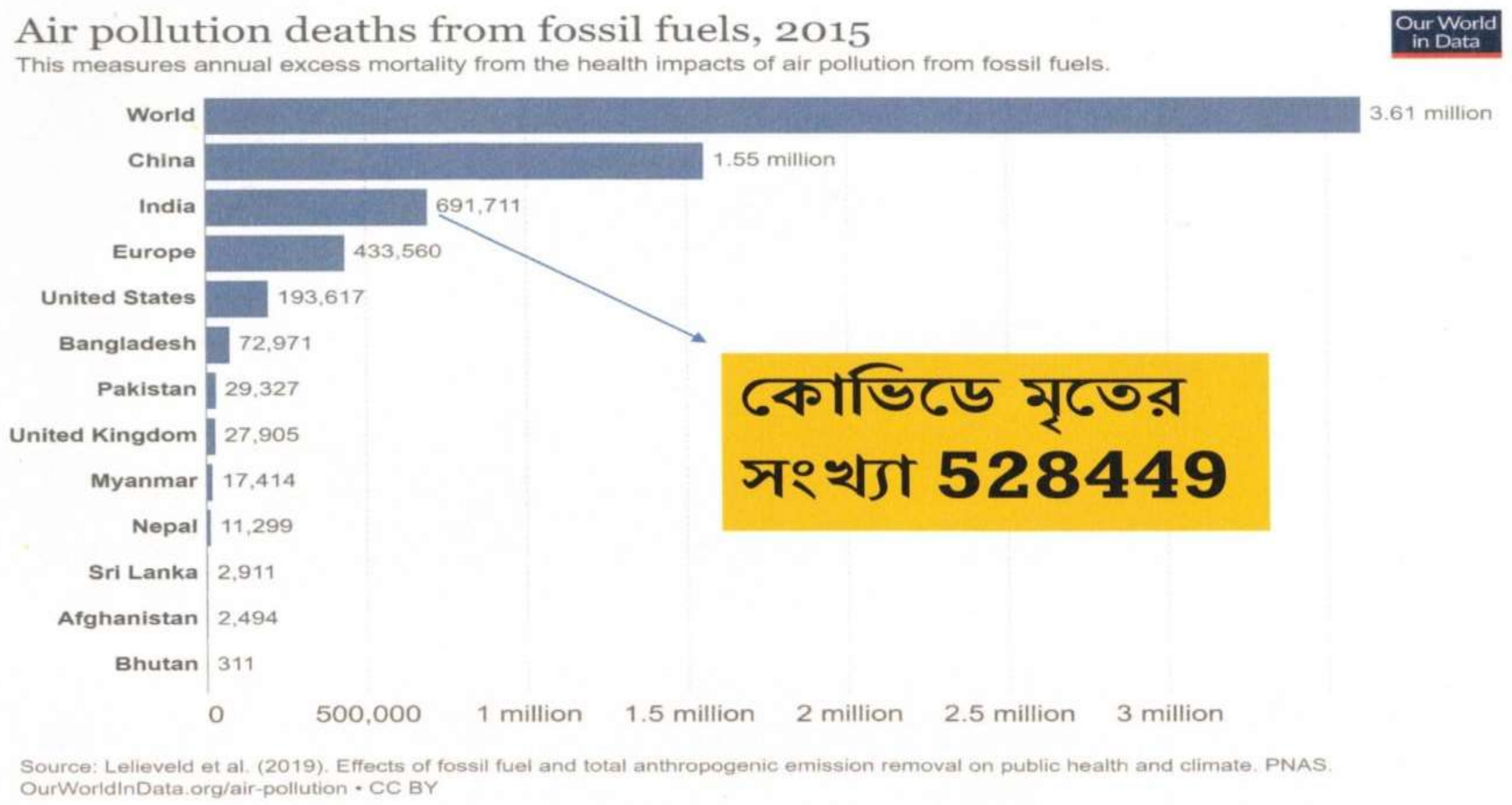
Air pollution deaths from fossil fuels, 2015

This measures annual excess mortality from the health impacts of air pollution from fossil fuels.

Our World in Data

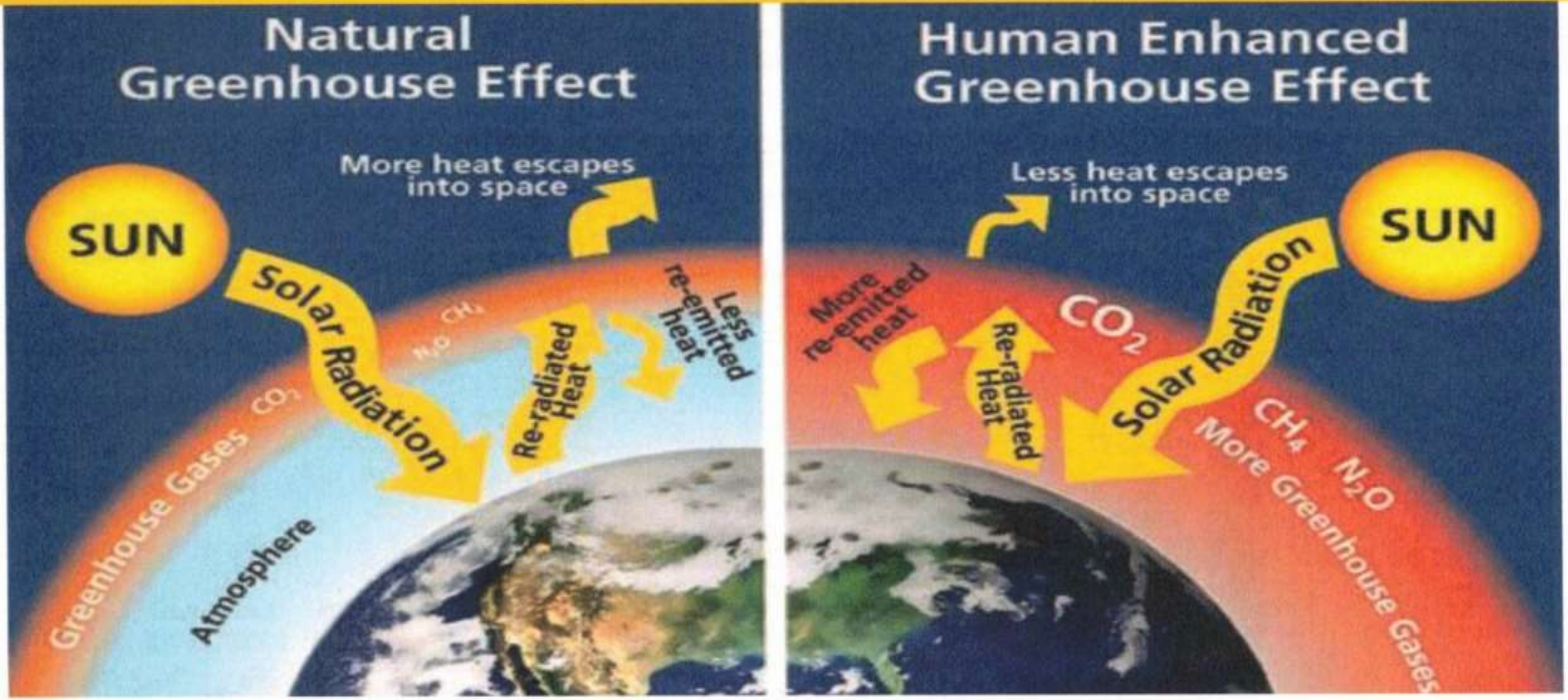


Source: Lelieveld et al. (2019). Effects of fossil fuel and total anthropogenic emission removal on public health and climate. PNAS.
OurWorldInData.org/air-pollution •


Air pollution deaths from fossil fuels, 2015
This measures annual excess mortality from the health impacts of air pollution from fossil fuels.
Our World in Data
World 3.61 million
China 1.55 million
India 691,711
Europe 433,560
United States 193,617
Bangladesh 72,971
Pakistan 29,327
United Kingdom 27,905
Myanmar 17,414
Nepal 11,299
Sri Lanka 2,911
Afghanistan 2,494
Bhutan 311
0
500,000
1 million
1.5 million
2 million
2.5 million
3 million
কোভিডে মৃতের
সংখ্যা 528449
Source: Lelieveld et al. (2019). Effects of fossil fuel and total anthropogenic emission removal on public health and climate. PNAS.
OurWorldInData.org/air-pollution • CC BY

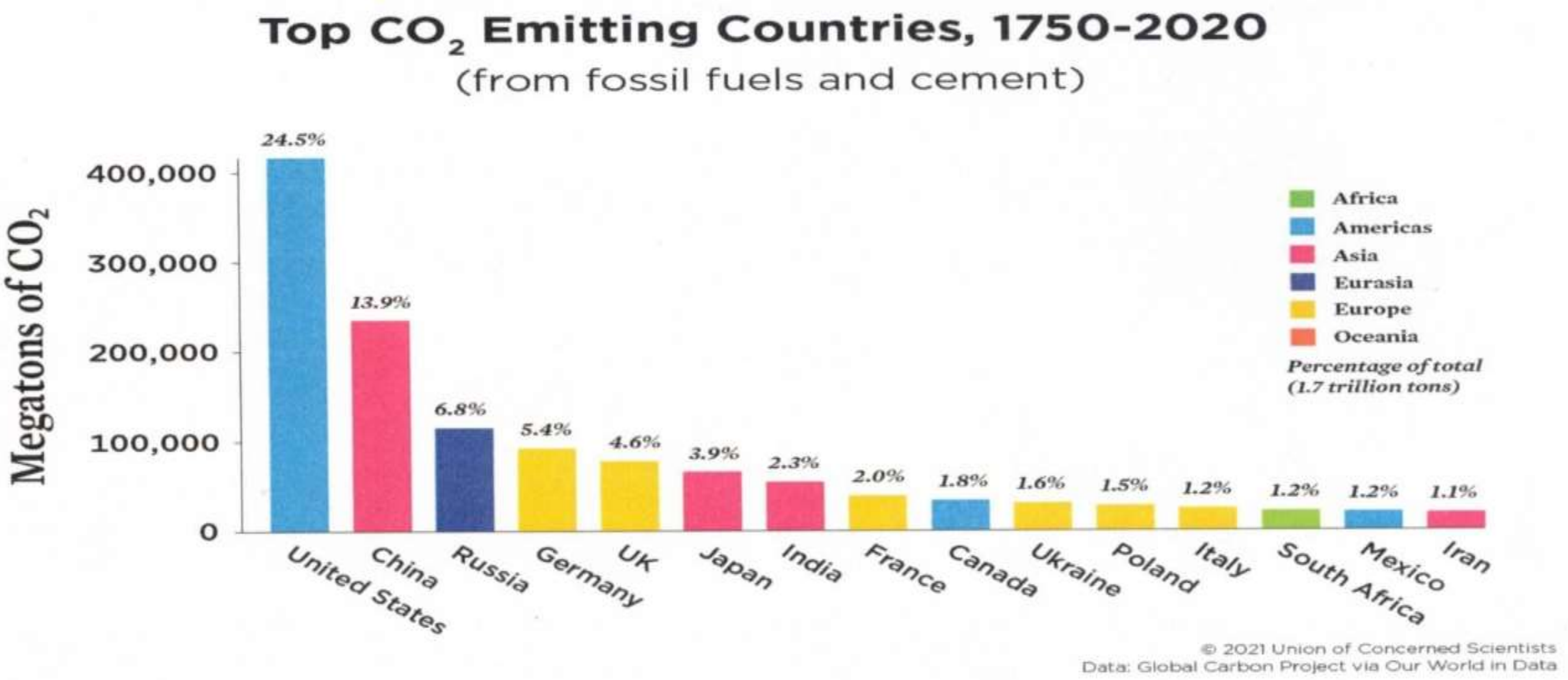
Green house প্রভাব ও বিশ্ব উষ্ণায়ণ

Green house প্রভাব



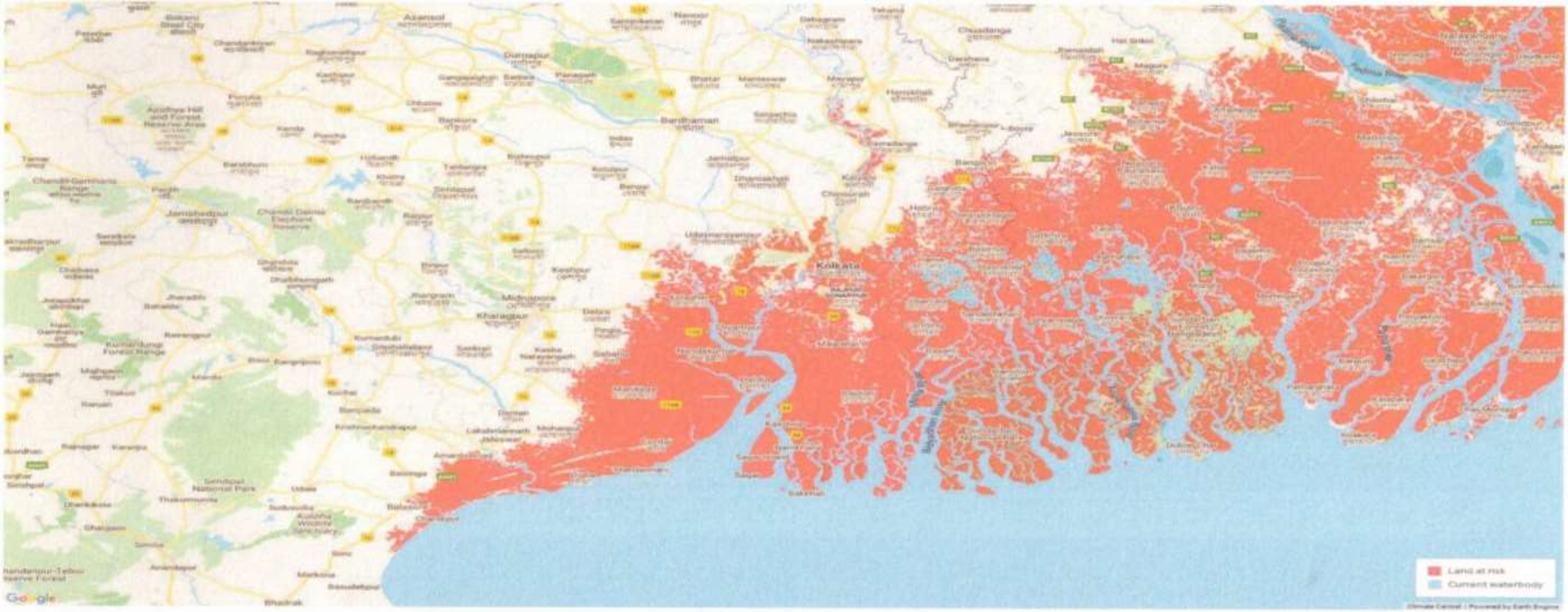
Earth's temperature has risen by **0.14° Fahrenheit (0.08° Celsius) per decade since 1880**, but the rate of warming since 1981 is more than twice that: 0.32° F (0.18° C) per decade. 2021 was the sixth-warmest year on record based on NOAA's temperature data

দেশ ভিত্তিক গ্রীন হাউসে গ্যাসের পরিমাণ



ভুটান একমাত্র কার্বন ঋণাত্মক দেশ।

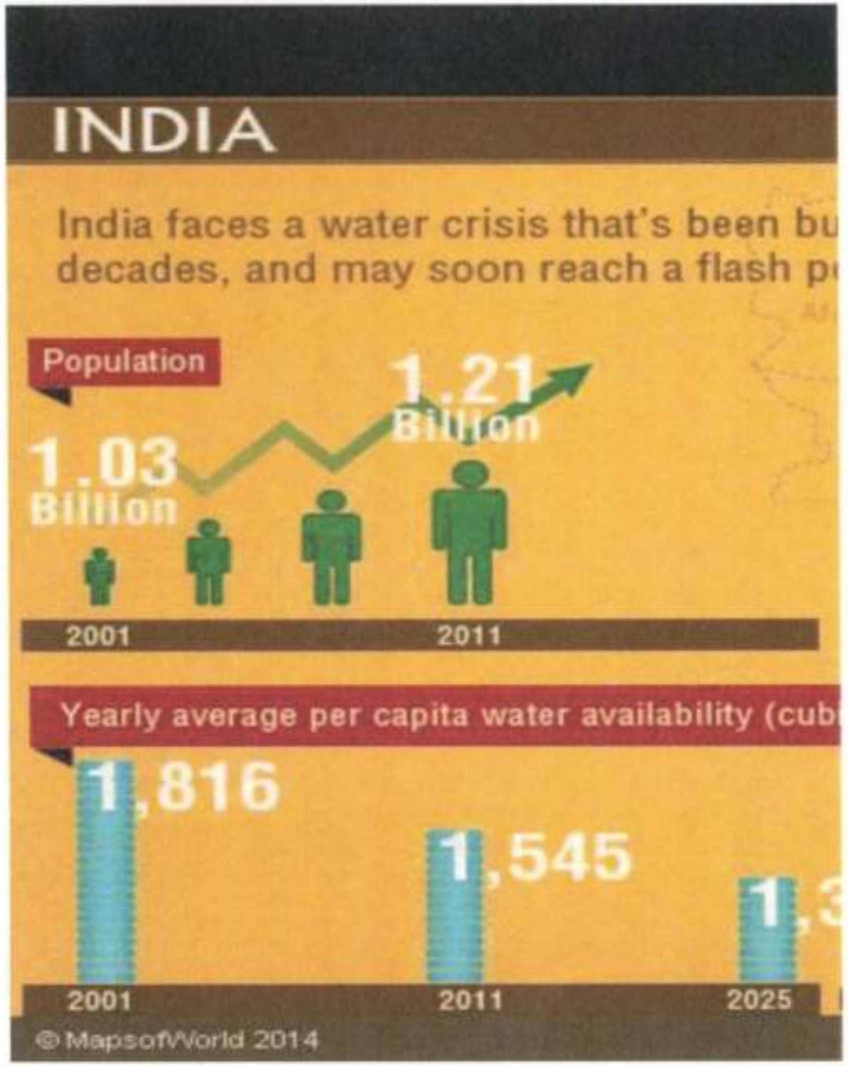
1880 সাল থেকে প্রায় 8-9 ইঞ্চি জলস্তর বৃদ্ধি পেয়েছে। ভারতে বৃদ্ধির হার 2.5mm/ yr যা অনান্য দেশের থেকে বেশী



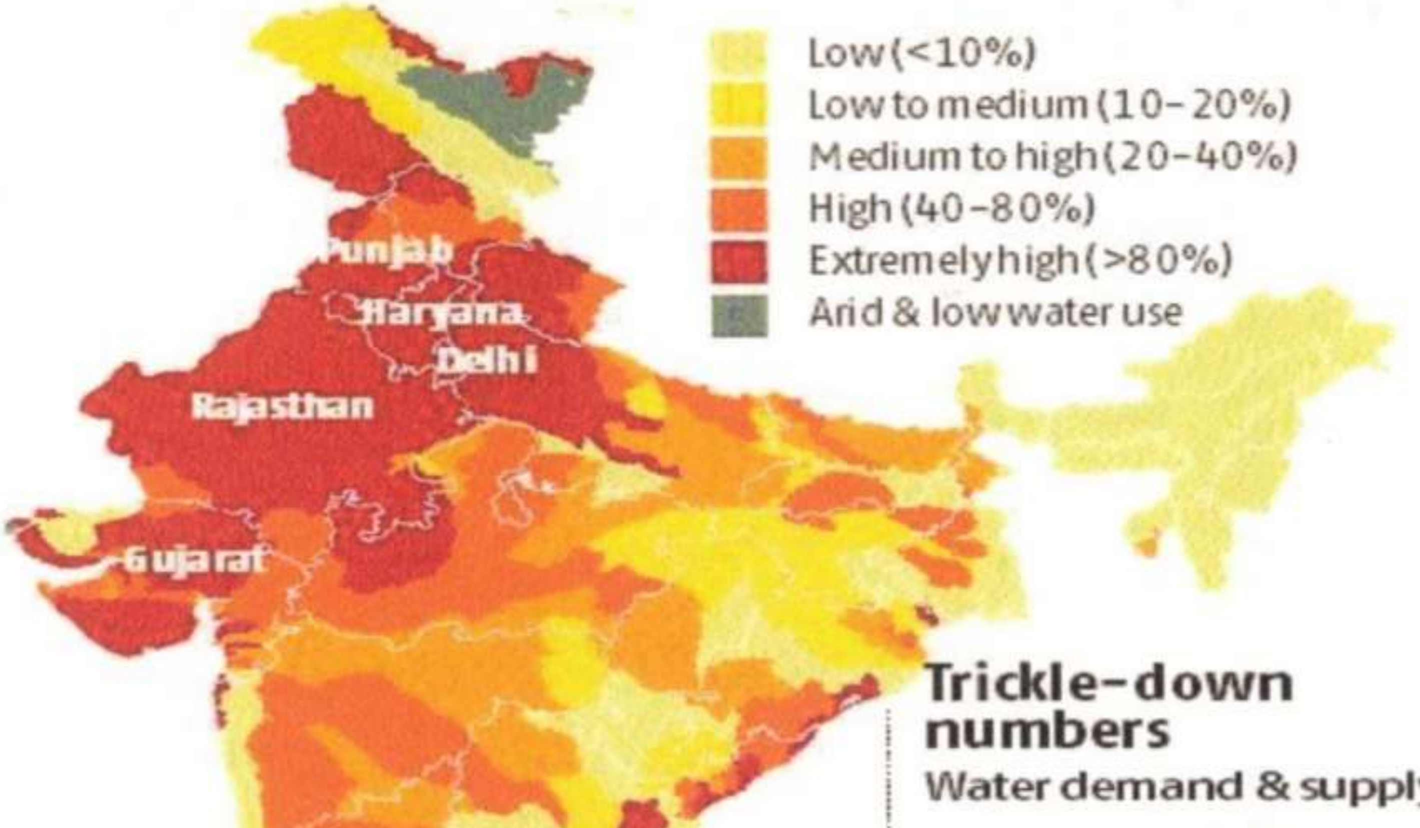
পানীয় জল সঙ্কট

- জীবাশ্ম জ্বালানী পোড়ানোর ফলে 600 মিলিয়ন নাগরিক পানীয় জলের সঙ্কটের সম্মুখীন এবং ভারতে 54% কূপ ভূগর্ভস্থ জলের স্তরের তীব্র হ্রাসের সম্মুখীন,

- আদমশুমারির তথ্য অনুযায়ী, ভারতে, 1951 সালে মাথাপিছু জলের প্রাপ্যতা ছিল 5,177 ঘনমিটার। 2011 সালের আদমশুমারির পরিসংখ্যানে, এটি 1,545 ঘনমিটারে নেমে আসে। এটি 60 বছরে প্রায় 70 শতাংশ হ্রাস। তাই ইন এক মাসে ভারতে মাথাপিছু জল পাওয়া যায় প্রায় 46350 লিটার।



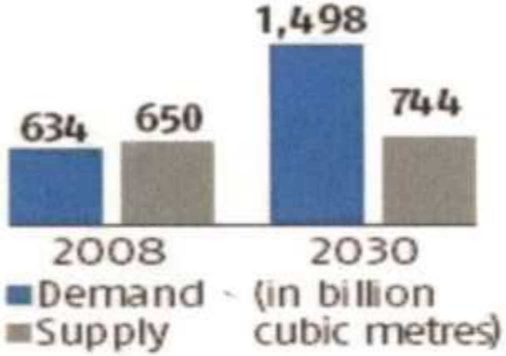
WATER-STRESSED AREAS



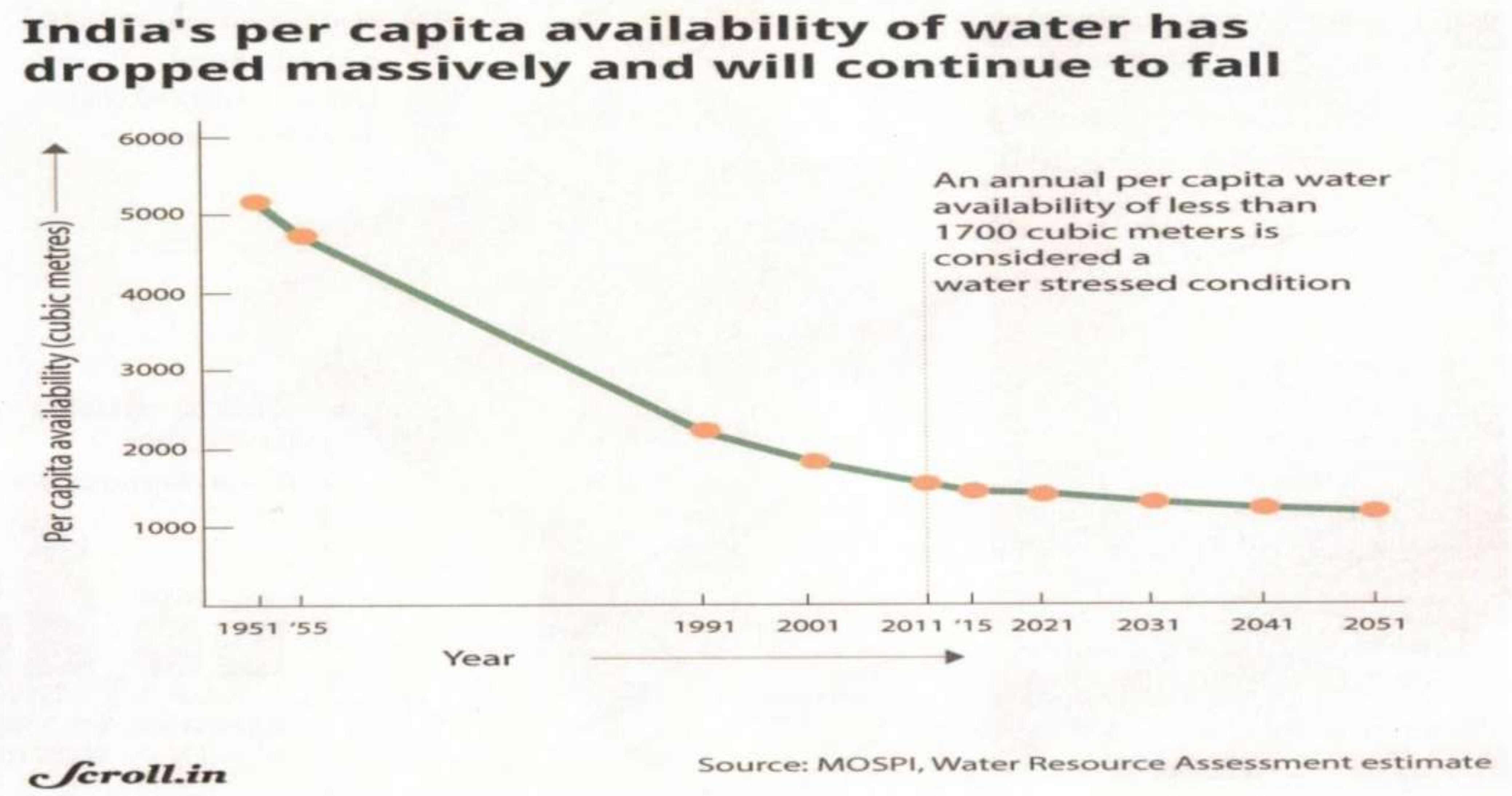
Sources: NITI Aayog's Composite Water Management Index, World Resource Institute

Trickle-down numbers

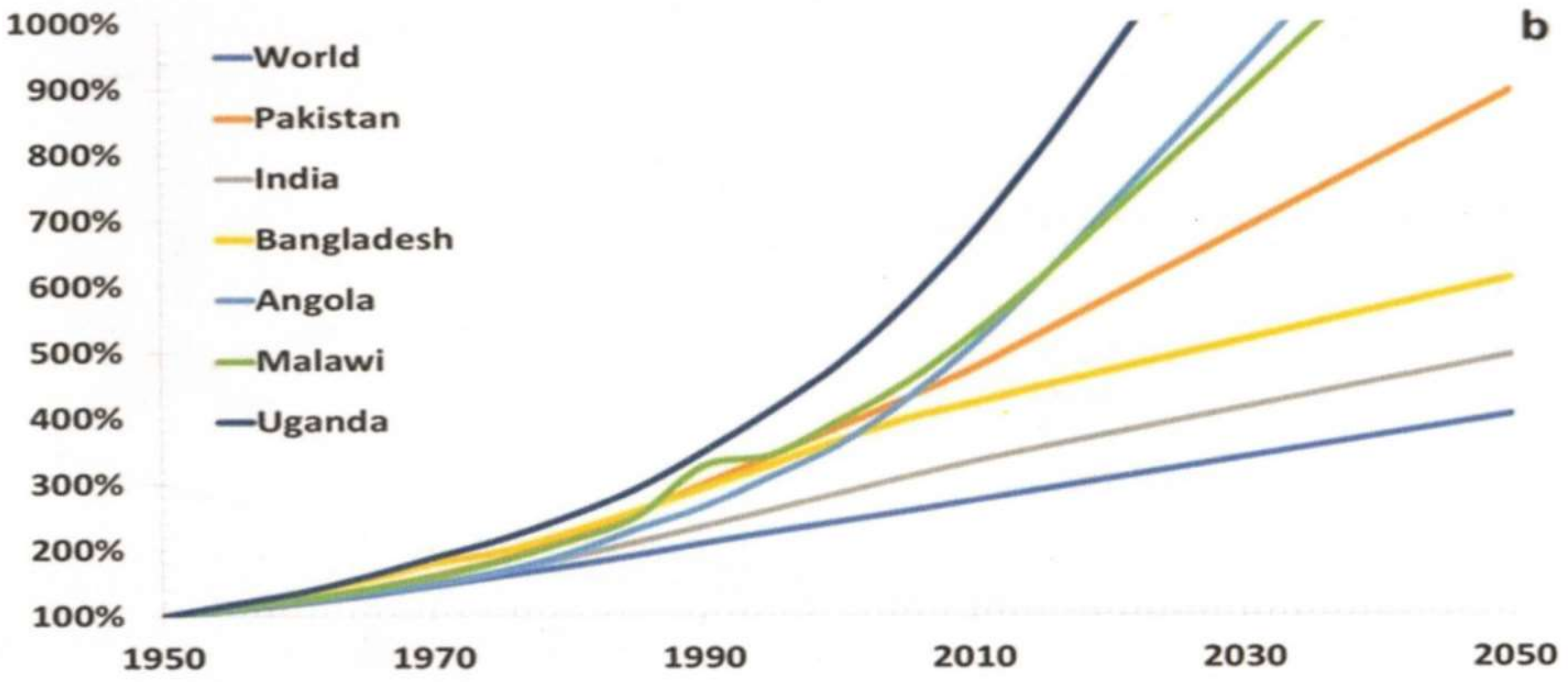
Water demand & supply



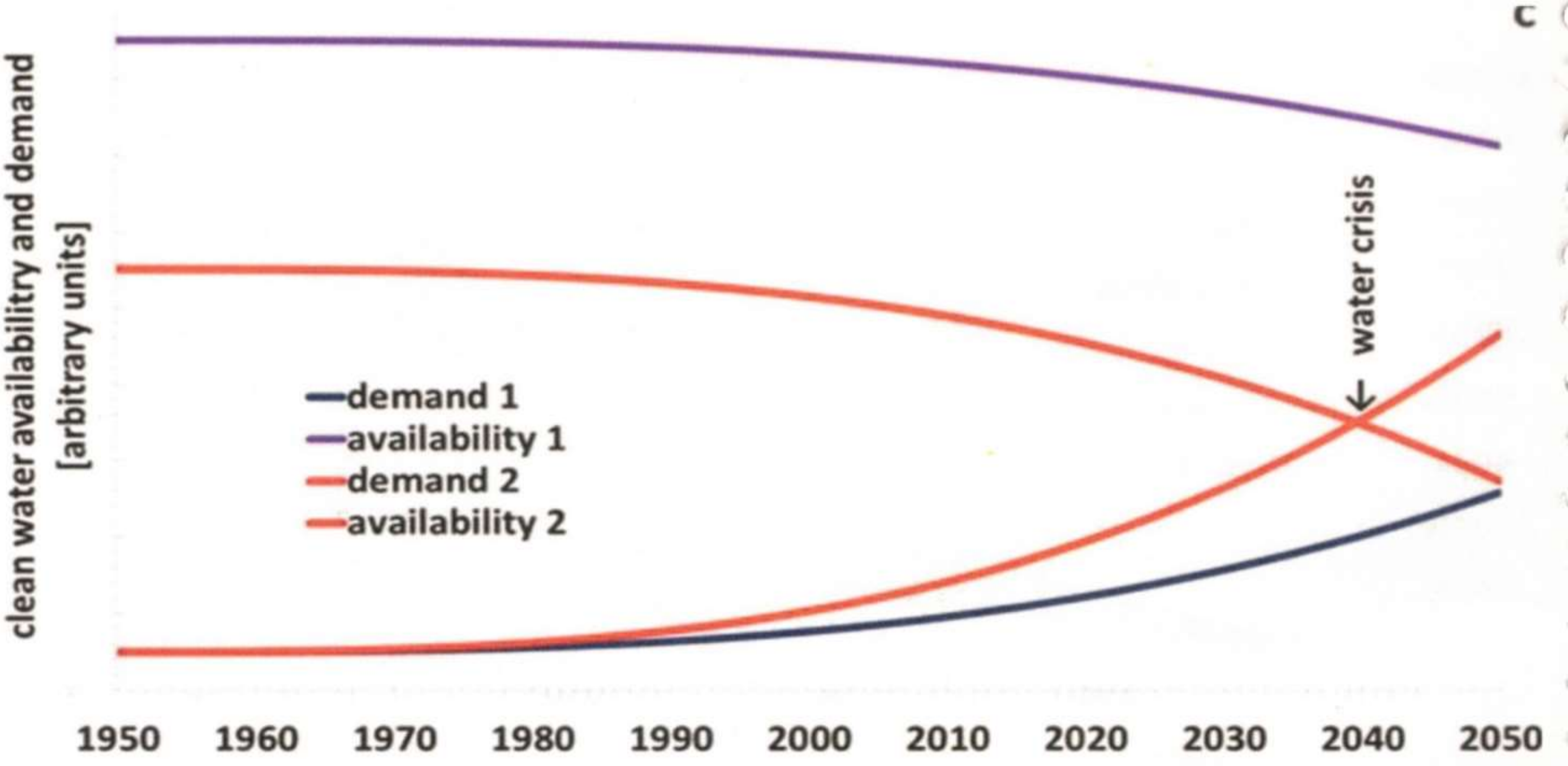
মাথা পিছু জলের পরিমাণ



ক্রমবর্ধমান জলের চাহিদা - পৃথিবী, ভারত ও প্রতিবেশী দেশঃ



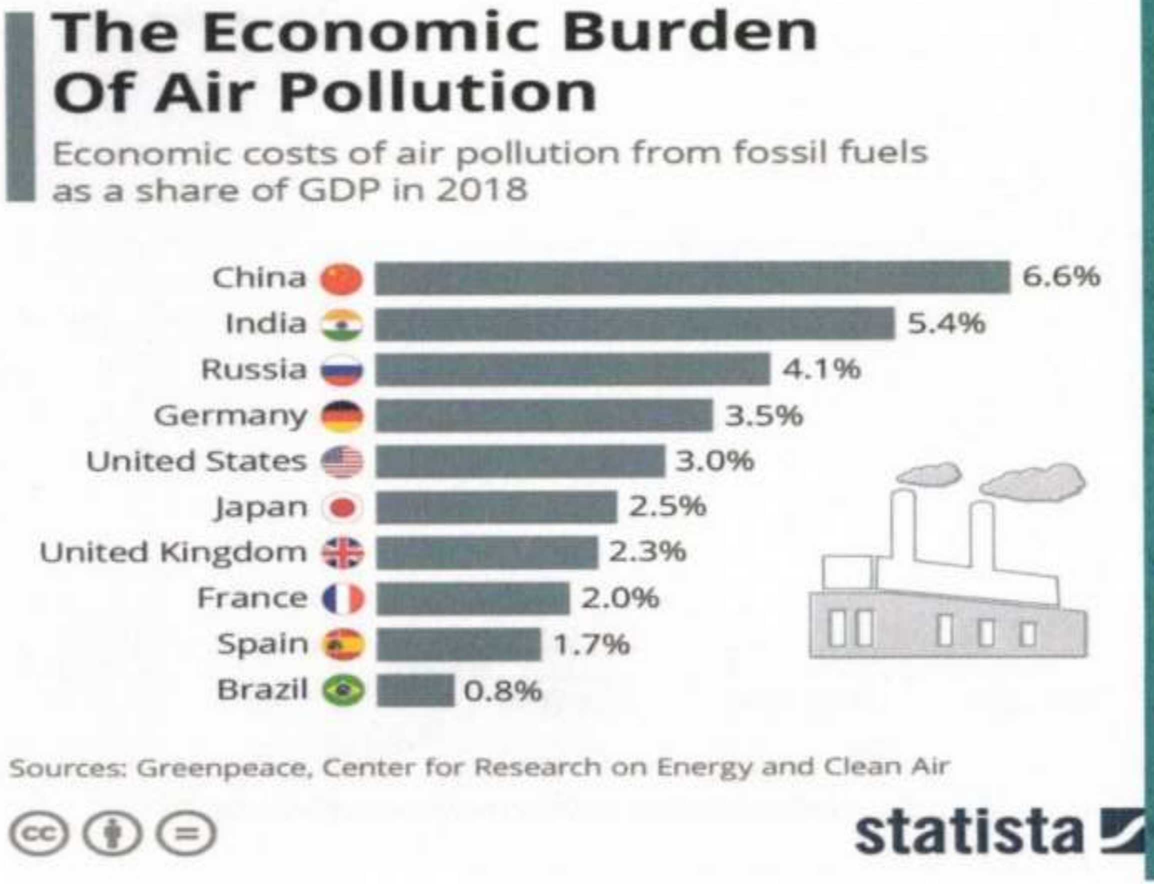
জলের জোগান এবং চাহিদা এর ভারসাম্যহীনতা



সুদূরপ্রসারী আর্থসামাজিক প্রভাবঃ

কার্যত সমস্ত বড় শহরগুলিতে 100 মিলিয়ন জীবন ঝুঁকির মধ্যে বর্তমান।

এর ক্ষতিকর প্রভাব স্বরূপ আনুমানিক স্বাস্থ্যসেবা ব্যয় উত্পাদনশীলতা **হ্রাস করে, যা ভারতের জিডিপির প্রায় দশ শতাংশের কাছাকাছি!!!**

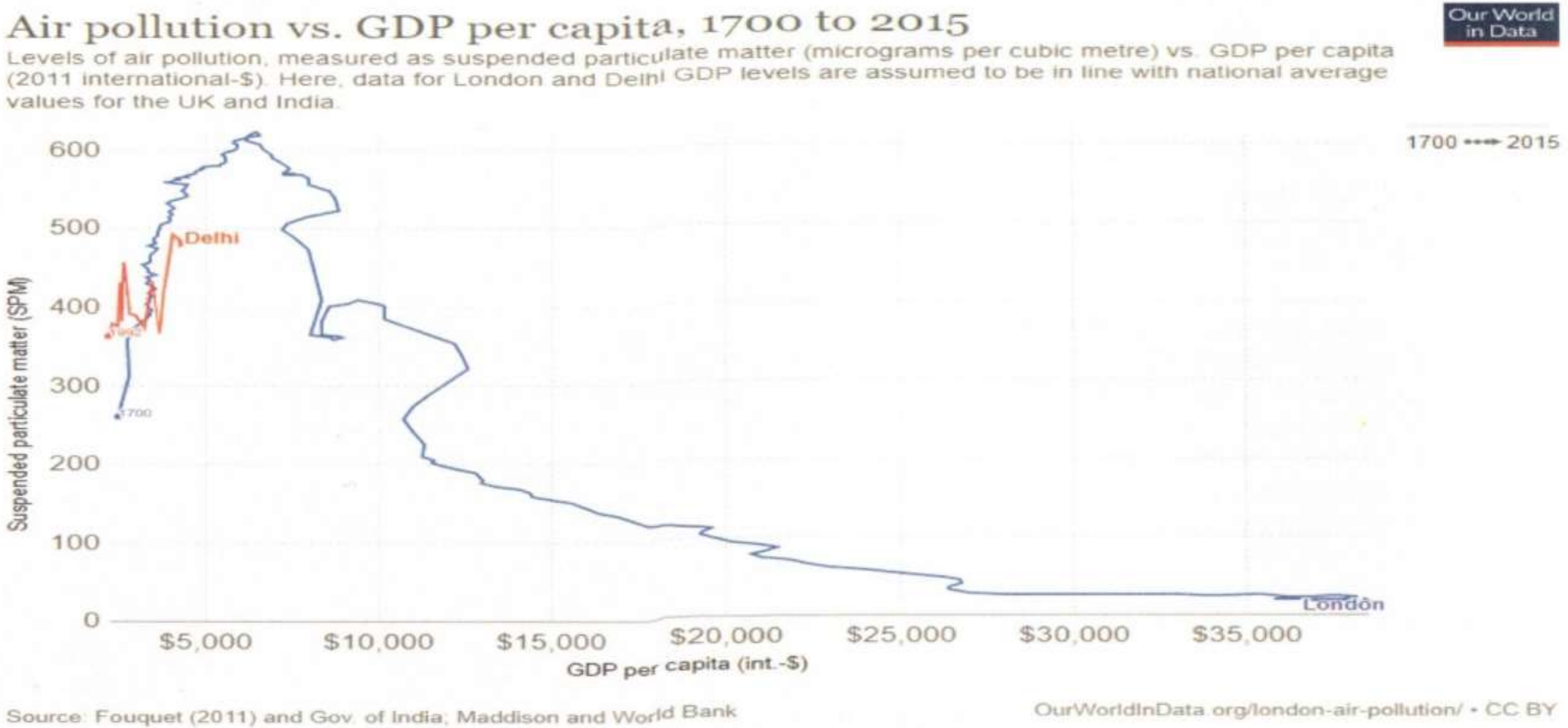


NEWS

COSTS OF AIR POLLUTION ON INDIAN CITIES

City	premature death	Cost, Percent of the city's GDP
Delhi	27,258	6.6%
Mumbai	15,743	5.5%
Hyderabad	6,228	4.5%
Patna	1,706	4.1%
Chennai	6,374	4.2%
Bengaluru	7,577	4.4%

উন্নত ও উন্নয়নশীল দেশে বায়ুদূষণের প্রভাব



- শক্তি চাহিদা পূরণে ব্যার্থ হলে ভারত কখনই উন্নায়নশীল দেশ থেকে উন্নত দেশে পরিণত হবে না।
- ভবিষ্যতের বর্ধিত চাহিদা পূরণে পুনরায় জীবাশ্ম জ্বালানী ব্যাবহার আমাদের আর বড় বিপর্জয় এর সৃষ্টি করবে। আমরা স্থিতিশীলতার লক্ষ্যে পৌছতে ব্যর্থ হব।

India's Development will not be sustainable

পরিত্রাণের পথ

নবায়নযোগ্য শক্তি
(Renewable Energy)

স্থিতিশীলতার লক্ষে ,

জীবাশ্ম জ্বালানী থেকে নবায়নযোগ্য শক্তির পথে

সম্যক ধারনা, সম্ভবনা ও উপায়

সংজ্ঞাঃ

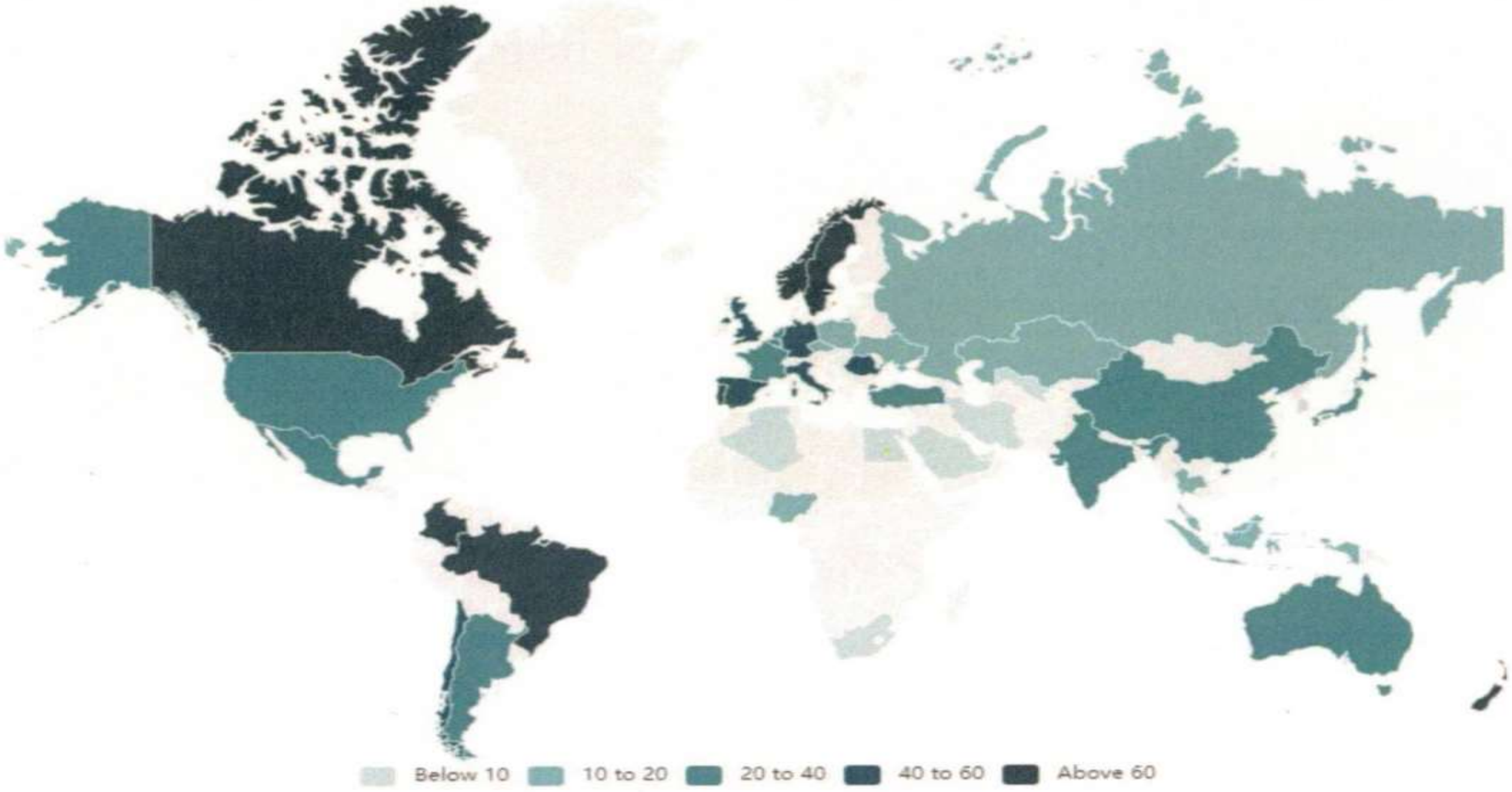
- Renewable energy is energy that is collected from renewable resources that are naturally replenished on a human timescale. It includes sources such as sunlight, wind, the movement of water, and geothermal heat. Although most renewable energy sources are sustainable, some are not. For example, some biomass sources are considered unsustainable at current rates of exploitation. Renewable energy often provides energy for electricity generation to a grid, air and water heating/cooling, and stand-alone power systems.

স্থিতিশীল বিকাশের মুল লক্ষ প্রাকৃতিক জীবন প্রবাহ বজায় রেখে শক্তির চাহিদা পূরণ

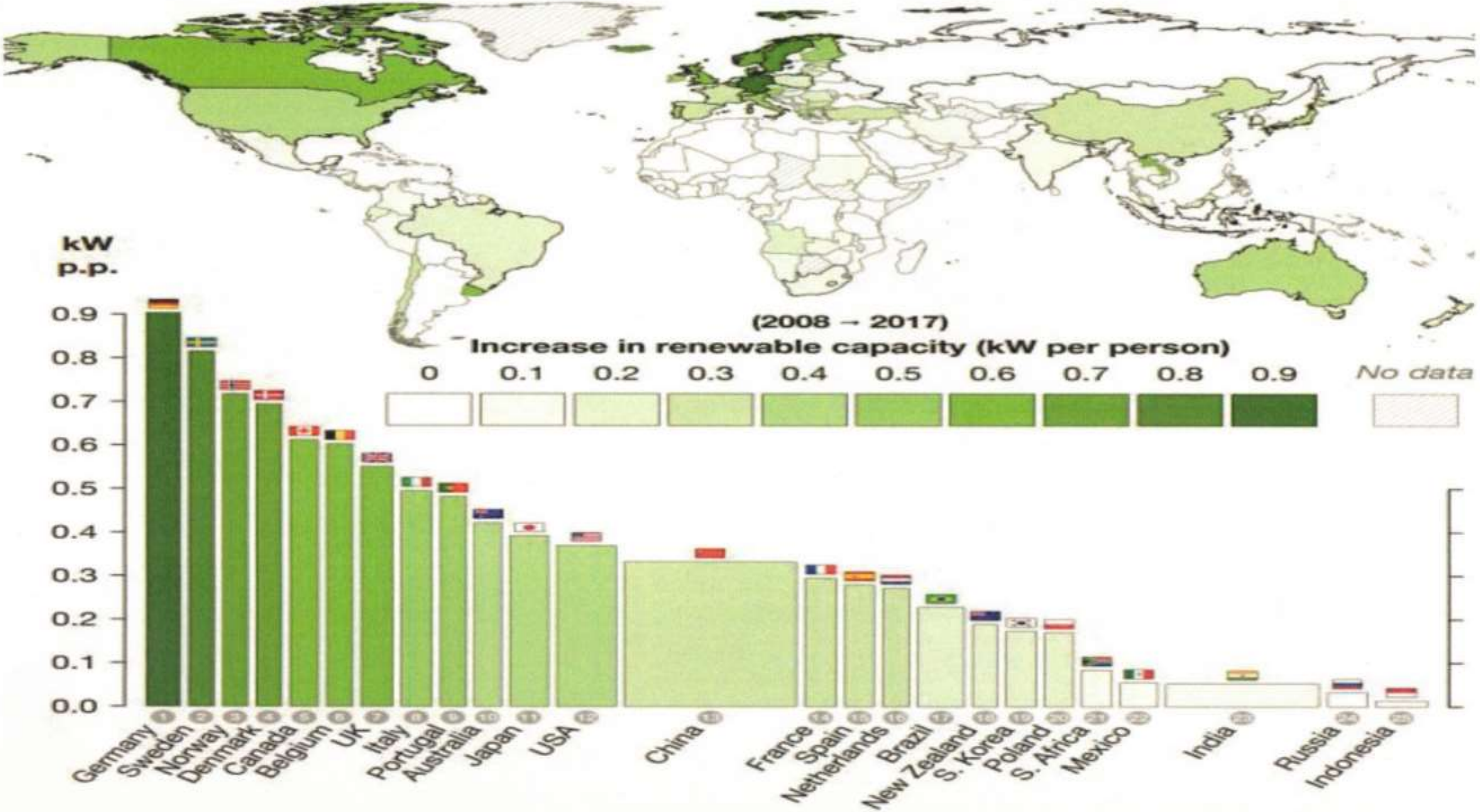
- Crisis a time of intense difficulty or danger.
- But it also corresponds to a time when a difficult or important decision must be made.
- **the turning point of a disease when an important change takes place, indicating either** *recovery or death*
- adoption of strategy is important.

অর্থাৎ সঠিক সিদ্ধান্ত গ্রহণের দ্বারাই লক্ষ্যে পৌঁছানো সম্ভব , অন্যথা বিপর্জয় অনিবার্য

উন্নত ও উন্নয়নশীল দেশে নবায়নযোগ্য শক্তির ভাগ



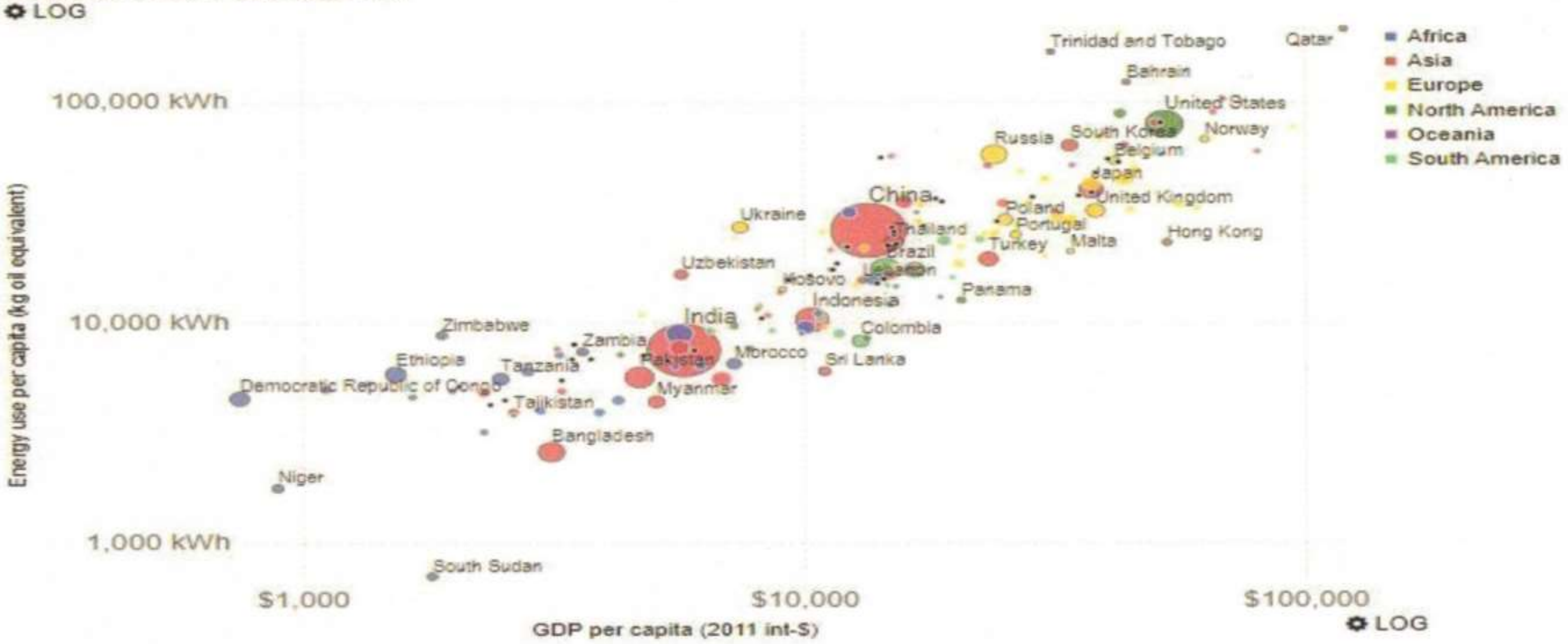
উন্নত ও উন্নয়নশীল দেশে নবায়নযোগ্য শক্তির ভাগ



Energy use per capita vs. GDP per capita, 2015

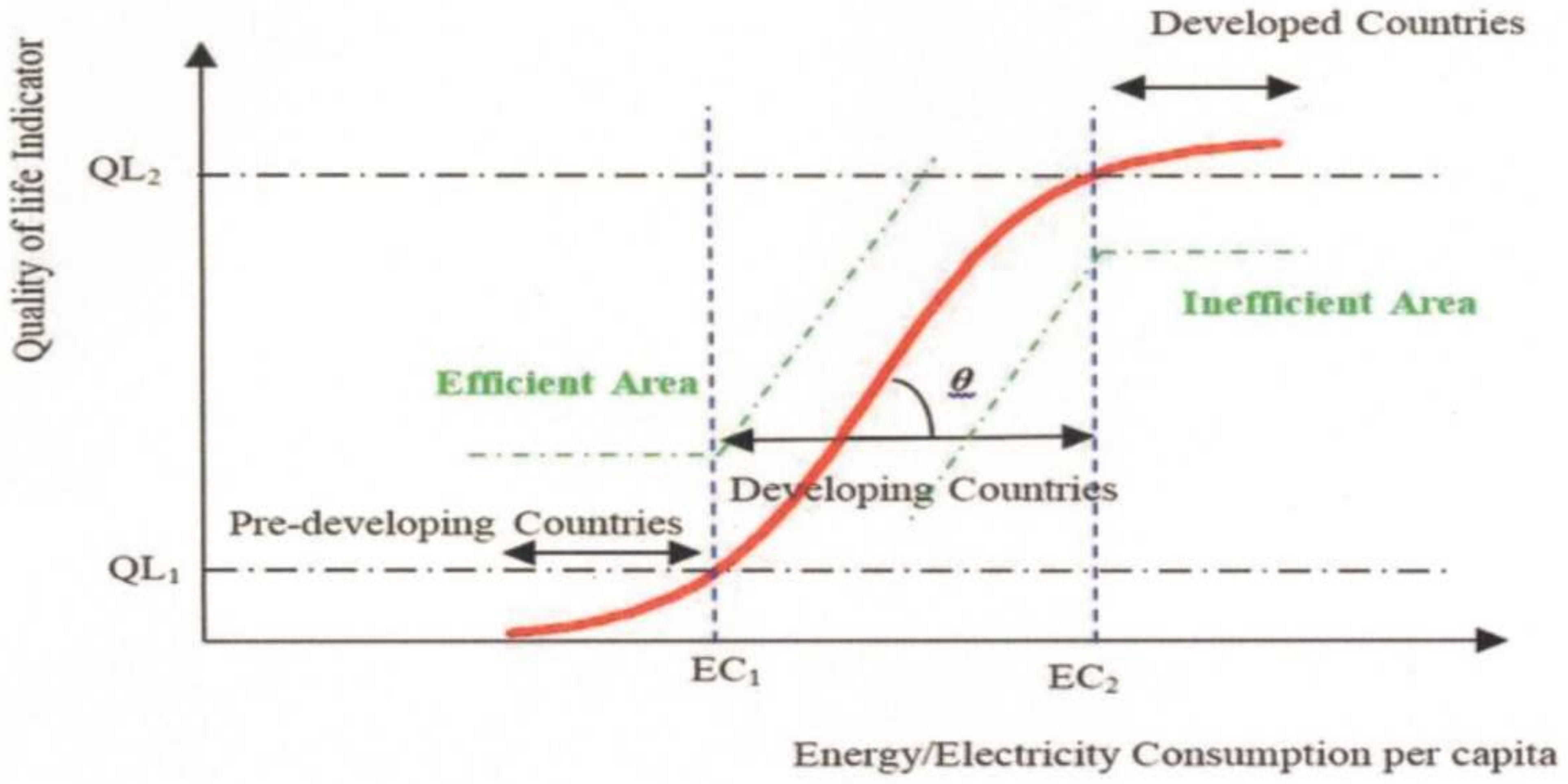
Our World in Data

Annual energy use per capita, measured in kilowatt-hours per person vs. gross domestic product (GDP) per capita, measured as 2011 international-$



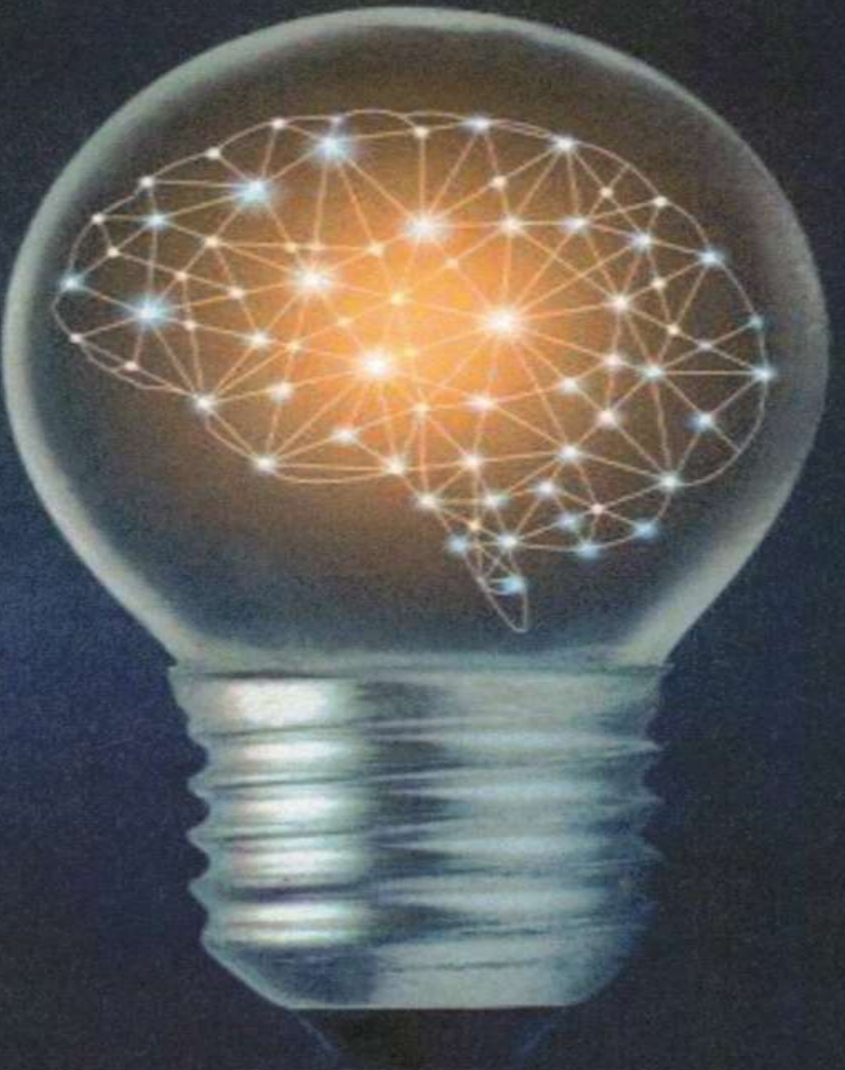
Source: International Energy Agency (IEA) via The World Bank

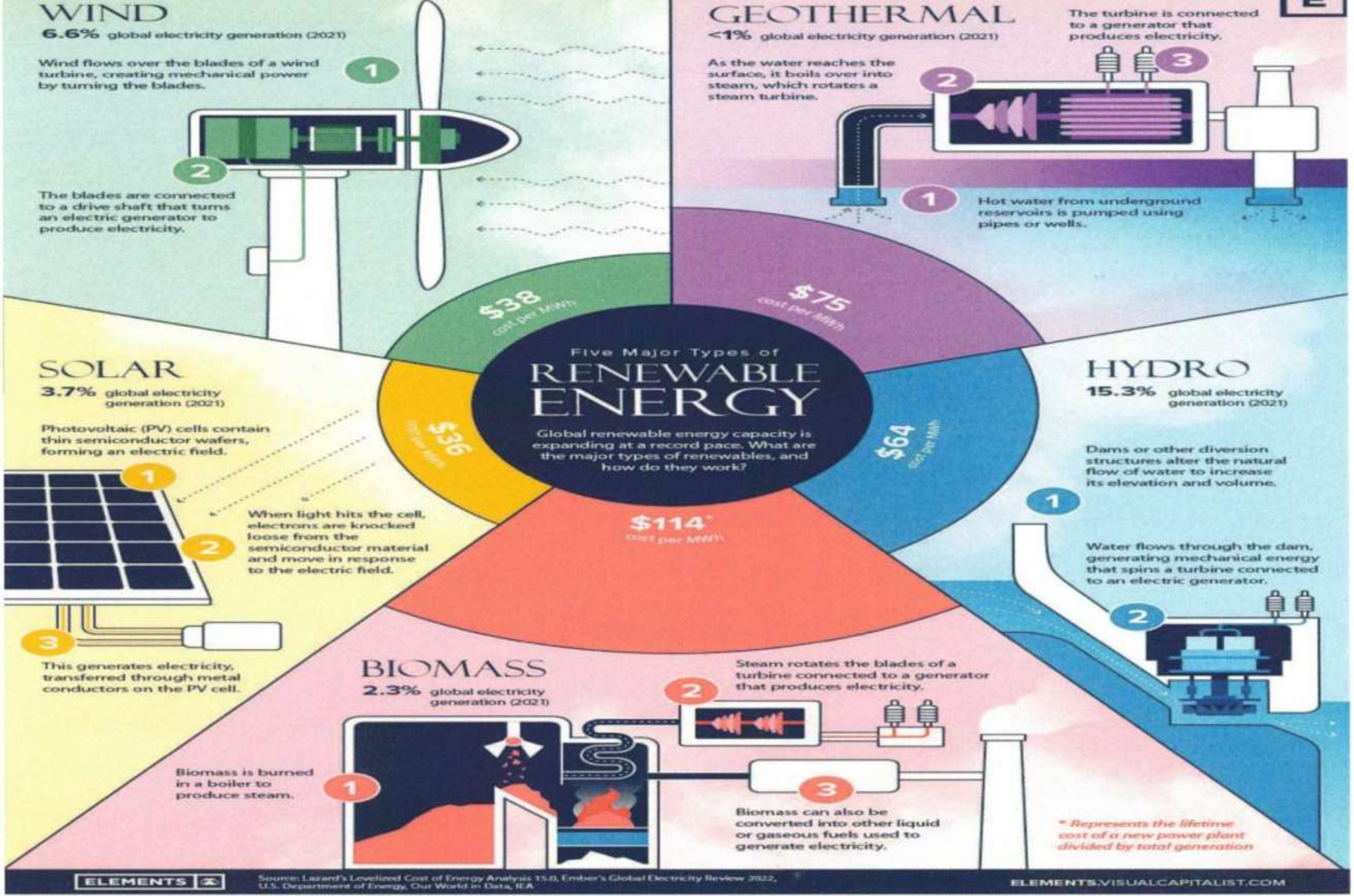
শক্তির ব্যাবহার ও জীবন যাত্রার মান



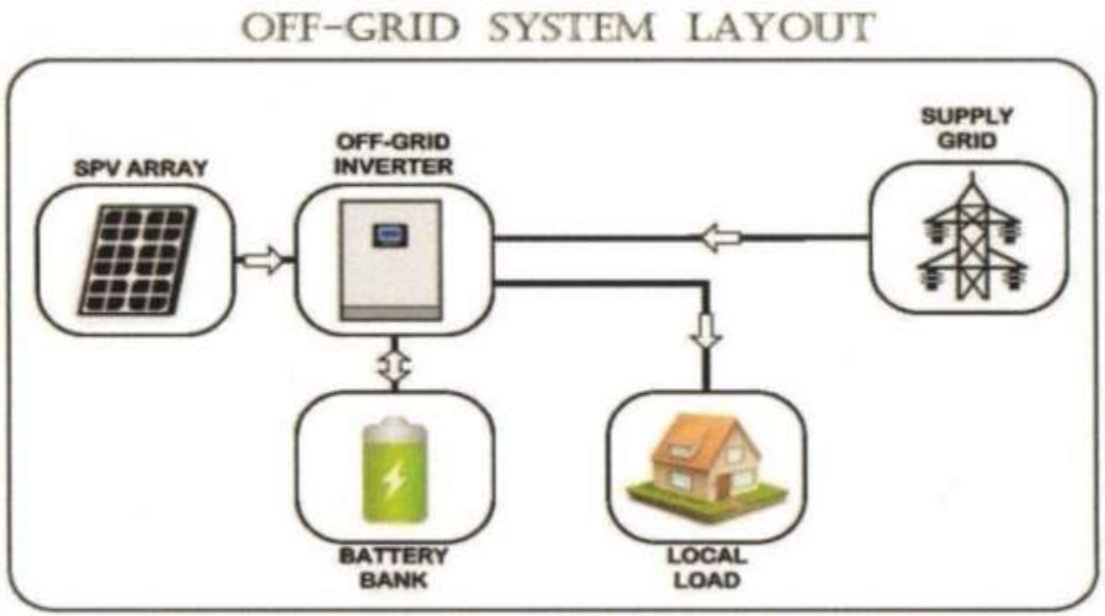
Lessons to learn

- যে সমস্ত দেশে জীবন যাত্রার মান উন্নত, সেখানে মাথা পিছু শক্তির ব্যাবহার বেশি।
- এরুপ অধিকাংশ দেশে ই মোট শক্তি উৎপাদনের সিংহ ভাগ নবায়ন যোগ্য শক্তি থেকে ই আসে।
- ভারত তথা অন্যান্য উন্নয়নশীল দেশের উন্নত ভবিষ্যতের লক্ষে এই পন্থাই অবলম্বন করা উচিত।

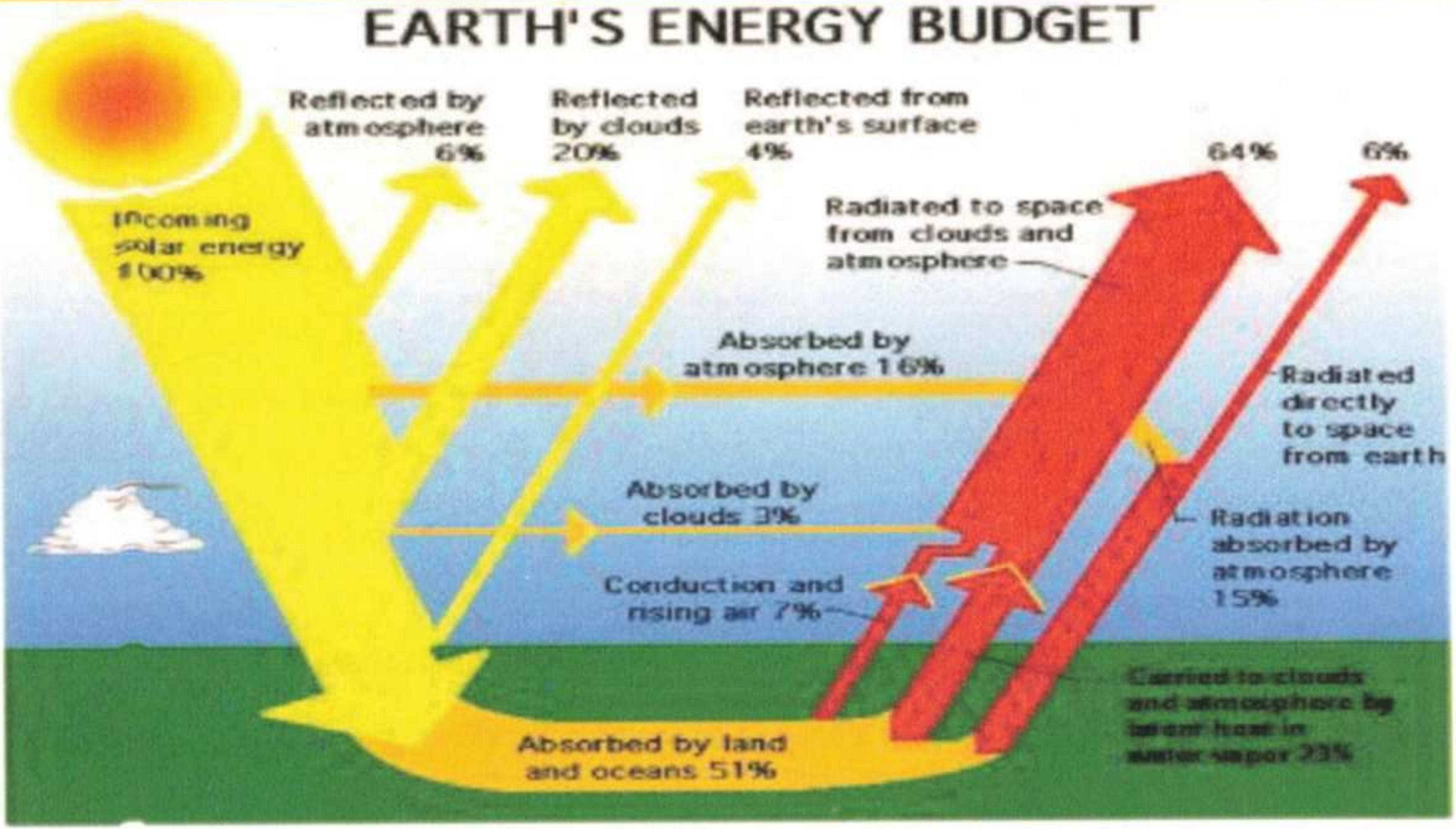



WIND
6.6% global electricity generation (2021)
Wind flows over the blades of a wind turbine, creating mechanical power by turning the blades.
The blades are connected to a drive shaft that turns an electric generator to produce electricity.
GEOTHERMAL
<1% global electricity generation (2021)
As the water reaches the surface, it boils over into steam, which rotates a steam turbine.
The turbine is connected to a generator that produces electricity.
Hot water from underground reservoirs is pumped using pipes or wells.
$38 cost per MWh
$75 cost per MWh
Five Major Types of
RENEWABLE ENERGY
Global renewable energy capacity is expanding at a record pace. What are the major types of renewables, and how do they work?
SOLAR
3.7% global electricity generation (2021)
Photovoltaic (PV) cells contain thin semiconductor wafers, forming an electric field.
When light hits the cell, electrons are knocked loose from the semiconductor material and move in response to the electric field.
This generates electricity, transferred through metal conductors on the PV cell.
$36 cost per MWh
$64 cost per MWh
$114* cost per MWh
HYDRO
15.3% global electricity generation (2021)
Dams or other diversion structures alter the natural flow of water to increase its elevation and volume.
Water flows through the dam, generating mechanical energy that spins a turbine connected to an electric generator.
BIOMASS
2.3% global electricity generation (2021)
Biomass is burned in a boiler to produce steam.
Steam rotates the blades of a turbine connected to a generator that produces electricity.
Biomass can also be converted into other liquid or gaseous fuels used to generate electricity.
* Represents the lifetime cost of a new power plant divided by total generation
ELEMENTS
Source: Lazard's Levelized Cost of Energy Analysis 15.0, Ember's Global Electricity Review 2022, U.S. Department of Energy, Our World in Data, IEA
ELEMENTS.VISUALCAPITALIST.COM

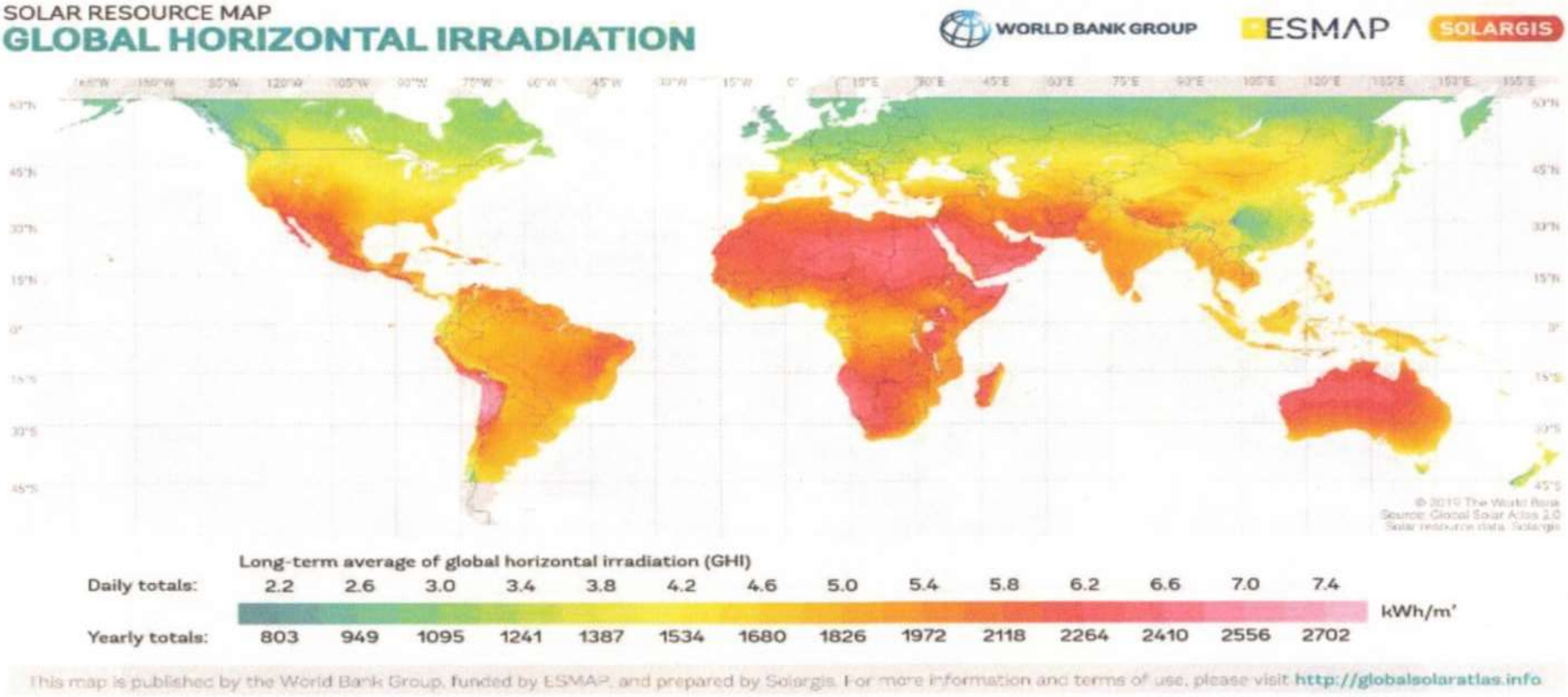
সৌর শক্তি


OFF-GRID SYSTEM LAYOUT
SPV ARRAY
OFF-GRID INVERTER
SUPPLY GRID
BATTERY BANK
LOCAL LOAD

সৌর বিকিরণ


EARTH'S ENERGY BUDGET
Reflected by atmosphere 6%
Reflected by clouds 20%
Reflected from earth's surface 4%
64%
6%
Incoming solar energy 100%
Radiated to space from clouds and atmosphere
Absorbed by atmosphere 16%
Radiated directly to space from earth
Absorbed by clouds 3%
Radiation absorbed by atmosphere 15%
Conduction and rising air 7%
Absorbed by land and oceans 51%

বিশ্ব ব্যাপী দৈনিক ও বার্ষিক সৌর বিকিরণ



কিছু পরিসংখ্যান

SURFACE AREA REQUIRED TO POWER THE WORLD

WITH ZERO CARBON EMISSIONS AND WITH SOLAR ALONE → www.landartgenerator.org

BOXES TO SCALE WITH MAP

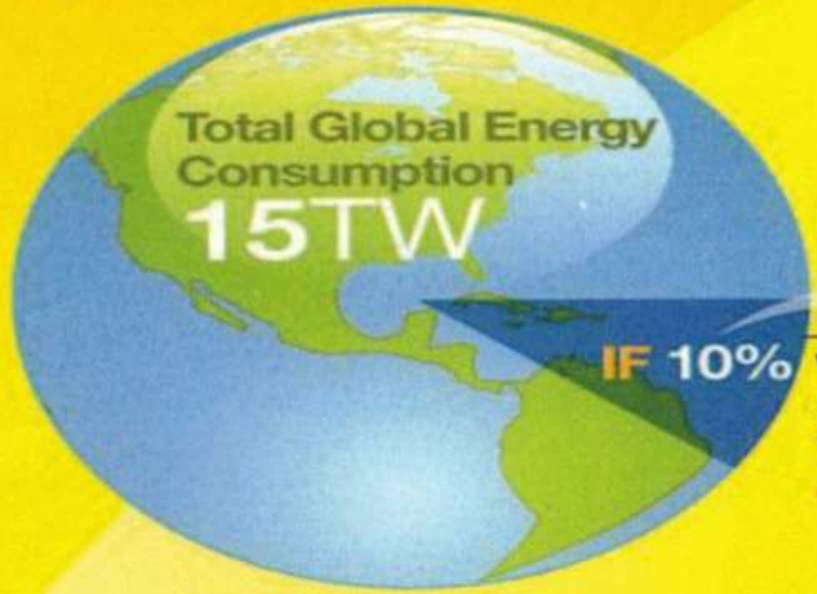
- 1980 (based on actual use) 207,368 SQUARE KILOMETERS
- 2008 (based on actual use) 366,375 SQUARE KILOMETERS
- 2030 (projection) 496,805 SQUARE KILOMETERS

Required area that would be needed in the year 2030 is shown as one large square in the key above and also as distributed around the world relative to use and available sunlight.

- Areas are calculated based on an assumption of 20% operating efficiency of collection devices and a 2000 hour per year natural solar input of 1000 watts per square meter striking the surface.
- These 19 areas distributed on the map show roughly what would be a reasonable responsibility for various parts of the world based on 2009 usage. They would be further divided many times, the more the better to reach a diversified infrastructure that localizes use as much as possible.
- The large square in the Saharan Desert (1/4 of the overall 2030 required area) would power all of Europe and North Africa. Though very large, it is 18 times less than the total area of that desert.
- The definition of "power" covers the fuel required to run all electrical consumption, all machinery, and all forms of transportation. It is based on the US Department of Energy statistics of worldwide Btu consumption and estimates the 2030 usage (678 quadrillion Btu) to be 44% greater than that of 2008.
- Area calculations do not include magenta border lines.

LAND ART GENERATOR INITIATIVE

Solar Potential



IF 10% was solar, the Solar Potential would be
1,500,000MW

Current Production
1,983MW

What Has Held Us Back?

- Previous inefficiencies of technology
- Reliance on incentives
- High/unpredictable total installed costs
- Little, to no, standardization

কিছু পরিসংখ্যান

Global electricity power generation capacity	849.5 GW (2021)
Global electricity power generation capacity annual growth rate	26% (2012-2021)
Share of global electricity generation	2% (2018)
Levelized cost per megawatt hour	Utility-scale photovoltaics: USD 38.343 (2019)
Primary technologies	Photovoltaics, concentrated solar power, solar thermal collector
Other energy applications	Water heating; heating, ventilation, and air conditioning (HVAC); cooking; process heat; water treatment

কিছু পরিসংখ্যান - ভারত - সম্ভাবনা

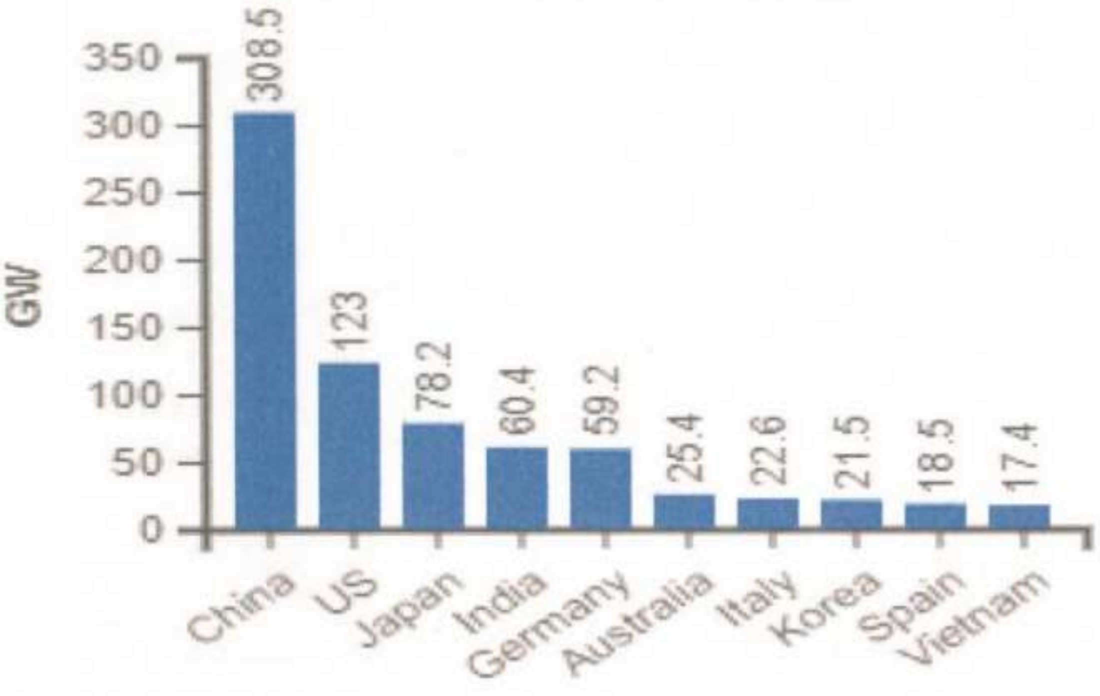
The average solar intensity received in India is about 200 MW/km2. With a geographical area of 3.287 million km2, this could lead up to an annual generation of 657.4 TW, enough to satisfy all of our energy needs

ভারতে প্রাপ্ত গড় সৌর তীব্রতা প্রায় 200 MW/km2। 3.287 মিলিয়ন কিমি 2 এর ভৌগোলিক এলাকা সহ, এটি 657.4 TW বার্ষিক উৎপাদন হতে পারে, যা আমাদের সমস্ত শক্তির চাহিদা মেটাতে যথেষ্ট

ন্যাশনাল সোলার মিশন অনুসারে, ভারত 2022 সালের মধ্যে 100 গিগাওয়াট সৌরবিদ্যুৎ স্থাপন করতে চলেছে। যার মধ্যে 4০ মেগাওয়াট হবে ছাদ থেকে, সৌরবিদ্যুৎ কেন্দ্র এবং 6০ মেগাওয়াট হবে গ্রাউন্ড সোলার প্ল্যান্ট থেকে।

কিছু পরিসংখ্যান - ভারত - বর্তমান

2022 সালের হিসাবে ভারতে ইনস্টল করা ক্ষমতা **57,705.72** মেগাওয়াট যার বৃদ্ধির হার **21.65%** (বিশ্বে প্রতি মেগাওয়াট ইনস্টলেশনের সর্বনিম্ন মূলধন খরচ)

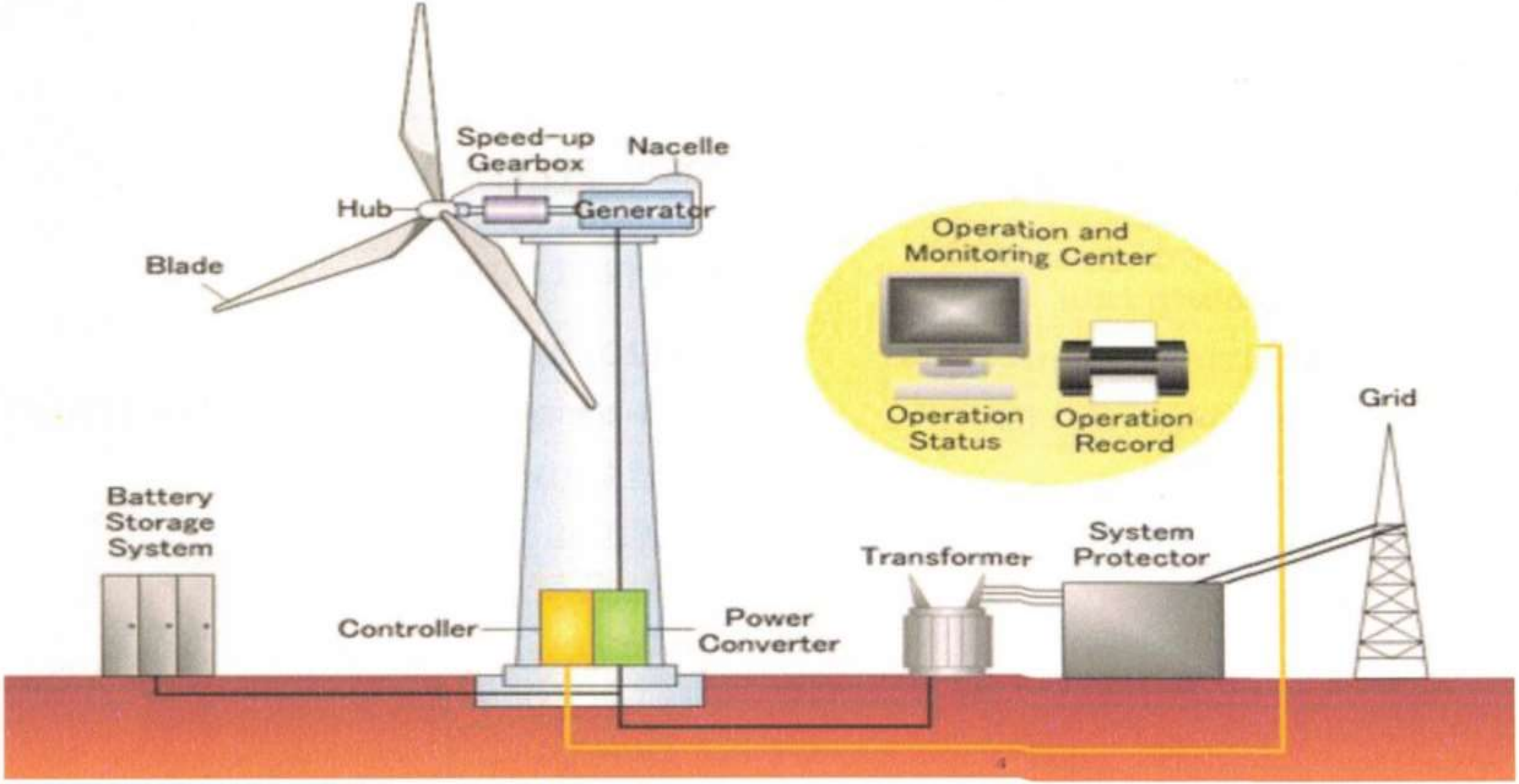


Top 10 countries by cumulative solar power installed capacity in 2021[1]

কিছু পরিসংখ্যান - ভারত - বর্তমান

Bhadla Solar Park 2021 সালের হিসাবে বিশ্বের বৃহত্তম সৌর উদ্যান
(ভাদলা, ফালোদি তহসিল, যোধপুর জেলা, রাজস্থান, ভারত)
মোট 5,700 হেক্টর (14,000 একর) এলাকা জুড়ে অবস্থিত। পার্কটির মোট ক্ষমতা 2245 মেগাওয়াট।

বায়ু শক্তি


Speed-up Gearbox
Nacelle
Hub
Generator
Blade
Operation and Monitoring Center
Operation Status
Operation Record
Grid
Battery Storage System
System Protector
Transformer
Controller
Power Converter

কিছু পরিসংখ্যান

Global electricity power generation capacity	824.9 GW (2021)
Global electricity power generation capacity annual growth rate	13% (2012-2021)
Share of global electricity generation	5% (2018)
Levelized cost per megawatt hour	Land-based wind: USD 30.165 (2019)
Primary technology	Wind turbine
Other energy applications	Windmill, windpump

বিশ্ব ব্যাপী বায়ুপ্রবাহের তীব্রতা

ONSHORE & OFFSHORE WIND RESOURCE MAP

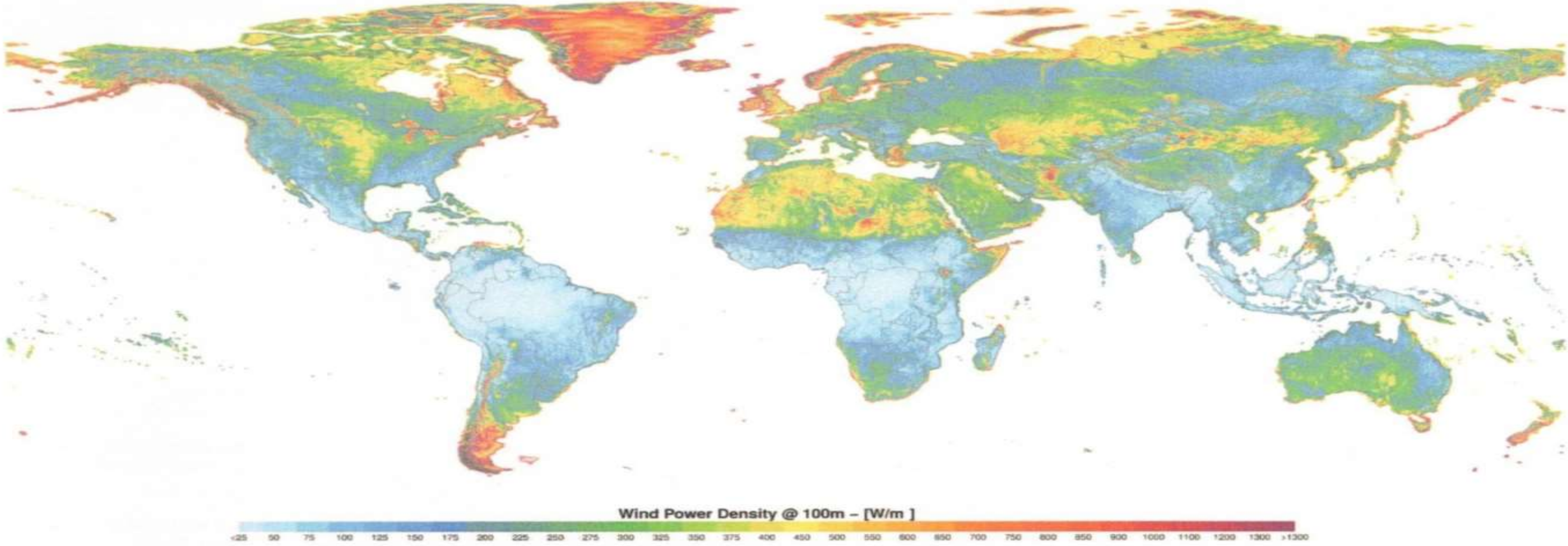
WORLD BANK GROUP

DTU Wind Energy
Department of Wind Energy

WIND POWER DENSITY POTENTIAL

ESMAP

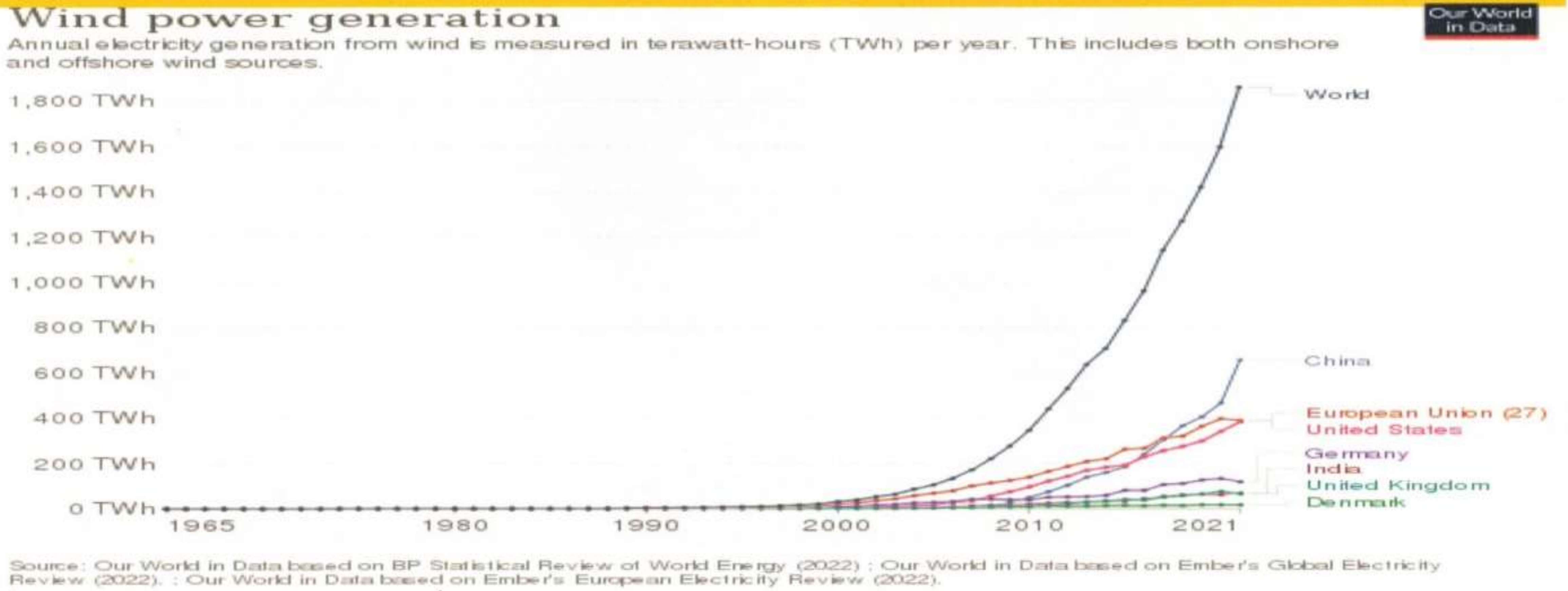
VORTEX

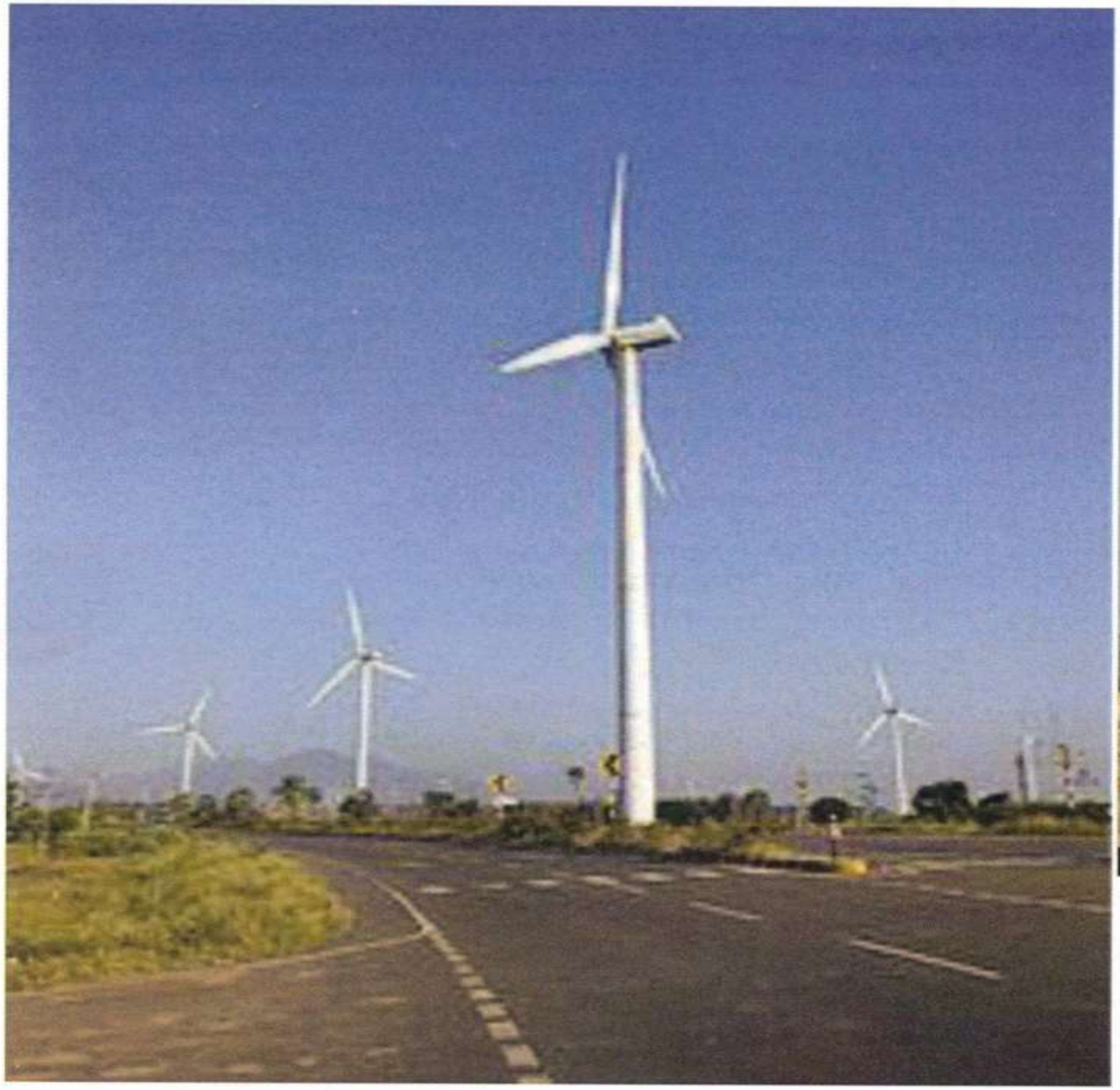


This map is published by the World Bank Group, funded by ESMAP, and prepared by DTU and Vortex. For more information and terms of use, please visit http://globalwindatlas.info

কিছু পরিসংখ্যান - ভারত - বর্তমান

31 জুলাই 2022 পর্যন্ত, মোট ইনস্টল করা বায়ু শক্তির ক্ষমতা ছিল 40.893 GW, যা বিশ্বের চতুর্থ বৃহত্তম ইনস্টল (প্রধানত দক্ষিণ, পশ্চিম এবং উত্তর পশ্চিম অঞ্চল)

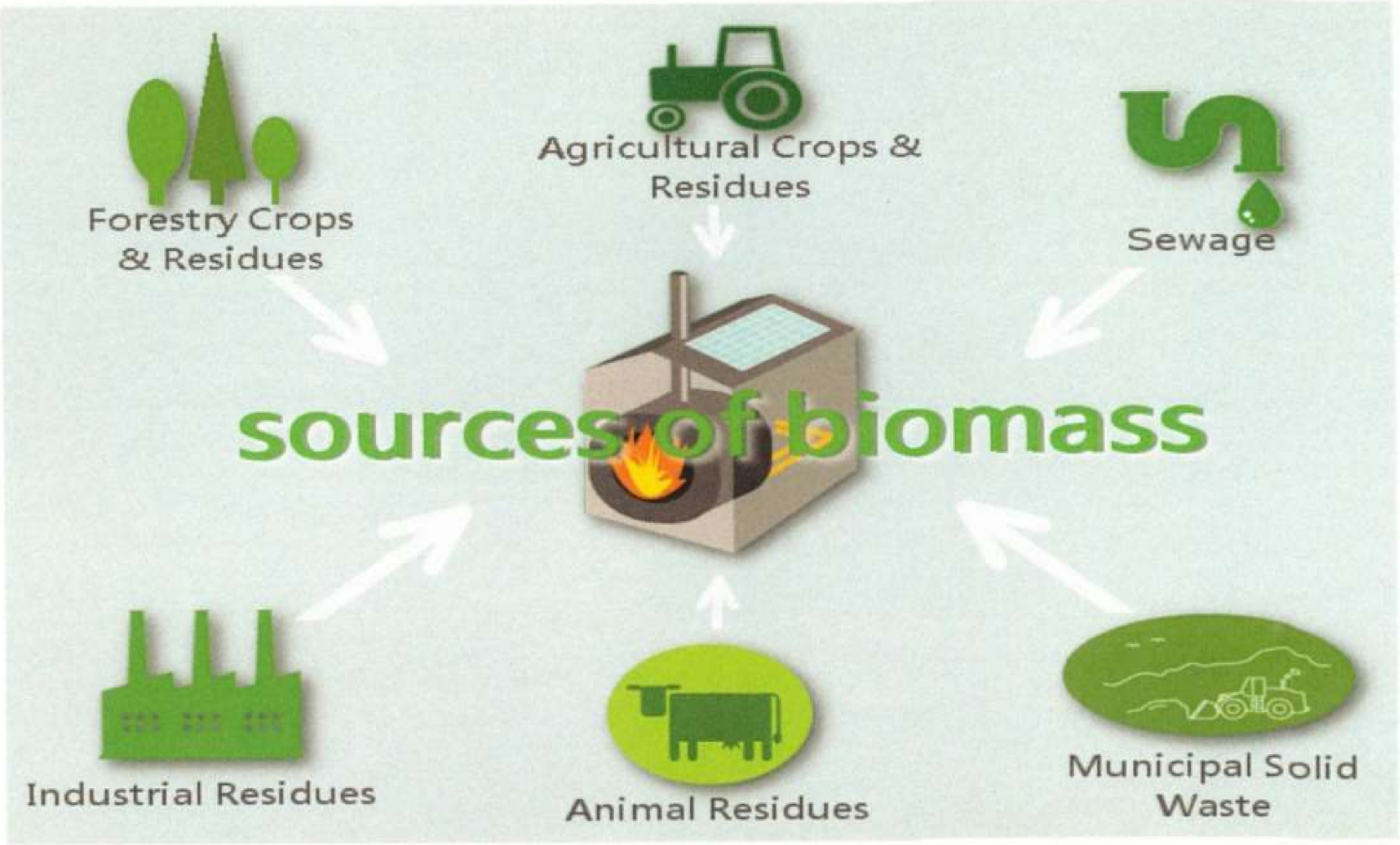




Bakkhali Wind farm

Muppandal Wind farm near NH44 1.5GW

জৈব শক্তি

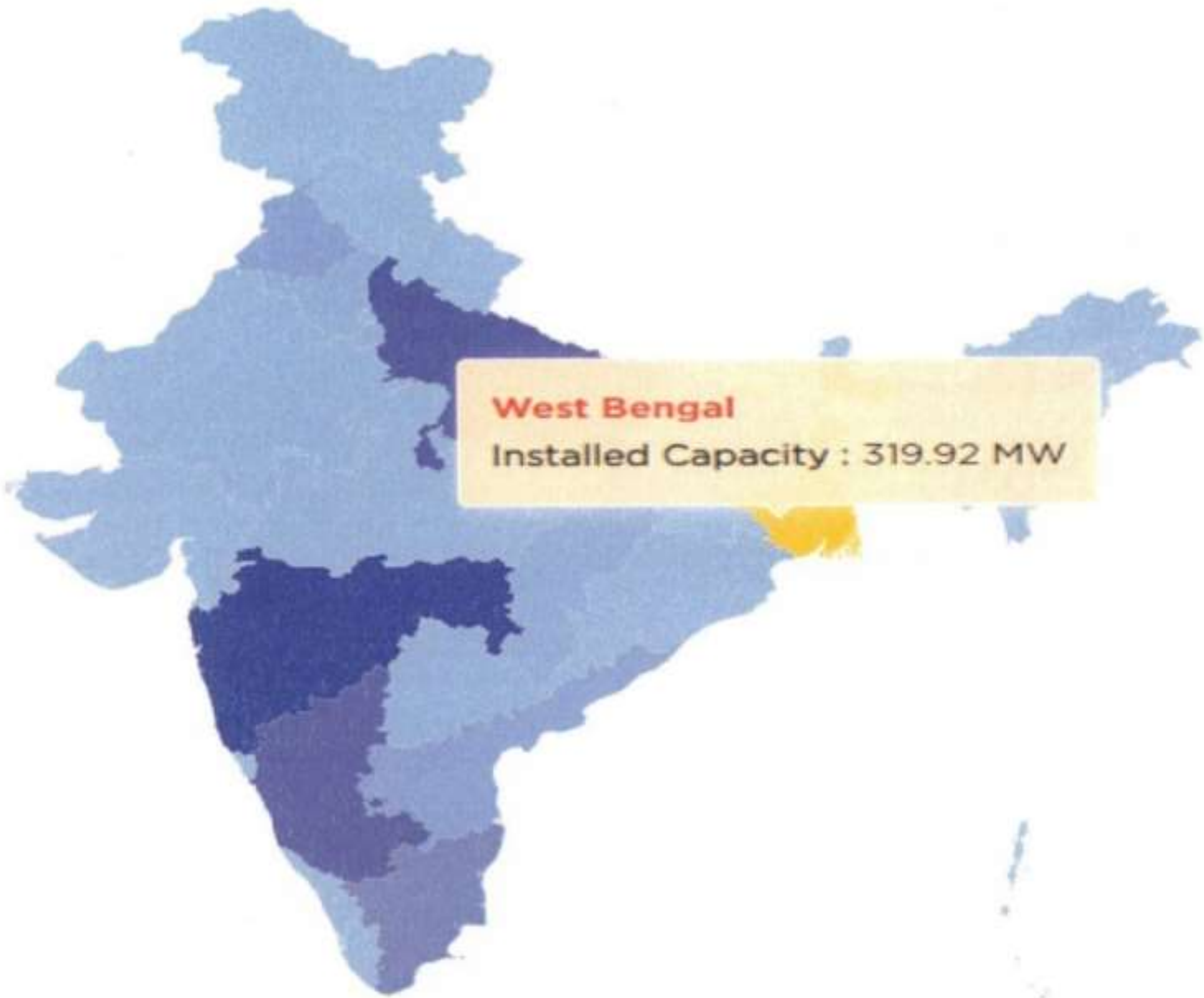


Forestry Crops & Residues
Agricultural Crops & Residues
Sewage
sources of biomass
Industrial Residues
Animal Residues
Municipal Solid Waste

কিছু পরিসংখ্যান

Global electricity power generation capacity	143.4 GW (2021)[89]
Global electricity power generation capacity annual growth rate	7.1% (2012-2021)[90]
Share of global electricity generation	2% (2018)[56]
Levelized cost per megawatt hour	USD 118.908 (2019)[91]
Primary technologies	Biomass, biofuel
Other energy applications	Heating, cooking, transportation fuels

কিছু পরিসংখ্যান

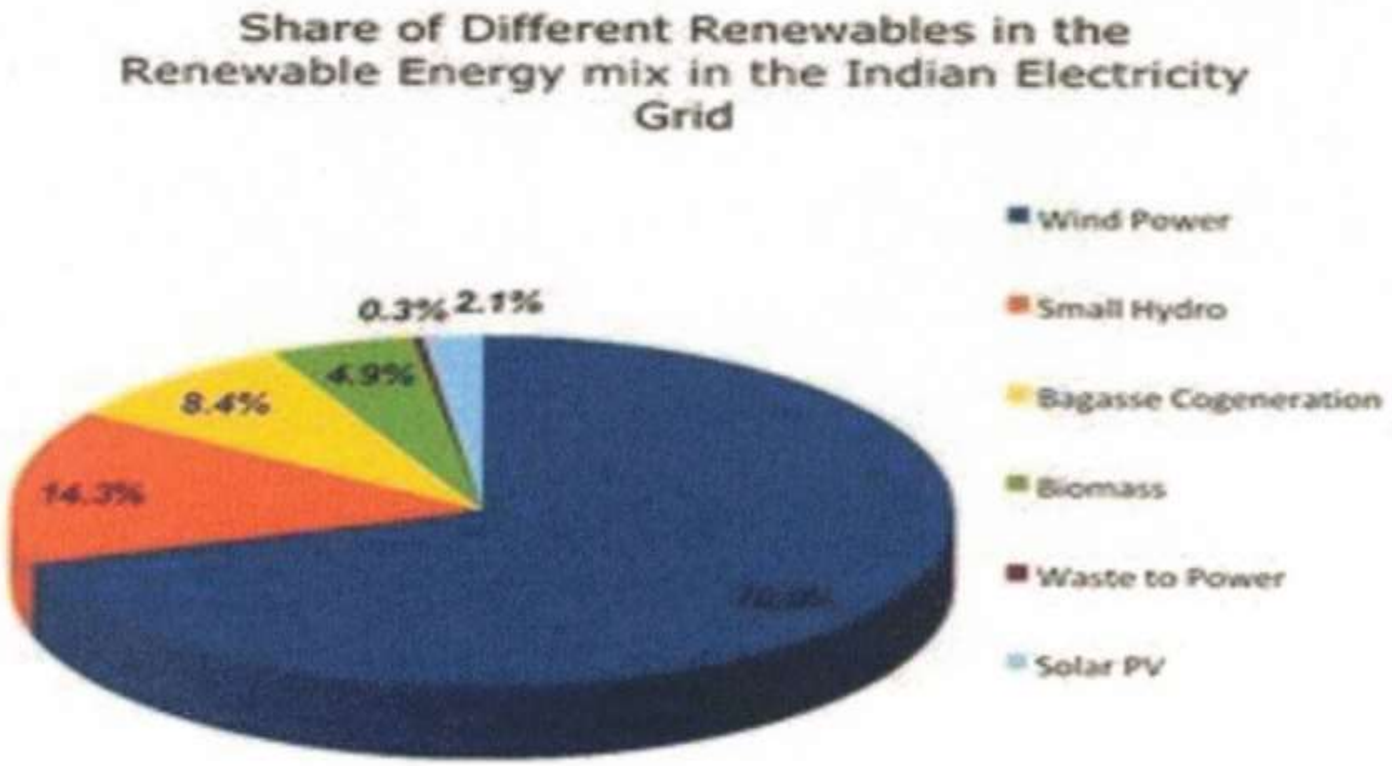

West Bengal
Installed Capacity : 319.92 MW


Overall Target(In GW)
Installed Capacity (In GW)
0
1
2
3
4
5
6
7
8
9
10

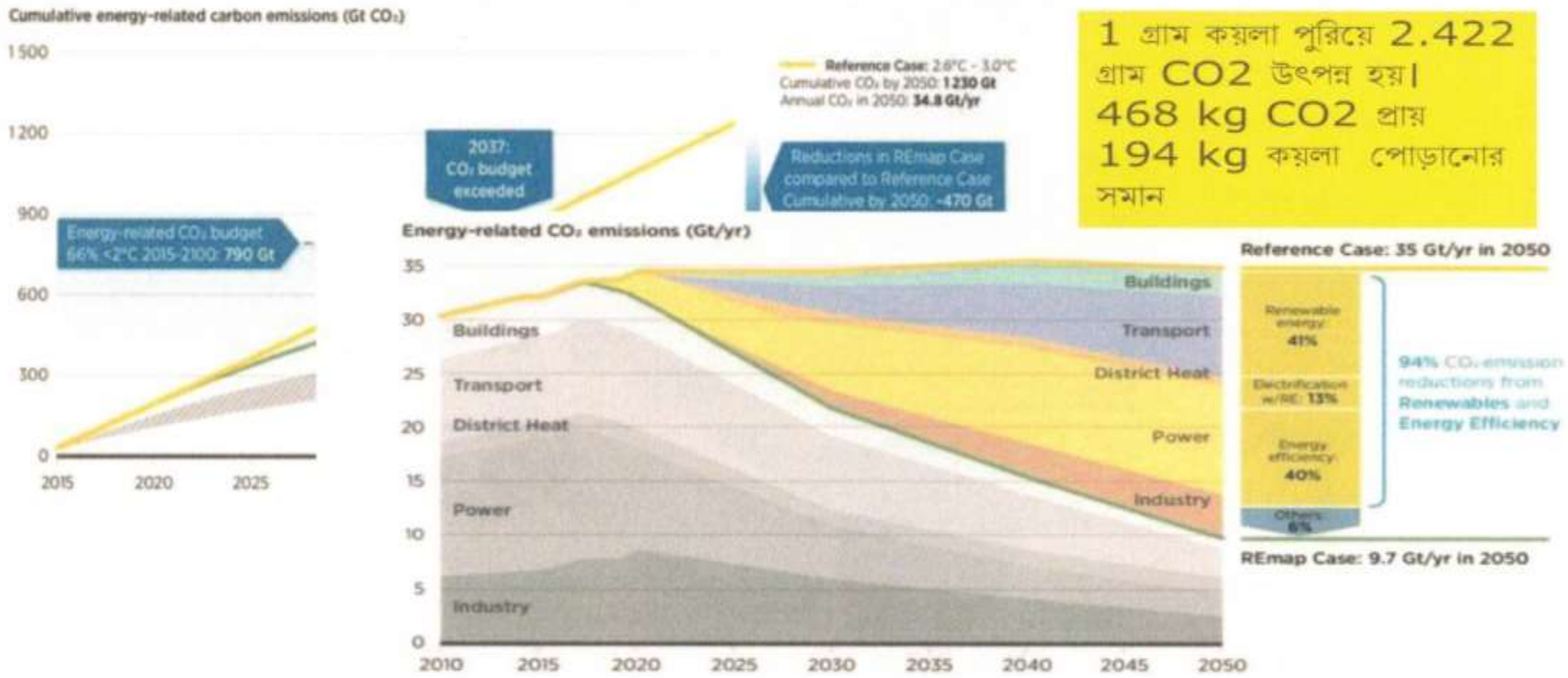
ফিরোজপুর পাঞ্জাব

অন্যান্য নবায়ন যোগ্য উৎস

geothermal energy - ভূ শক্তি
tidal wave energy - জোয়ার তরঙ্গ শক্তি
small hydro power - ক্ষুদ্র জলবিদ্যুৎ প্রকল্প

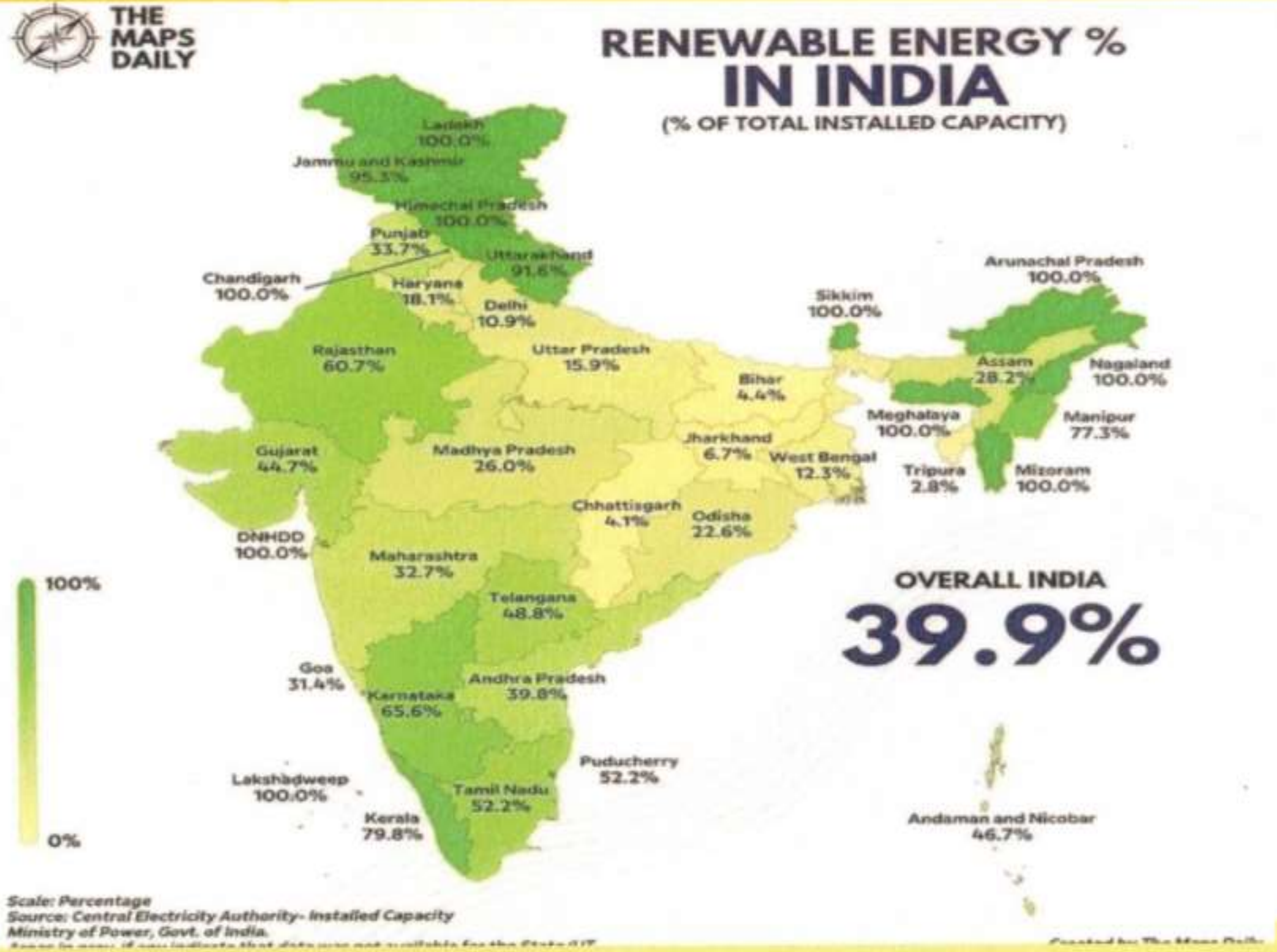


উপযোগিতা



1 গ্রাম কয়লা পুরিয়ে 2.422 গ্রাম CO2 উৎপন্ন হয়।
468 kg CO2 প্রায় 194 kg কয়লা পোড়ানোর সমান

ভারতে প্রদেশভিত্তিক বন্টন



শক্তির চাহিদা মেটানোর চেয়ে শক্তির চাহিদা কমানো:

- গার্হস্থ্য শক্তি প্রয়োজন নিয়ন্ত্রণ সোলার কুকার/বায়ো গ্যাস। সরকার ইনসেনটিভ সহায়ক হতে পারে
- সবুজ শাকসবজি/ কম প্রক্রিয়াজাত খাবার। খাদ্য শিল্পের শক্তির চাহিদা অটোমোবাইলের চেয়ে বেশি এবং বেশি গ্যাস নির্গমন
- সৌর আলো
- কম শক্তি ব্যবহার করার অভ্যাস করা –
- সাইকেল চালানো

2. *Proper transition into* **EV, Solar vehicles.**

3. **Green hydrogen** *cultivation.*

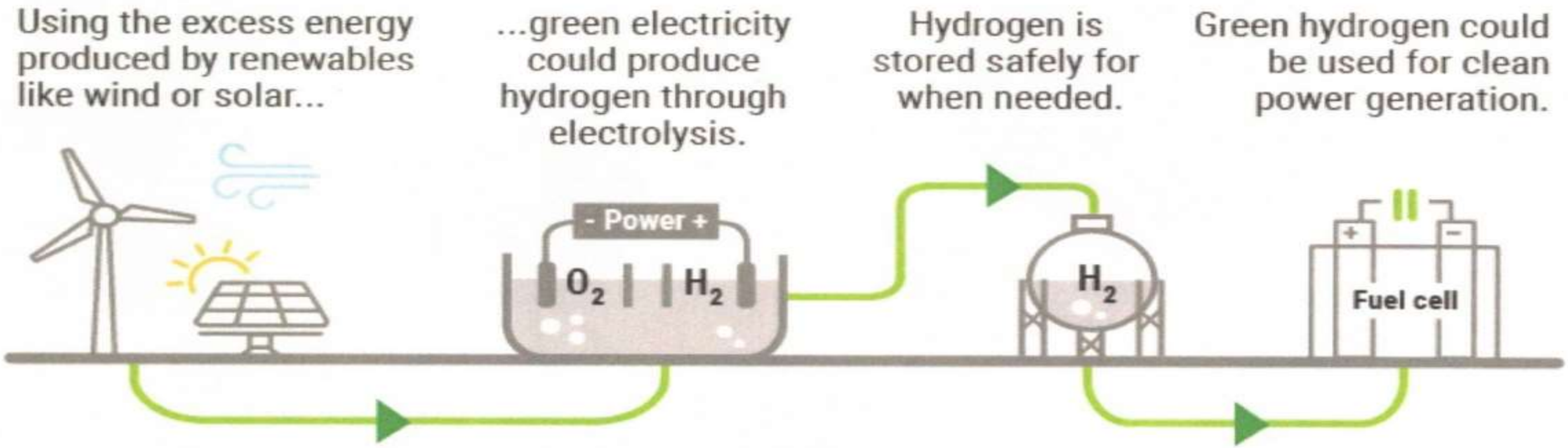
বৈদ্যুতিন যানবাহন

Electric vehicle charging

Solar TOTO developed at IIEST Shibpur

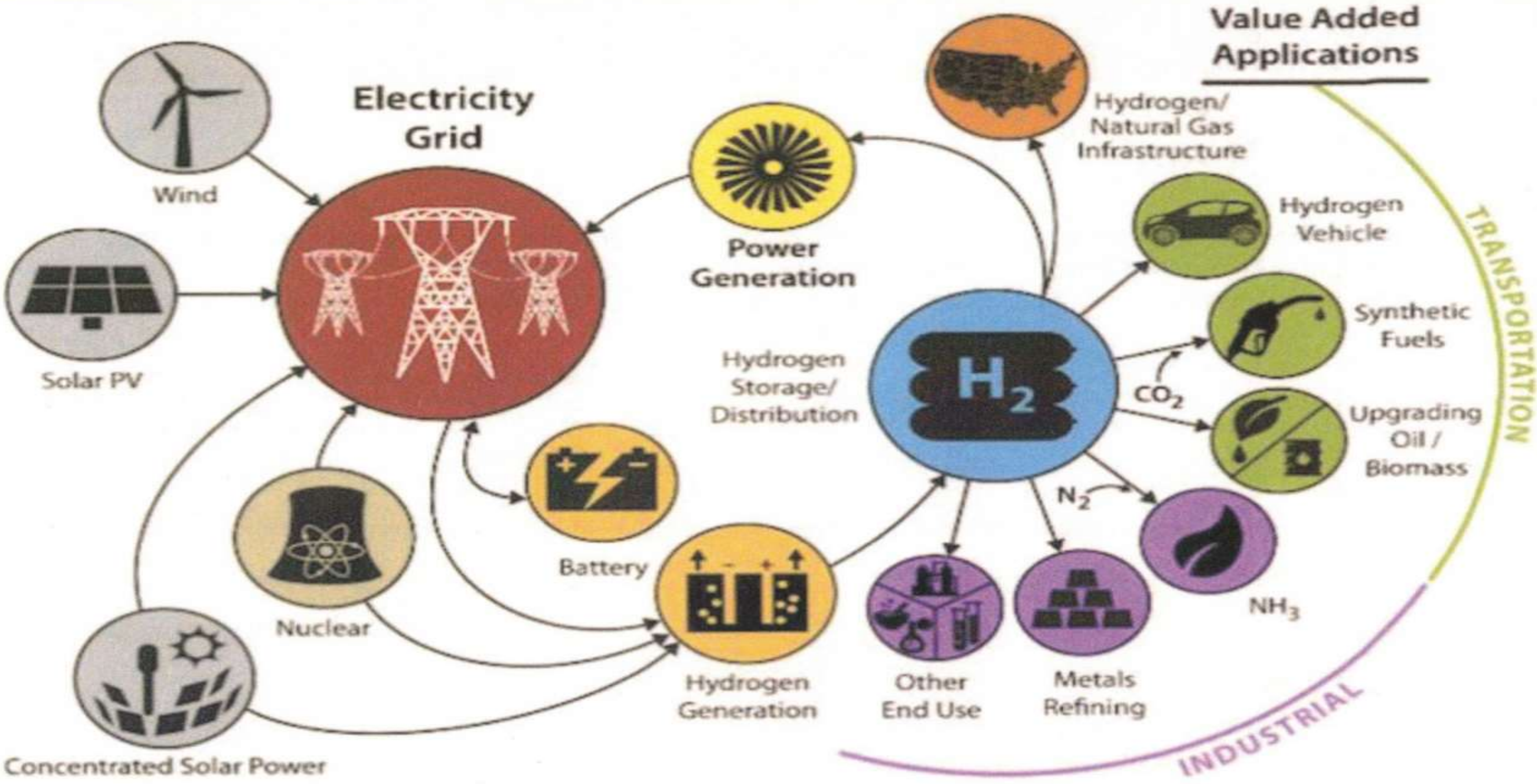
Green hydrogen

সম্ভাব্য উপায়ঃ



Source: New York ISO

Hydrogen অর্থনীতি



মুখ্য বৈশিষ্ট ও উপাদান

Green hydrogen production

Major cost components

Electrolysers – ~36 per cent to the levelised cost of production

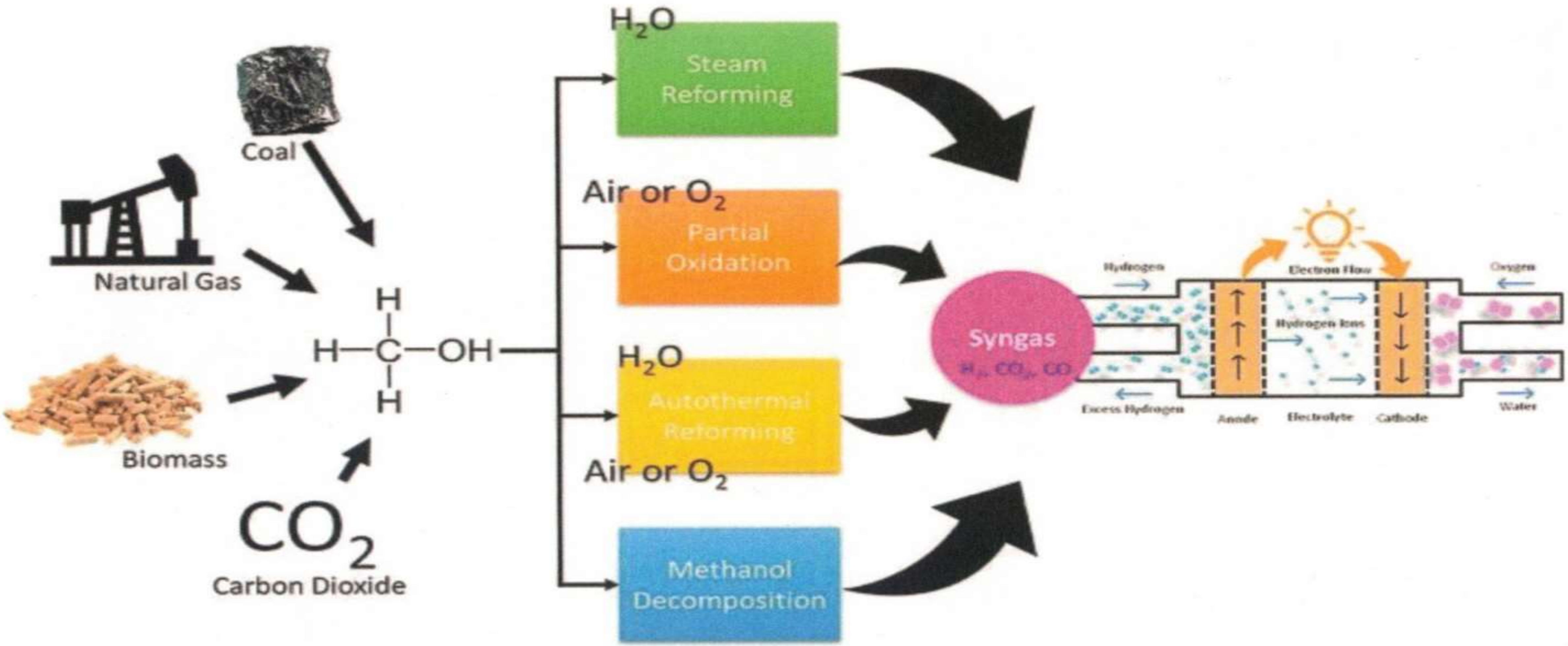
Energy – ~48 per cent to the levelised cost of production

Storage – ~12 per cent to the levelised cost of production

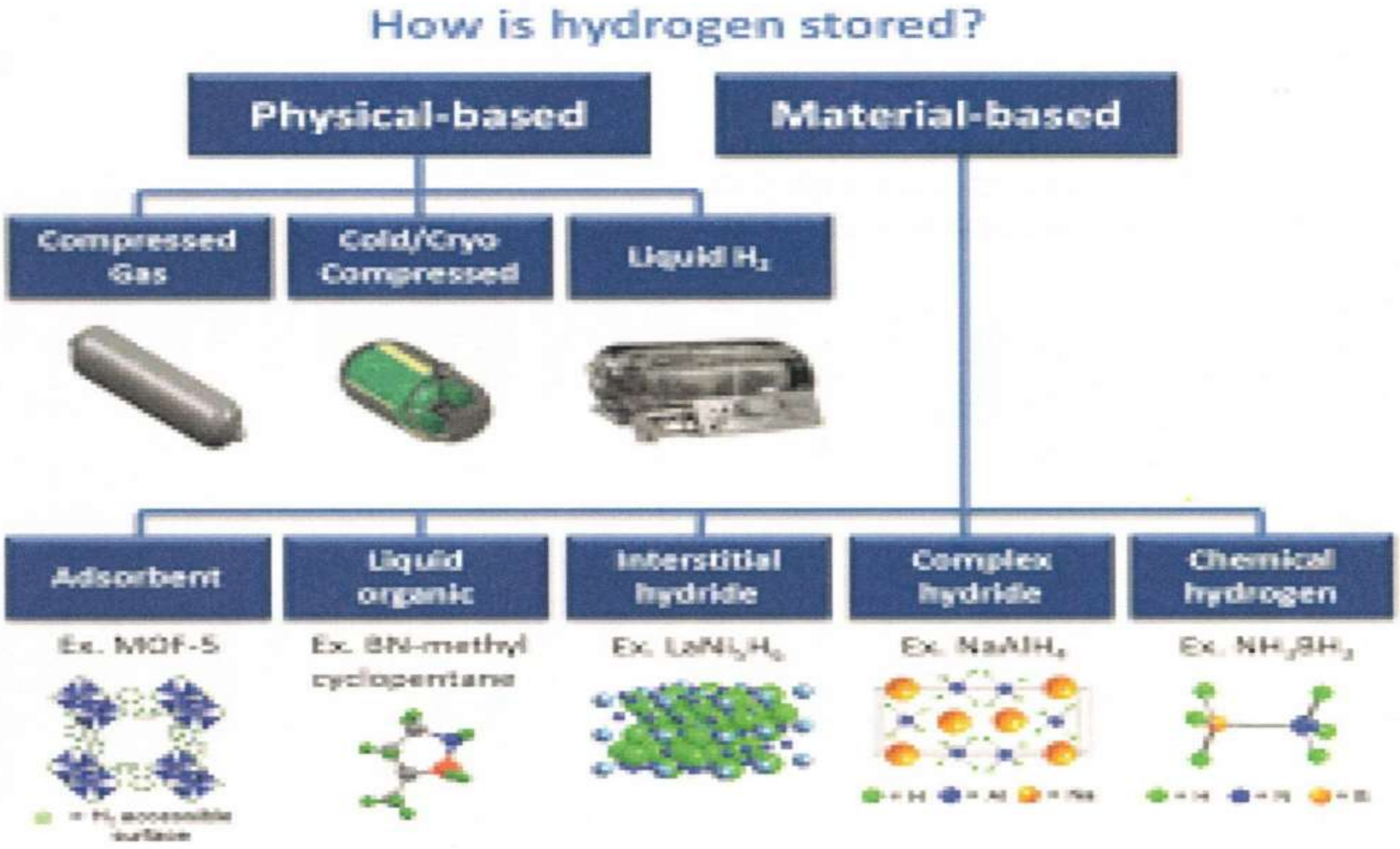
Key challenges

- High levelised cost of green hydrogen production – The levelised cost of green hydrogen (LCOH) production is around two times that of grey/black hydrogen, which translates to a poor business case for setting up green hydrogen production facilities. (LCOH: green hydrogen – USD 3.6–5.8/kg; grey hydrogen – USD 1.7–2.3/kg; black/brown hydrogen – USD 0.9–1.5/kg).
- Large capital requirements.

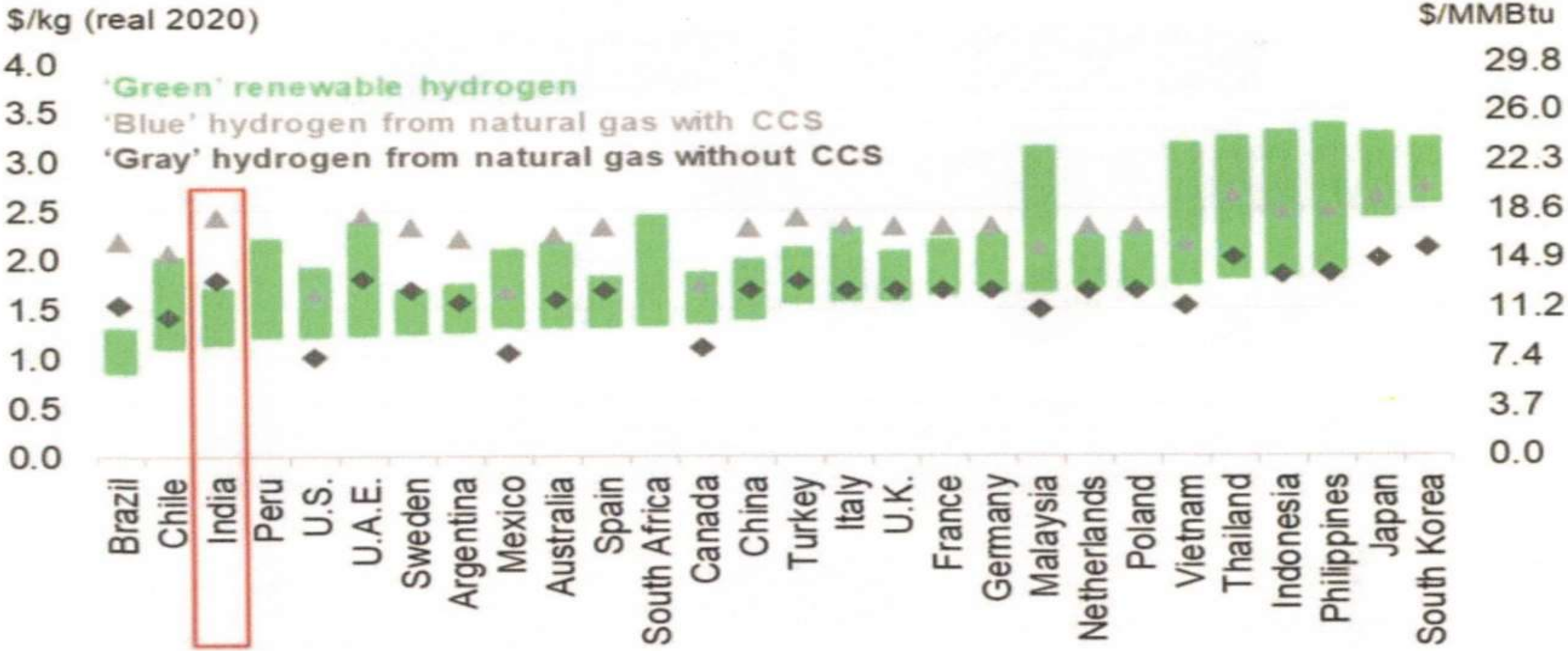
Hydrogen উৎপাদন



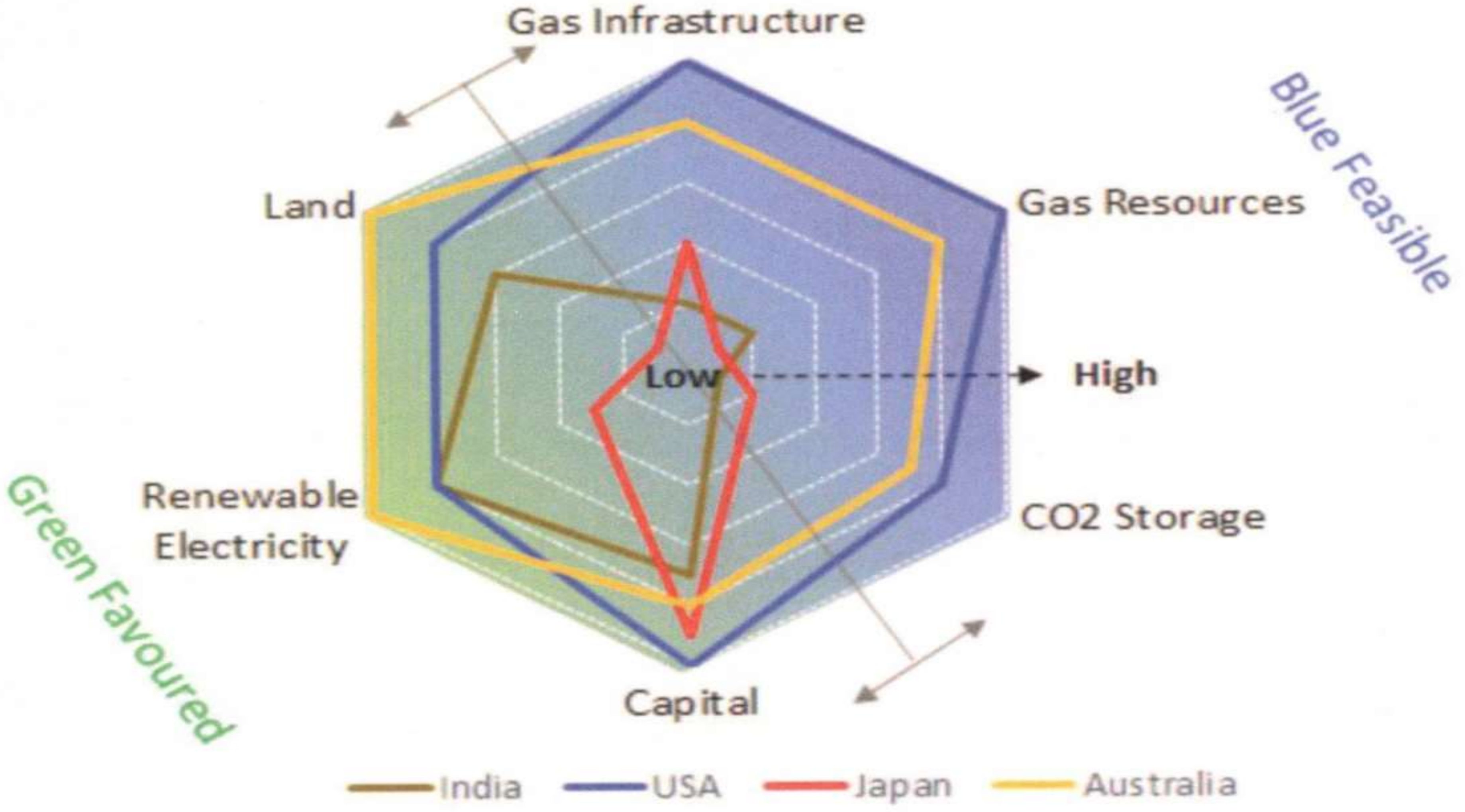
Hydrogen সঞ্চয়



Hydrogen অর্থনীতি - ভারত - বর্তমান ও ভবিষ্যৎ



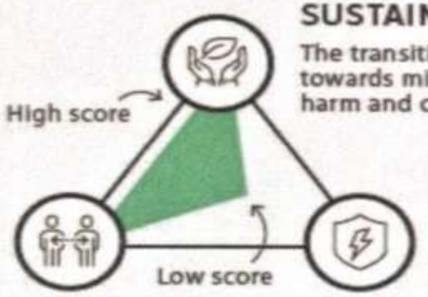
Hydrogen অর্থনীতি - ভারত - বর্তমান ও ভবিষ্যৎ



Energy Trilemma Index

COUNTRY SPOTLIGHT

Energy Trilemma Index scores are calculated using three measures:



SUSTAINABILITY

The transition of a country's energy system towards mitigating potential environmental harm and climate change impacts.

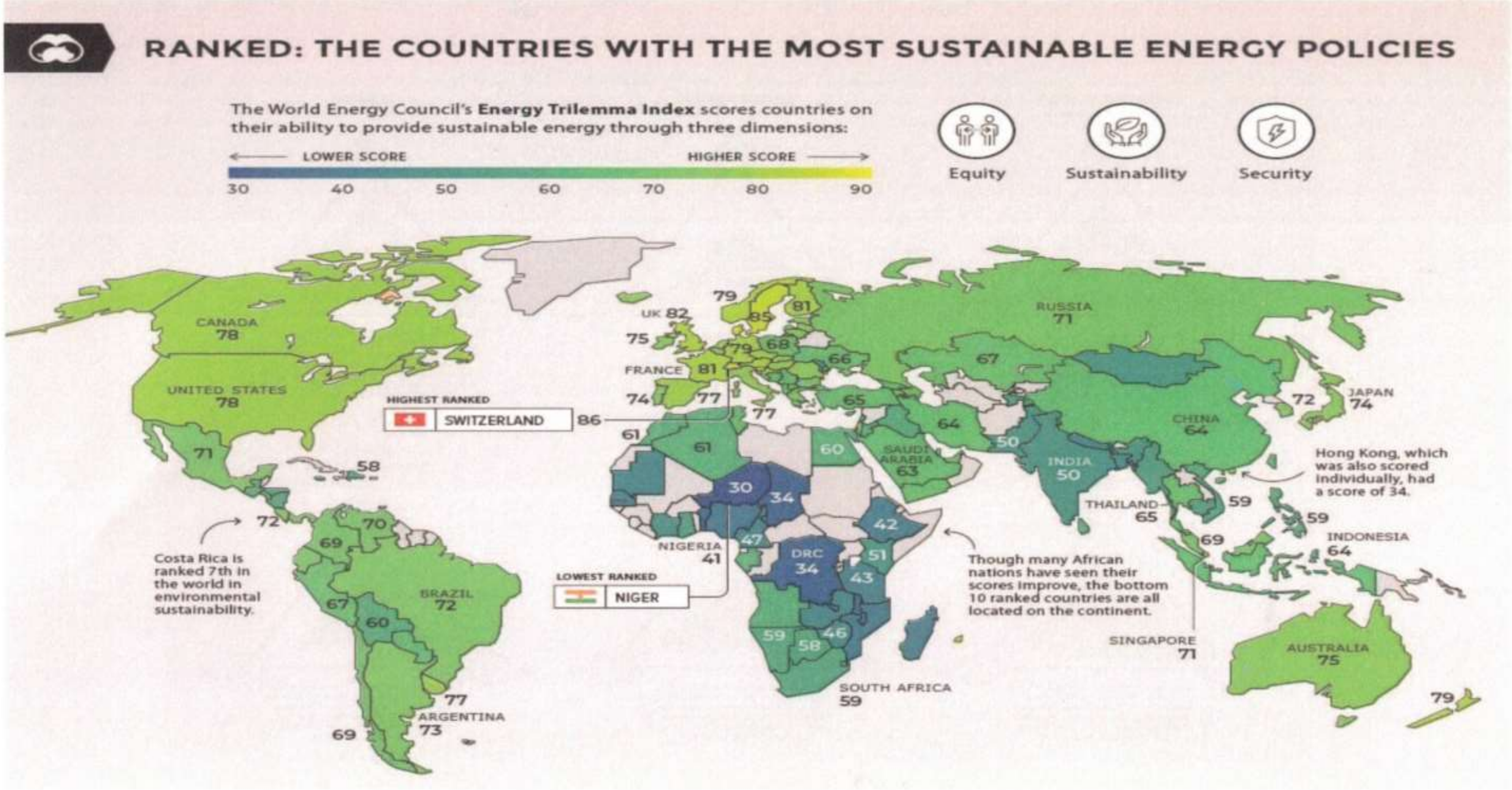
EQUITY

Basic access to reliable, affordable, and abundant energy for domestic and commercial use.

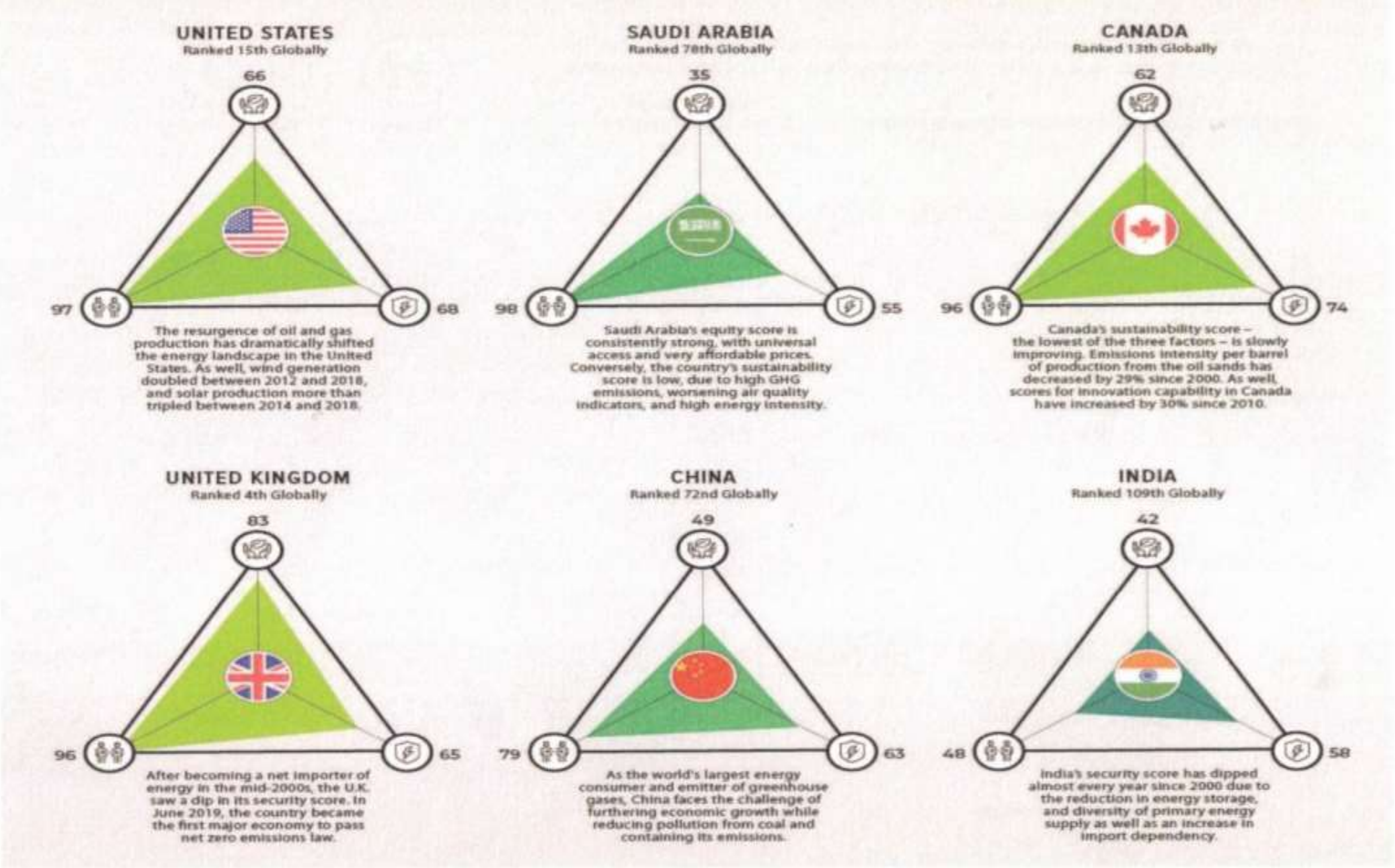
SECURITY

Energy Security measures a nation's capacity to meet demand reliably, withstand system shocks.

বিশ্বব্যাপী স্থিতিশীলতা



ভারত সহ বিভিন্ন দেশ – ত্রিশঙ্কুর এর নিরিখে



ত্রুটিপূর্ণ বাস্তবায়নের প্রভাব:

বিকল্পই শক্তি উৎসেই সমাধান, কিন্তু পথ নির্ধারণ করতে হবে।

- **Sri - Lankan Case study: -**

Organic farming crisis

1. lack of infrastructure

2. Poor planning/ illogical assessment

back to traditional, **shows requirement of a strong base of change**

- **Indian Coal - Crisis case study:**

Though conventional

1. lack of planning

2. lack of situational awareness

Shows requirement of a **contingency**

বিকল্প বা নবায়ন যোগ্য শক্তির সমস্যা

প্রযুক্তি গত সমস্যা

- Low efficiency
- irregular source
- Massive installation cost
- Not fully proven
- Risk factor high : Nuclear

প্রশাসনিক সমস্যা

- Less awareness in public
- Lack of industrial policy
- Loose safety protocol
- Lack of policies in context of global supply chain.

সম্ভাব্য উপায়ঃ

- সংঘর্ষ এড়াতে সরকারের উচ্চ ও নিম্ন উভয় স্তরেই নীতিমালা।
- শিক্ষা বিশেষ করে *কারিগরি শিক্ষাকে স্থিতিশীল ধারণার* ওপর ভিত্তি করে গড়ে তুলতে হবে।
- এনার্জি গ্রিড / সংযোগকারী মাইক্রো *গ্রিডের স্থানীয়করণ*।
- উদ্ভাবনী ধারণা সহ কোম্পানি এবং ছোট স্টার্ট আপ সাহায্য করার জন্য ভর্তুকি। যেমন – *প্রভাইগ ডায়নামিক্স*
- বাস্তবায়নের ক্ষেত্রে সঙ্কট এড়াতে একটি আকস্মিক পরিকল্পনা রাখুন।
- *অর্থনৈতিক মুনাফা অনুযায়ী নয়, জরুরি ভিত্তিতে* নীতি তৈরি করুন।
- হাইব্রিড পুনর্নবীকরণযোগ্য শক্তি সংগ্রহ
- 25 বছরের জন্য 5-বছরের পরিকল্পনা
- শুধুমাত্র প্রথম 2টি পরিকল্পনা মেয়াদে প্রাথমিকভাবে যৌথ বিদেশী সহযোগিতা
- *10 বছর পরে সমস্ত মেড-ইন-ইন্ডিয়া*
- 20 বছর পর সবুজ শক্তি রপ্তানিকারক

কিছু গুরুত্বপূর্ণ পদক্ষেপ

- বিদ্যুৎ ক্রয়ের বাধ্যবাধকতার প্রবর্তন (**"PPO"**),
- ট্যারিফ নীতির সংশোধন,
- পাওয়ার ক্রয় চুক্তি প্রদানের জন্য বিপরীত বিডিংয়ের প্রবর্তন
- বিভিন্ন প্রত্যক্ষ এবং পরোক্ষ ভর্তুকি বিধান.
- সৌর মডিউলে মৌলিক কাস্টম শুল্ক
- রিলায়েন্স/আদানির মতো বড় কোম্পানিগুলি পুনর্নবীকরণযোগ্য বিনিয়োগ করছে।

INDIA MUST RECOGNIZE THE OBVIOUS TRUTH

1. THE COUNTRY IS BLESSED WITH SOLAR ENERGY AS NO OTHER!
2. Sun's Energy input to India=60x of all global E output=3500 TW!!!
3. INDIA MUST GET RID OF FOSSIL FUEL DEPENDENCY OF FOREIGN POWERS ASAP AND CLAIM ENERGY INDEPENDENCE THRU GREEN OPTIONS
4. INDIA IS BLESSED WITH 92,000 SQUARE MILES OF GREAT THOR DESERT OF RAJASTHAN: MOSTLY INHOSPITABLE & IDEAL AND ECOLOGICALLY APPROPRIATE TO ESTABLISH SOLAR POWER PLANTS
5. INDIA NEEDS ONLY 1500 SQUARE MILES [1.63% OF THOR] OF DESERT AREA FOR SOLAR PLANTS TO FULFILL ALL ENERGY NEEDS
6. INDIA WOULD NEED TO INVEST ESTIMATED ONLY 2% OF GDP FOR INDEPENDENCE AND PROSPERITY AND HEALTH AND PRODUCTIVITY
7. INDIA COULD BE AN EXPORTER OF GREEN ENERGY TO NEIGHBORS AND AID BOTH PROSPERITY AND GLOBAL SUSTAINABILITY

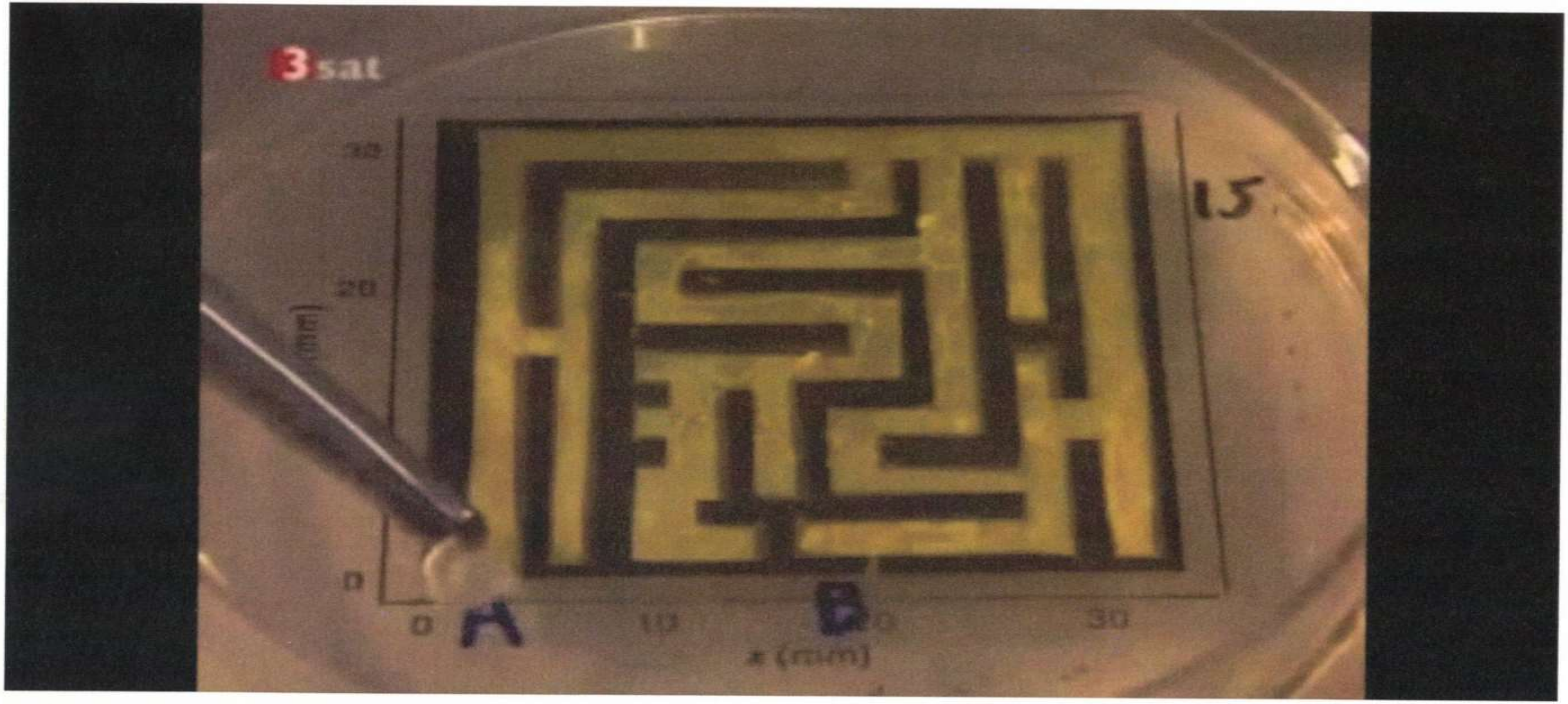
মন্তব্য

প্রকৃতির পথই একমাত্র পথ।

প্রকৃতির বিরুধহে গিয়ে উন্নতি সম্ভব নয়।

প্রকৃতি ও প্রযুক্তির সহাবস্থান ই স্থিতিশীল উন্নতির প্রধান উপায়

Classic example of nature's way



ধন্যবাদ

বিজ্ঞান ও প্রযুক্তির মাধ্যমে সুস্থির জীবন ও অস্তিত্ব

II

A DISCUSSION ON

EXISTENCE, LIFE, SUSTAINABLE LIVING THROUGH SCIENCE AND TECHNOLOGY

14th December

Time 11.30 pm

INNOVATION FOR GLOBAL SUSTAINABILITY 5I
INNOVATION
INSPIRATION
INVOLVEMENT
INFORMATION
INQUIRY
BHATTACHARYYA FOUNDATION

SARBODAY SANGHA
AJAYA, PURBA MEDINIPUR

IIEST, Shibpur
आई आई ई एस टि, शिवपुर
Erstwhile B E College (Estd 1856)

Anandalok Energy Pvt. Ltd.

Renewable energy harvesting system

What is Solar Energy?

- The most precise Solar Energy definition : **Energy from the sun.**
- But <u>what is solar energy</u> really?

  There are two types of solar energy: ***Thermal Energy*** ***&*** ***Electric Energy***
- **Thermal Energy: Thermal** Energy is everywhere. It's lights up our days. It heats the earth, our bodies and our homes. It dries our clothes . All for free!
- **Electric Energy: Electric** Energy uses the power of the sun to produce electricity through solar cells, otherwise known as ***Photovoltaics*** (PV).

Photovoltaics

Photovoltaics (PV) is the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect,

When the source light is from Sun it is called Solar Photovoltaic

- **The photovoltaic effect is the generation of voltage and electric current in a material upon exposure to light.**
- **It is a physical and chemical phenomenon**

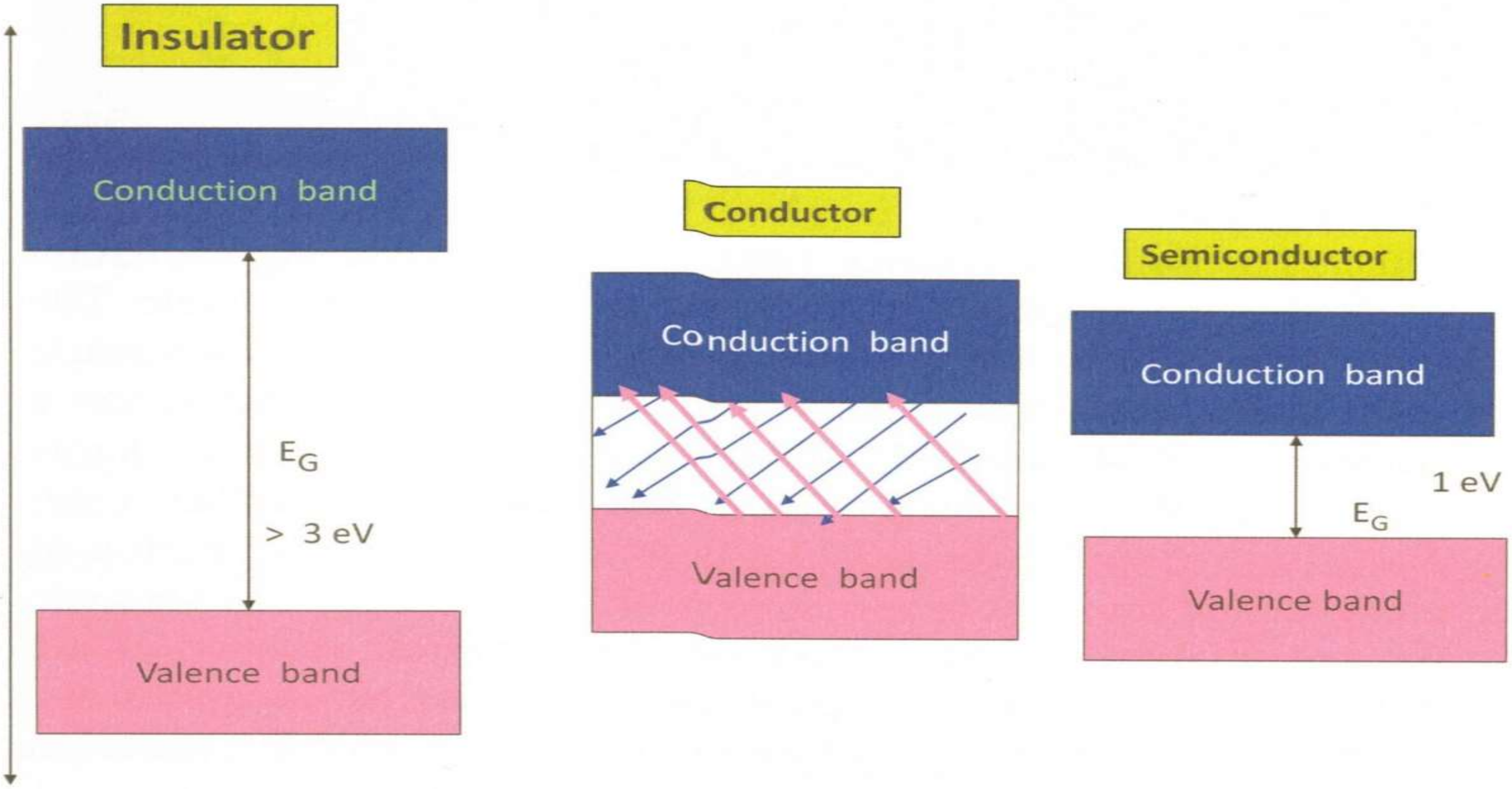
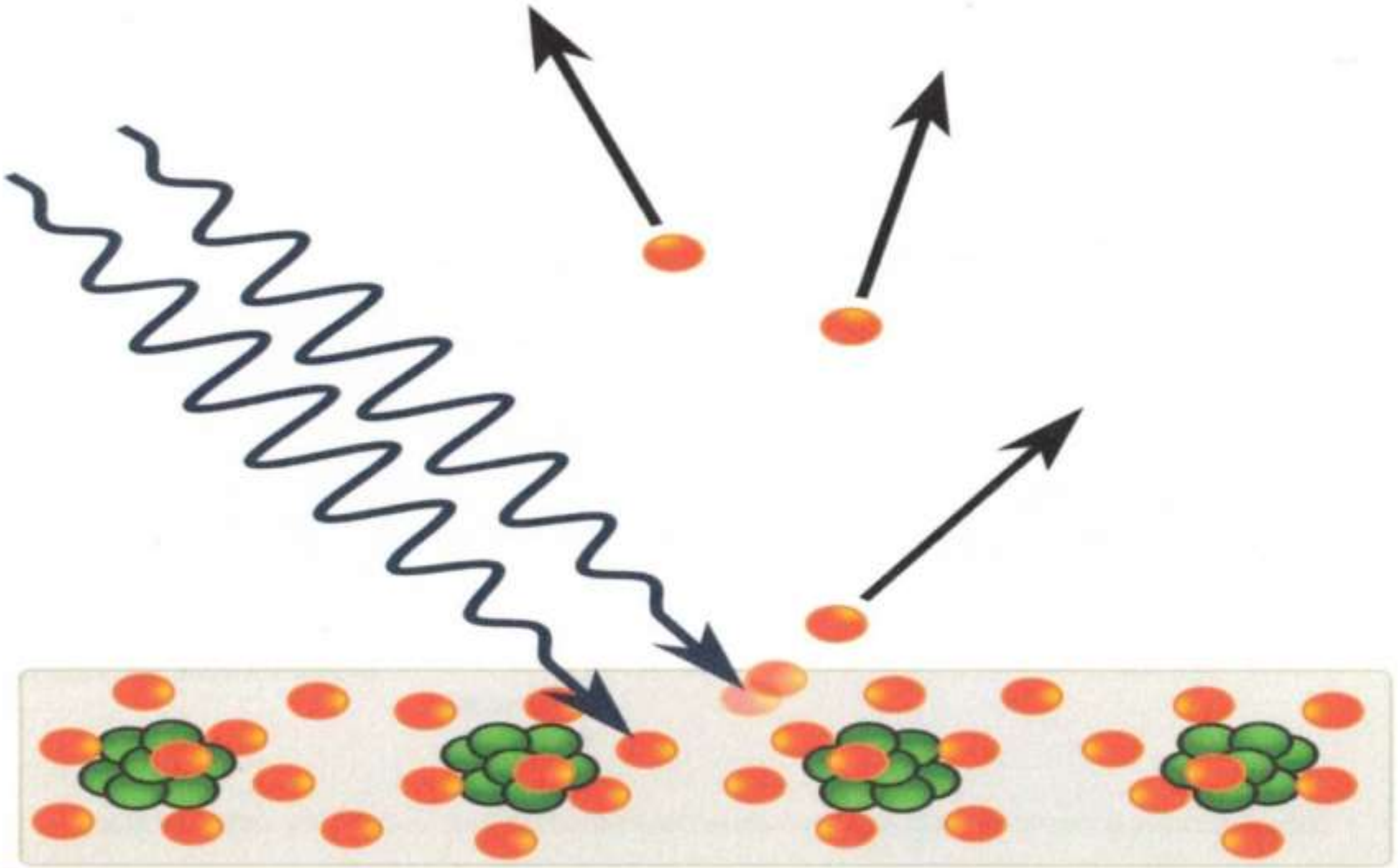

Insulator
Conduction band
E_G
> 3 eV
Valence band
Conductor
Conduction band
Valence band
Semiconductor
Conduction band
1 eV
E_G
Valence band

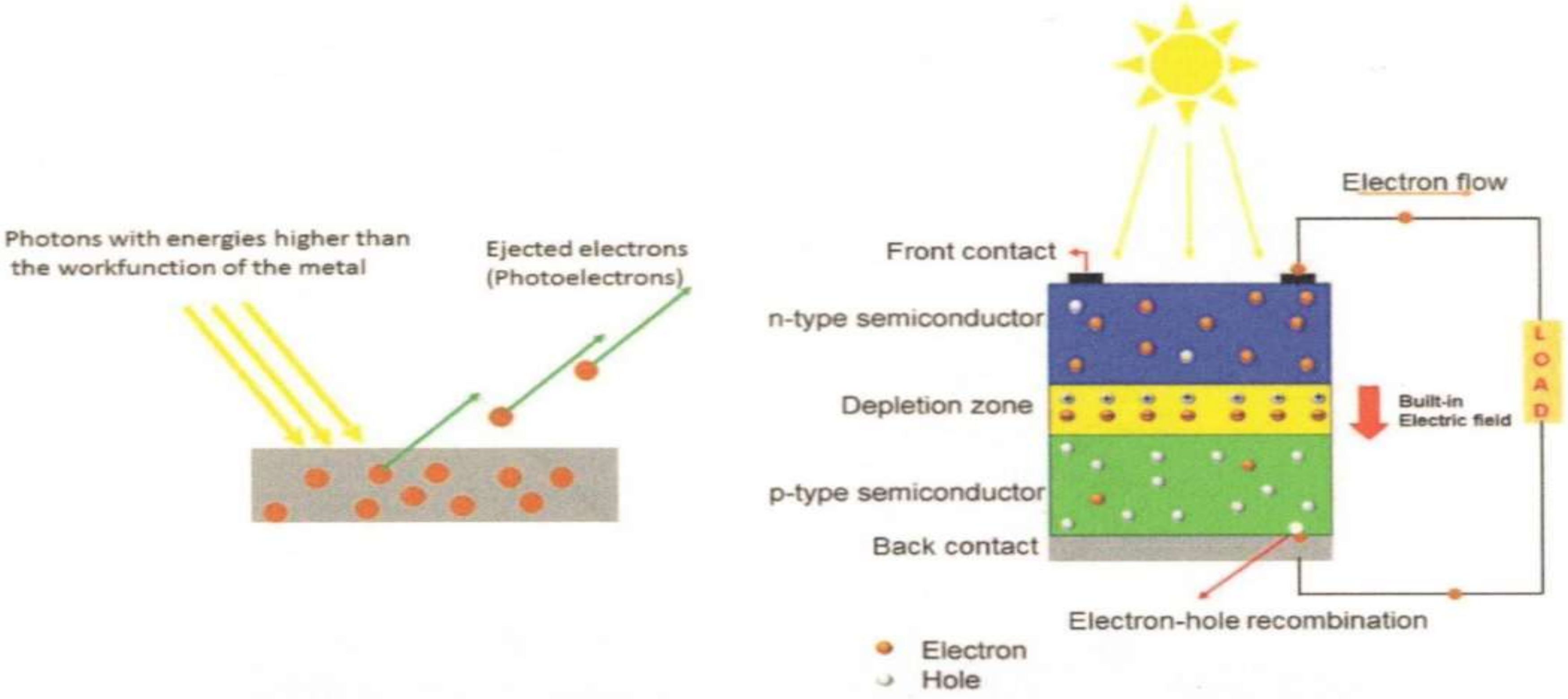
Photo electric effect vs Photovoltaic effect

The photovoltaic effect is closely related to the photoelectric effect. For both phenomena, light is absorbed, causing excitation of an electron or other charge carrier to a higher-energy state. The main distinction is that the term photoelectric effect is now usually used when the electron is ejected out of the material (usually into a vacuum) and photovoltaic effect used when the excited charge carrier is still contained within the material. In either case, an electric potential (or voltage) is produced by the separation of charges, and the light has to have a sufficient energy to overcome the potential barrier for excitation. The physical essence of the difference is usually that photoelectric emission separates the charges by ballistic conduction and photovoltaic emission separates them by diffusion,

Photoelectric effect



Photovoltaic effect

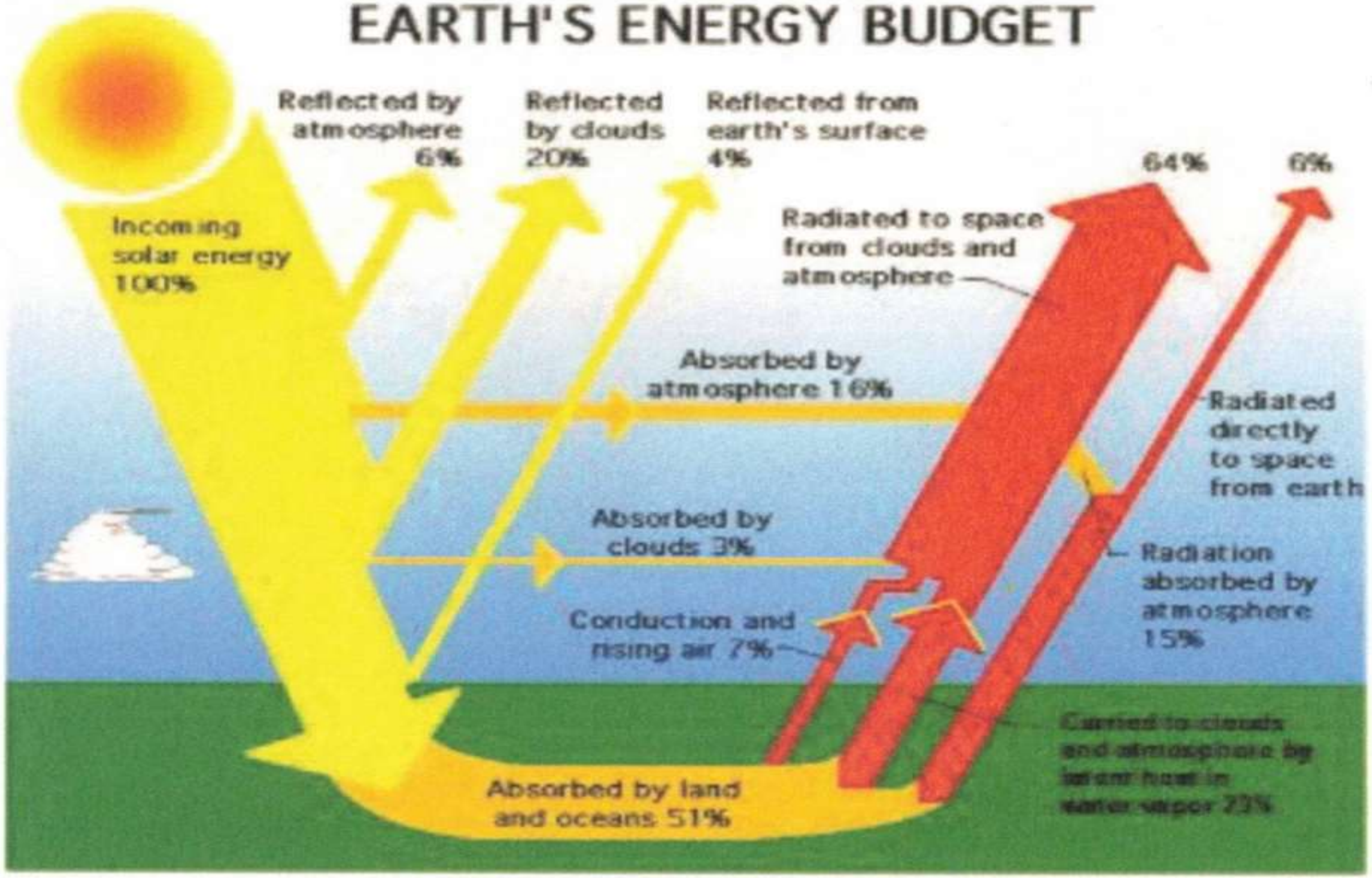


Schematic representation of what happens in photoelectric effect (left) and in a PV solar cell (right).

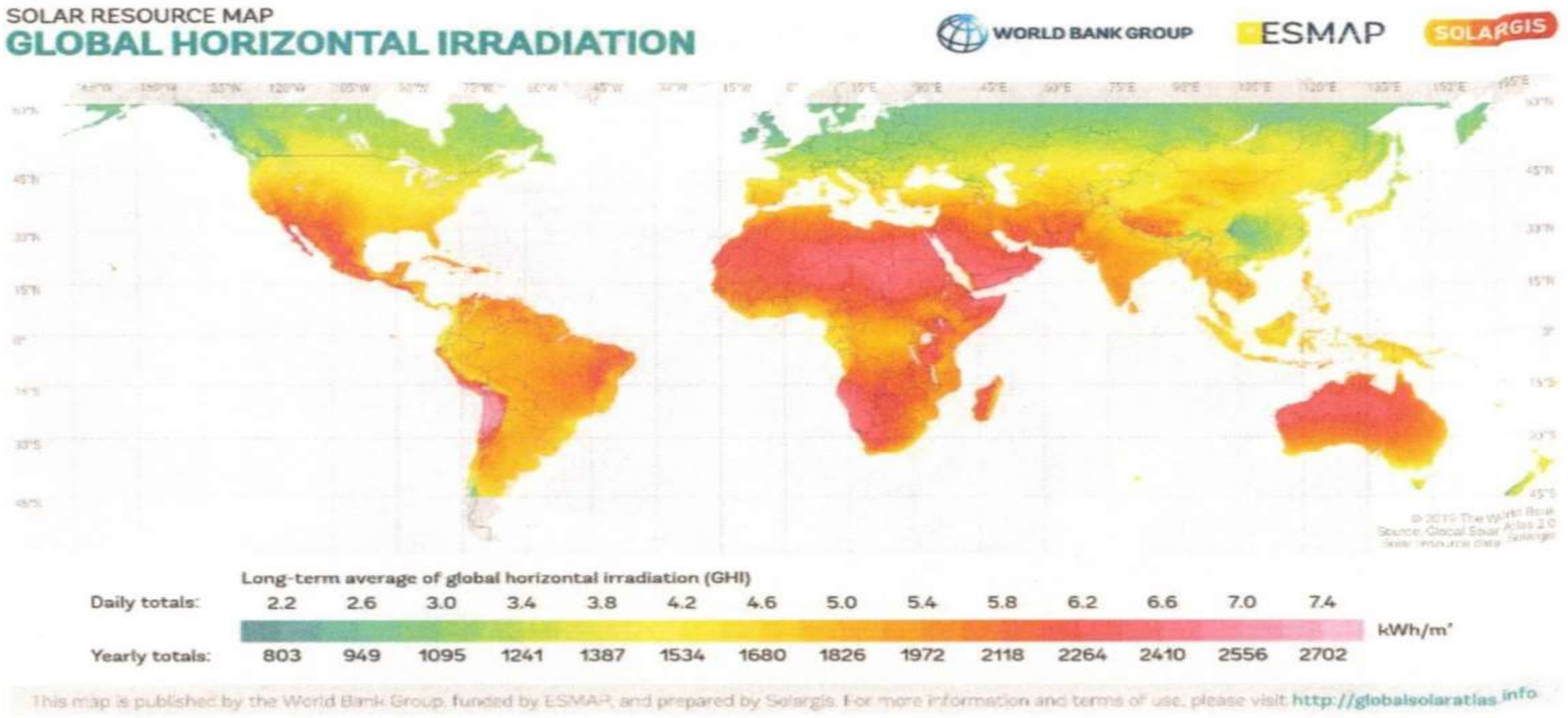
Solar Photovoltaics

The Sun

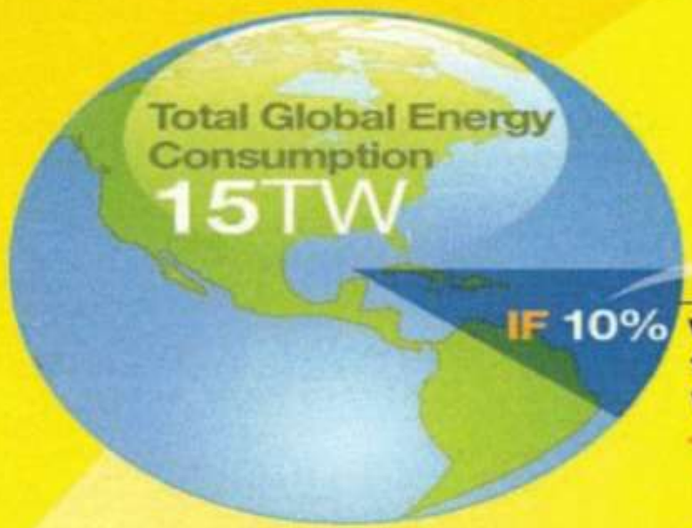
- Diameter: 1.39E9 m (120 x greater than earth)
- Distance from earth = 1.495E11 m (93 million miles) ± 1.7%
- Center: Density ≅ 100 x density of water and T>1E6 K
- Powered by hydrogen fusion
- Composed of layers. The outer layer is the photosphere
- Effective blackbody temperature of 5777 K


EARTH'S ENERGY BUDGET
Reflected by atmosphere 6%
Reflected by clouds 20%
Reflected from earth's surface 4%
64%
6%
Incoming solar energy 100%
Radiated to space from clouds and atmosphere
Absorbed by atmosphere 16%
Radiated directly to space from earth
Absorbed by clouds 3%
Radiation absorbed by atmosphere 15%
Conduction and rising air 7%
Absorbed by land and oceans 51%

বিশ্ব ব্যাপী দৈনিক ও বার্ষিক সৌর বিকিরণ



Solar Potential



IF 10% was solar, the Solar Potential would be
1,500,000MW

Current Production
1,983MW

What Has Held Us Back?

- Previous inefficiencies of technology
- Reliance on incentives
- High/unpredictable total installed costs
- Little, to no, standardization

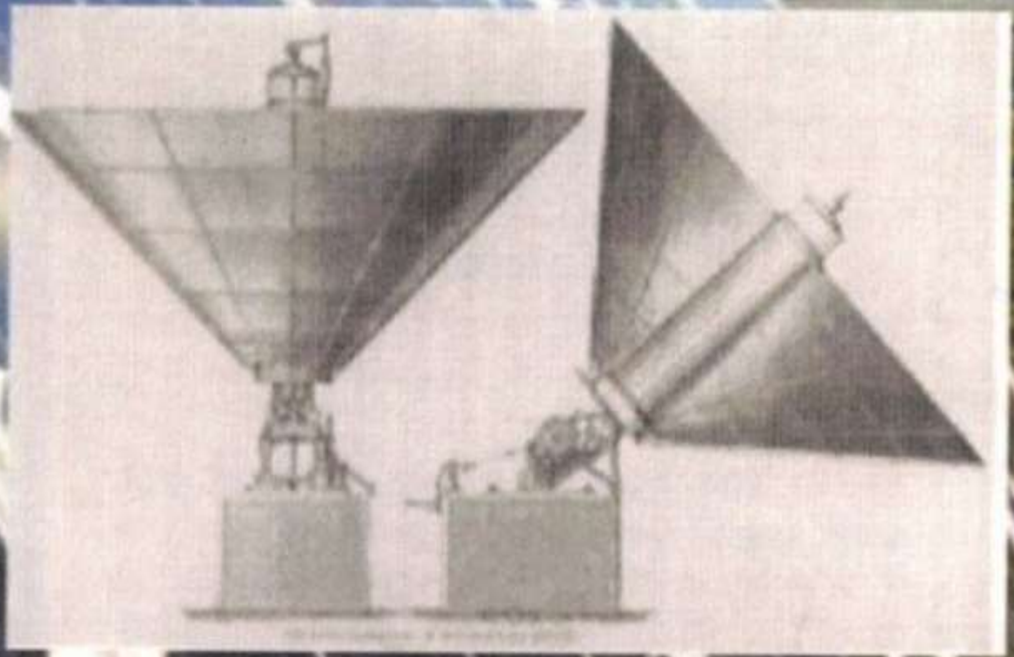
কিছু পরিসংখ্যান


SURFACE AREA REQUIRED TO POWER THE WORLD
WITH ZERO CARBON EMISSIONS AND WITH SOLAR ALONE
www.landartgenerator.org
BOXES TO SCALE WITH MAP
1980 (based on actual use)
207,368 SQUARE KILOMETERS
2008 (based on actual use)
2030 (projection)
Areas are calculated based on an assumption of 20% operating efficiency of collection devices and a 2000 hour per year natural solar input of 1000 watts per square meter striking the surface.
These 19 areas distributed on the map show roughly what would be a reasonable responsibility for various parts of the world based on 2009 usage. They would be further divided many times, the more the better to reach a diversified infrastructure that localizes use as much as possible.
The large square in the Saharan Desert (1/4 of the overall 2030 required area) would power all of Europe and North Africa. Though very large, it is 18 times less than the total area of that desert.
The definition of "power" covers the fuel required to run all electrical consumption, all machinery, and all forms of transportation. It is based on the US Department of Energy statistics of worldwide Btu consumption and estimates the 2030 usage (678 quadrillion Btu) to be 44% greater than that of 2008.
Area calculations do not include magenta border lines.
LAND ART GENERATOR INITIATIVE

HISTORICAL MILESTONES

- **1838** - Edmund Becquerel observed materials which turn light into energy
- **1876 - 78** - William Adams, wrote the first book about Solar Energy called: **A Substitute for Fuel in Tropical Countries** and was able to power a 2.5 horsepower steam engine
- **1860**- Auguste Mouchout, used direct conversion of solar radiation into mechanical power.
- **1895** - Aubrey Eneas formed the first Solar Energy company
- **1904** - Henry Willsie built 2 huge plants in California to store generated power. He was the first to successfully use power at night after generating it during the day

Mouchout's Solar collector

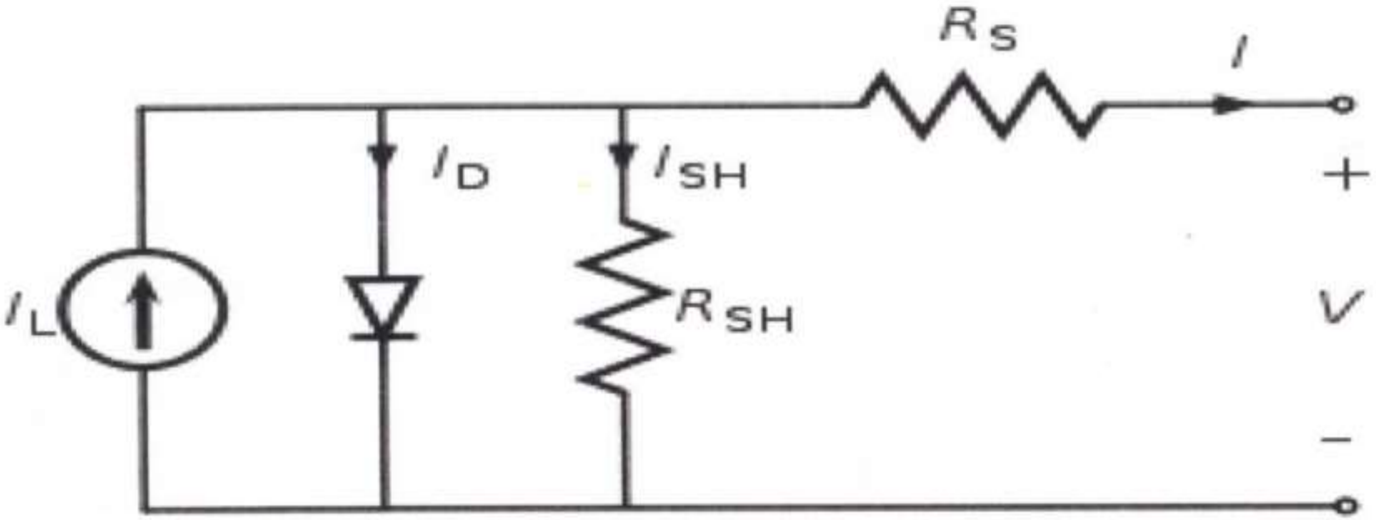


Cont'd

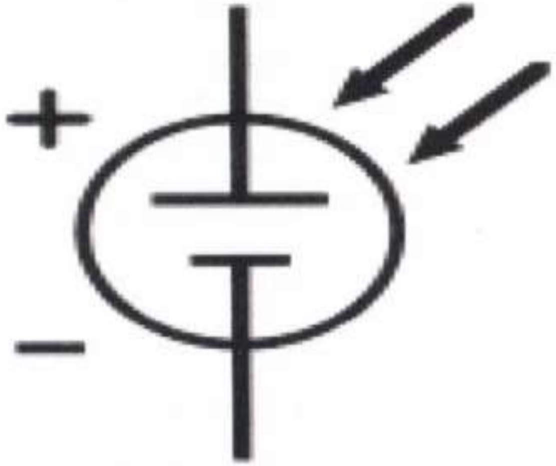
HISTORICAL MILESTONES

- **1954** -Calvin Fuller, Gerald Pearson and Daryl Chaplin of Bell Laboratories discovered the use of silicon as a semi-conductor, which led to the construction of a solar panel with an efficiency rate of 6%.
- **1956** -The first commercial solar cell was made available to the public at a very expensive **$300 per watt**
- **1958-** Vanguard I the first satellite was launched that used solar energy to generate electricity.
- **1970- The Energy Crisis ! (OPEC oil embargo)** Solar energy history was made as the price of solar cells dropped dramatically to about **$20 per watt.**

Cont'd

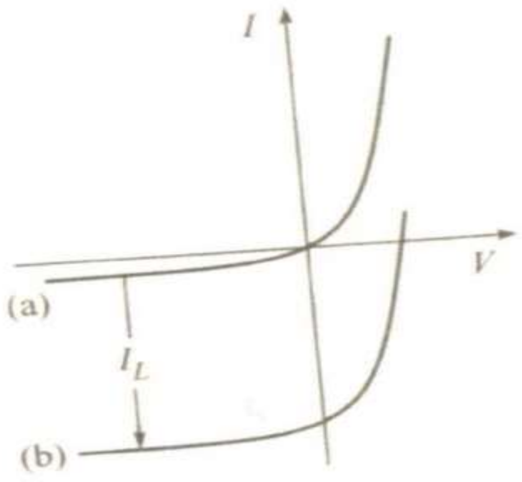


Equivalent circuit of a solar cell



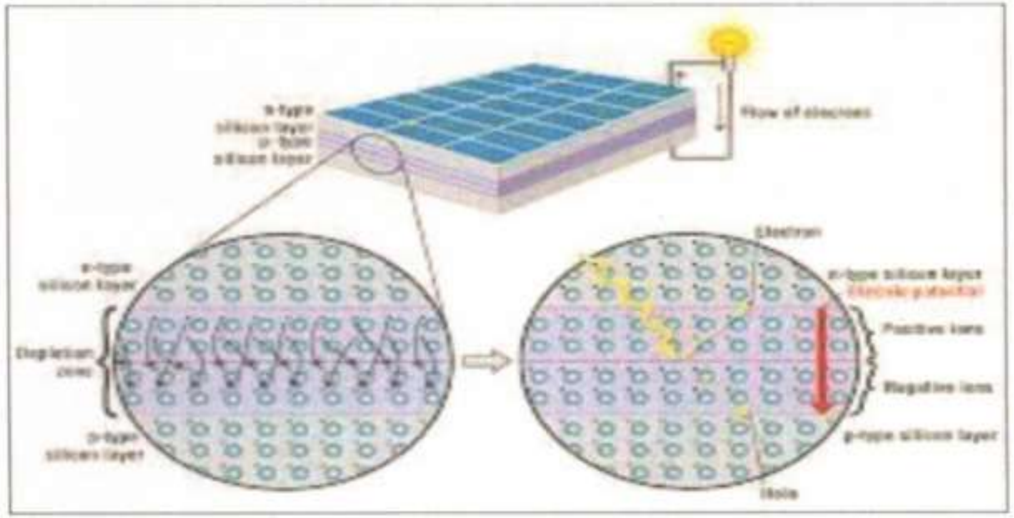
Schematic symbol of a solar cell

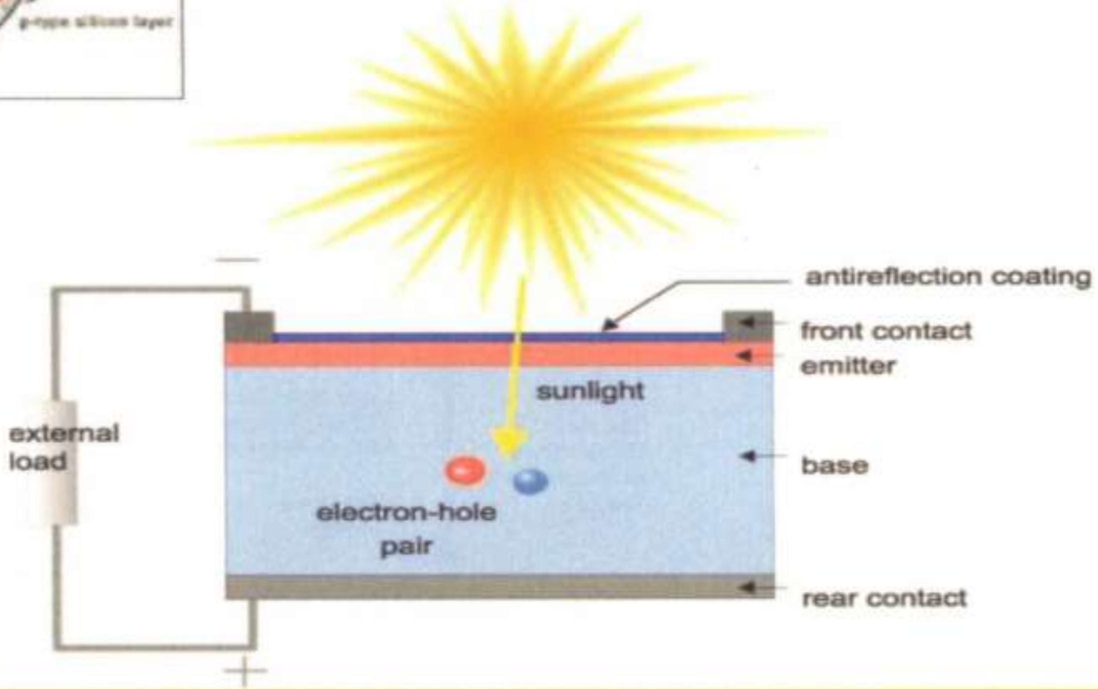
Light generated current



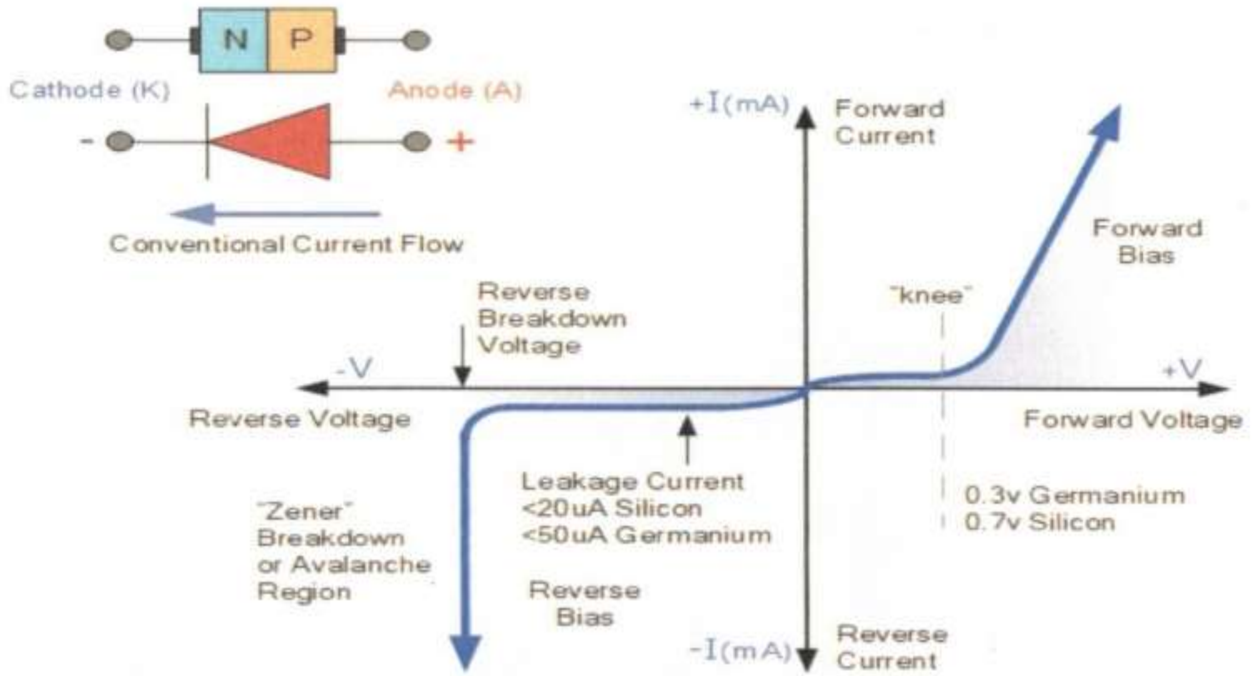
Downward shifting of dark IV curve. When light shines on a pn junction diode i.e curve (b) is illuminated IV curve.

- When light falls on the solar cells two process occurs. In the first step light is being absorbed by the semiconducting material to create e-h pair. Then the e-h pair will be separated out by the electric field that exists in the pn junction.
- In the fourth quadrant of the curve, voltage is positive and current is negative, resulting a –ve power.
- The –ve power implies that the power can be extracted from the device. Therefore, solar cell generates power rather than consuming power like other electronic devices where power is positive.

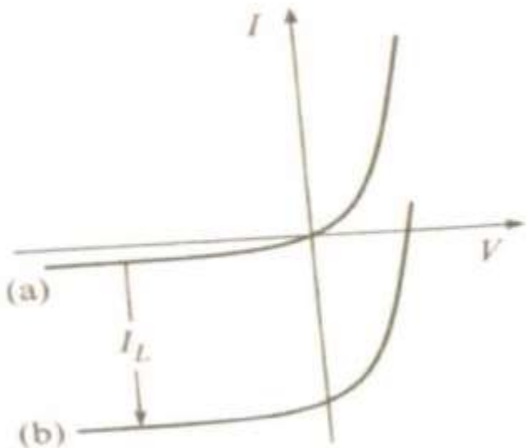

Flow of electrons
Positive ions
Negative ions
Hole


antireflection coating
front contact
emitter
sunlight
external
load
base
electron-hole
pair
rear contact

PN JUNCTION effect



Light generated current



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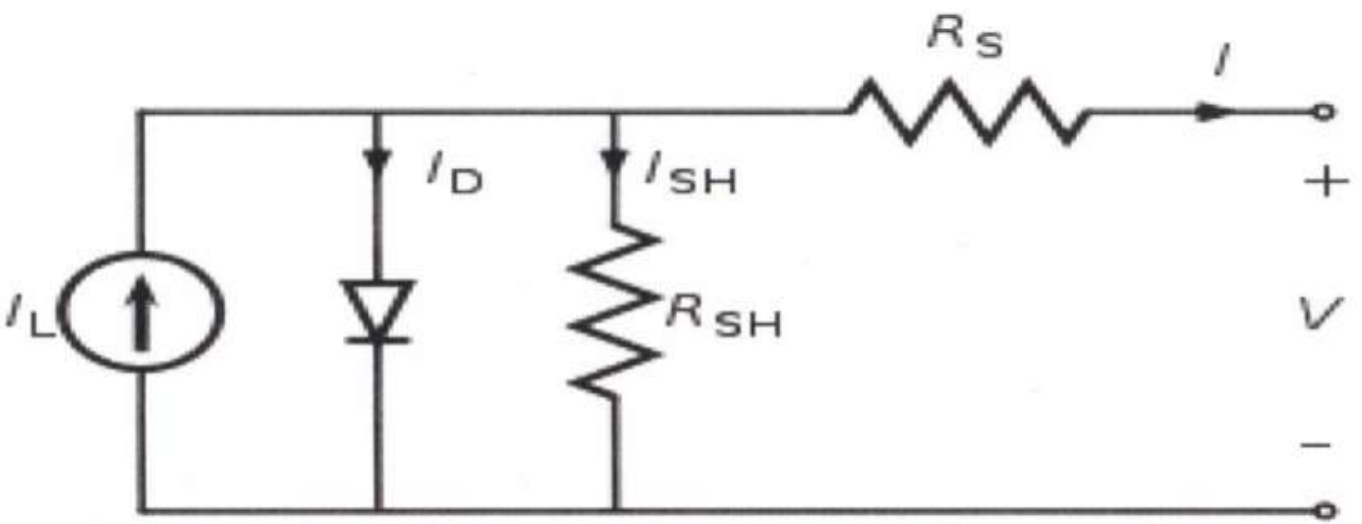
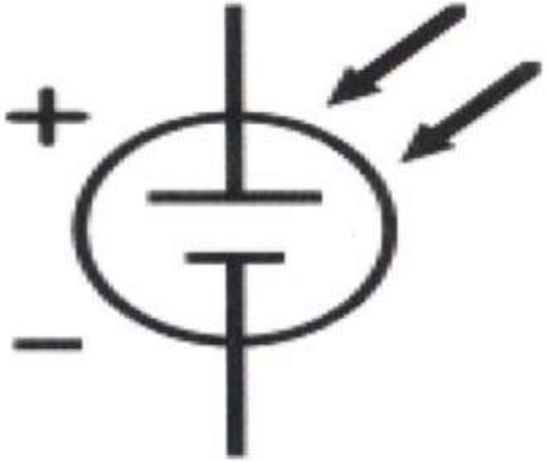


Equivalent circuit of a solar cell



Schematic symbol of a solar cell

- In ideal diodes a current source is there in parallel with a diode.
- But in practice no solar cells are ideal. For real solar cells series resistance and shunt resistance component must be there.
- From the equivalent circuit it is evident that the current produced by the solar cell is equal to that produced by the current source, minus that which flows through the diode, minus that which flows through the shunt resistor.

$$I = I_L - I_D - I_{SH}$$

where

I = output current (ampere)

I_L = photogenerated current (ampere)

I_D = diode current (ampere)

I_{SH} = shunt current (ampere)

- The current through these elements is governed by the voltage across them:

$$V_j = V + IR_S$$

where

V_j = voltage across both diode and resistor R_{SH} (volt)

V = voltage across the output terminals (volt)

I = output current (ampere)

R_S = series resistance (Ω).

By the Shockley diode equation, the current diverted through the diode is:

$$I_D = I_0 \left\{ \exp\left[\frac{qV_j}{nkT}\right] - 1 \right\}$$

where

I_o = reverse saturation current (ampere)

n = diode ideality factor (1 for an ideal diode)

q = elementary charge

k = Boltzmann's constant

T = absolute temperature

At 25°C, KT/q = 0.025 volt.

- By Ohm's law, the current diverted through the shunt resistor is:

$$I_{SH} = \frac{V_j}{R_{SH}}$$

where

R_{SH} = shunt resistance (Ω).

Substituting these into the first equation produces the characteristic equation of a solar cell, which relates solar cell parameters to the output current and voltage:

$$I = I_L - I_0 \left\{ \exp\left[\frac{q(V + IR_S)}{nkT} \right] - 1 \right\} - \frac{V + IR_S}{R_{SH}}.$$

The parameters I_o, n, R_S, and R_{SH} cannot be measured directly. So open circuit voltage and short circuit current has to be measured.

Open-circuit voltage and short-circuit current

- When the cell is operated at open circuit, $I = 0$ and the voltage across the output terminals is defined as the open-circuit voltage. Assuming the shunt resistance is high enough to neglect the final term of the characteristic equation, the open-circuit voltage V_{OC} is:

$$V_{OC} \approx \frac{nkT}{q} \ln\left(\frac{I_L}{I_0} + 1\right).$$

- Similarly, when the cell is operated at short circuit, $V = 0$ and the current I through the terminals is defined as the *short-circuit current*. It can be shown that for a high-quality solar cell (low R_S and I_o, and high R_{SH}) the short-circuit current I_{SC} is:

$$I_{SC} \approx I_L.$$

- It should be noted that it is not possible to extract any power from the device when operating at either open circuit or short circuit conditions.

- The values of I_o, R_S, and R_{SH} are dependent upon the area of the solar cell.
- If we compare two cells, a cell with twice the surface area of another. In principle, the cell which has double surface area has double the the value of I_o since it has twice the junction area across which current can leak. It will also have half the R_S and R_{SH} because it has twice the cross-sectional area through which current can flow. So it is necessary to write the characteristic equation in terms of current density, or current produced per unit cell area.

$$J = J_L - J_0 \left\{ \exp\left[\frac{q(V + Jr_S)}{nkT} \right] - 1 \right\} - \frac{V + Jr_S}{r_{SH}}$$

where

J = current density (ampere/cm²)

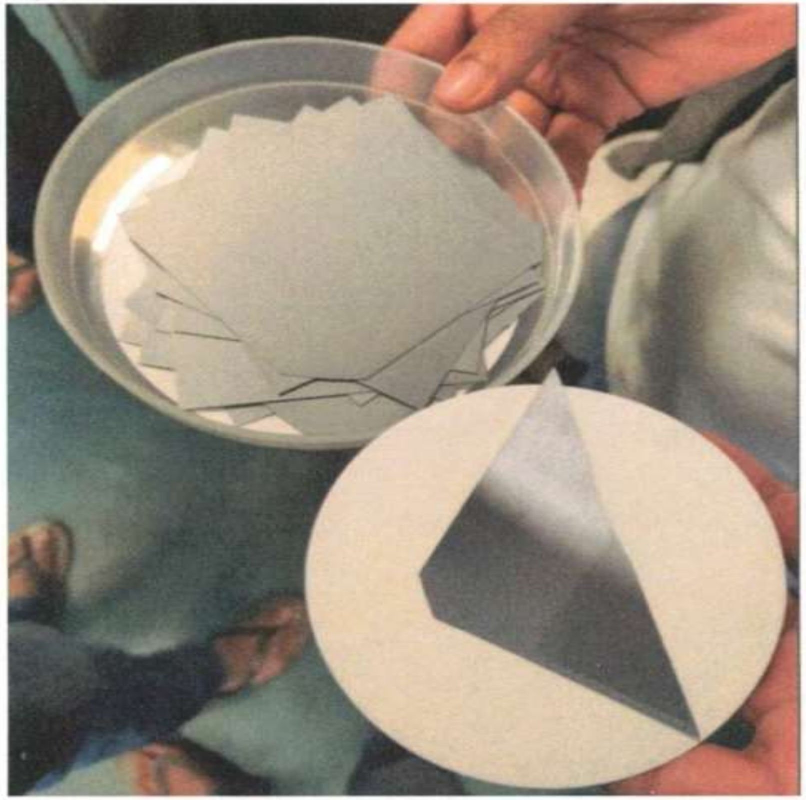
J_L = photogenerated current density (ampere/cm²)

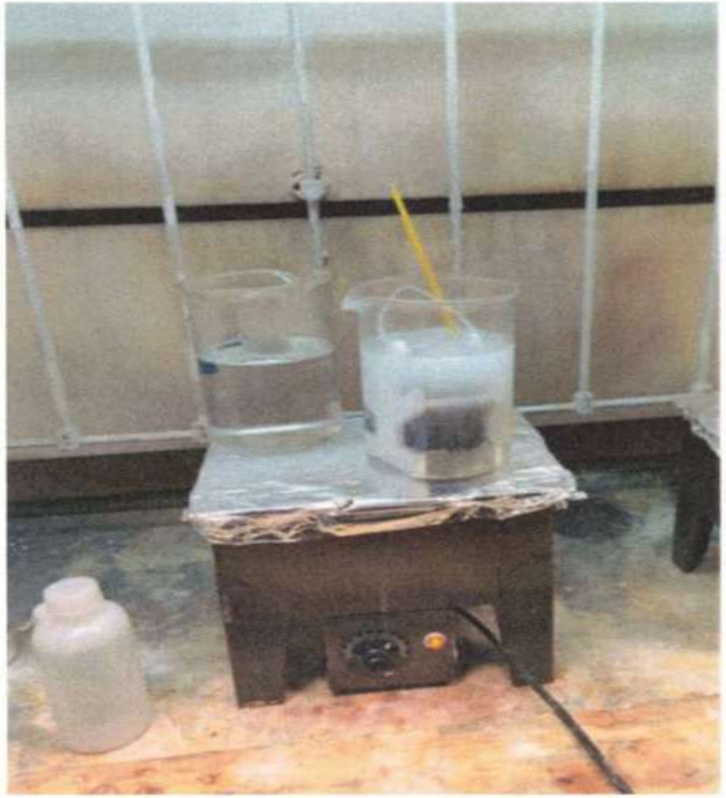
J_o = reverse saturation current density (ampere/cm²)

r_S = specific series resistance (Ω-cm²)

r_{SH} = specific shunt resistance (Ω-cm²).

C Si Fabrication at IIEST shibpur:





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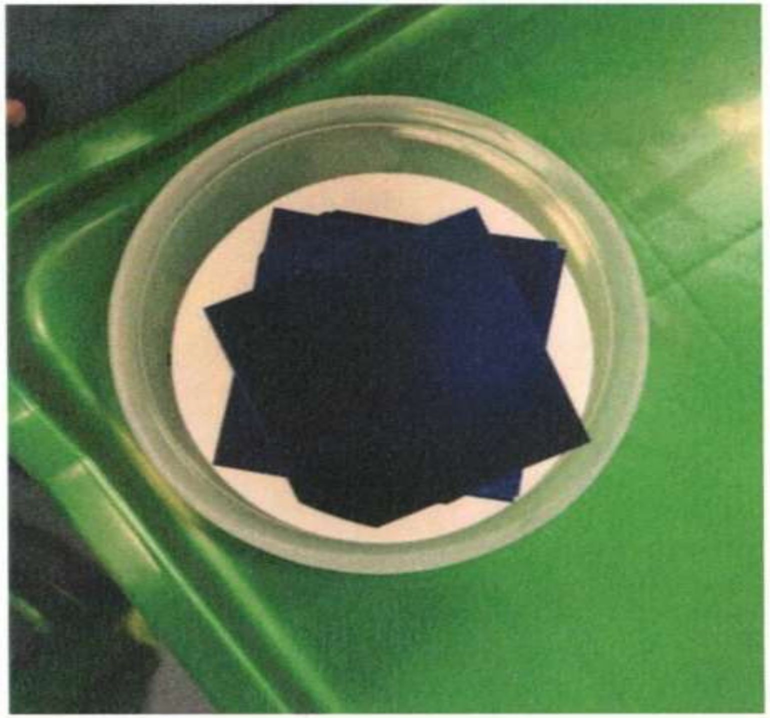
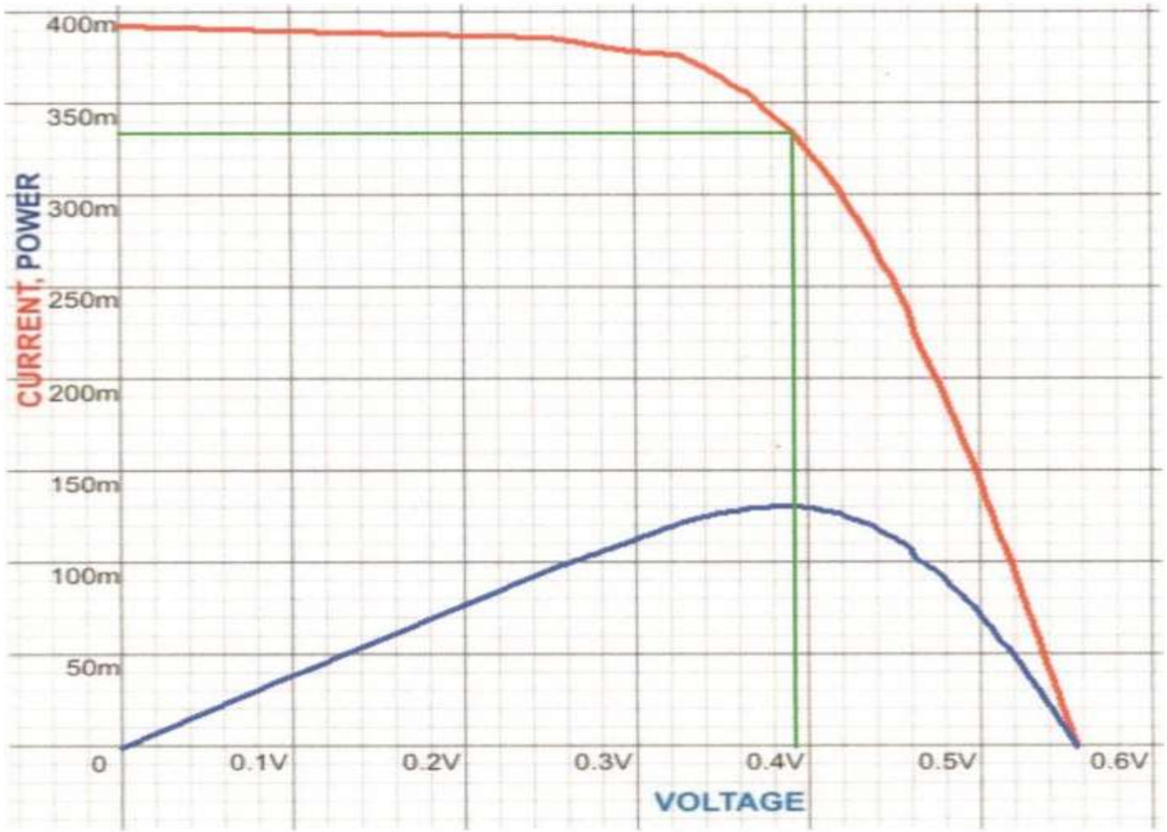
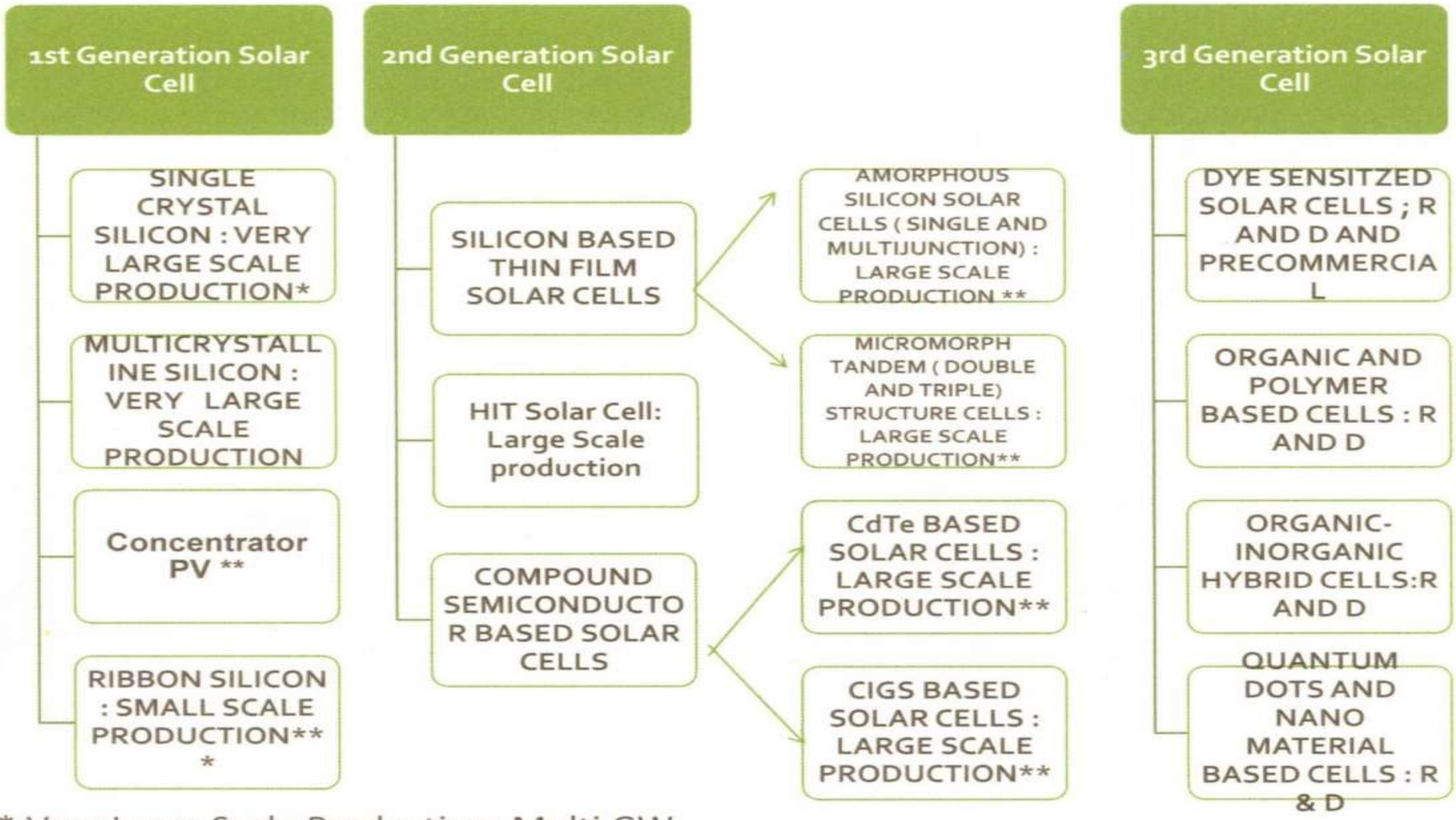


CHARACTERISTICS:

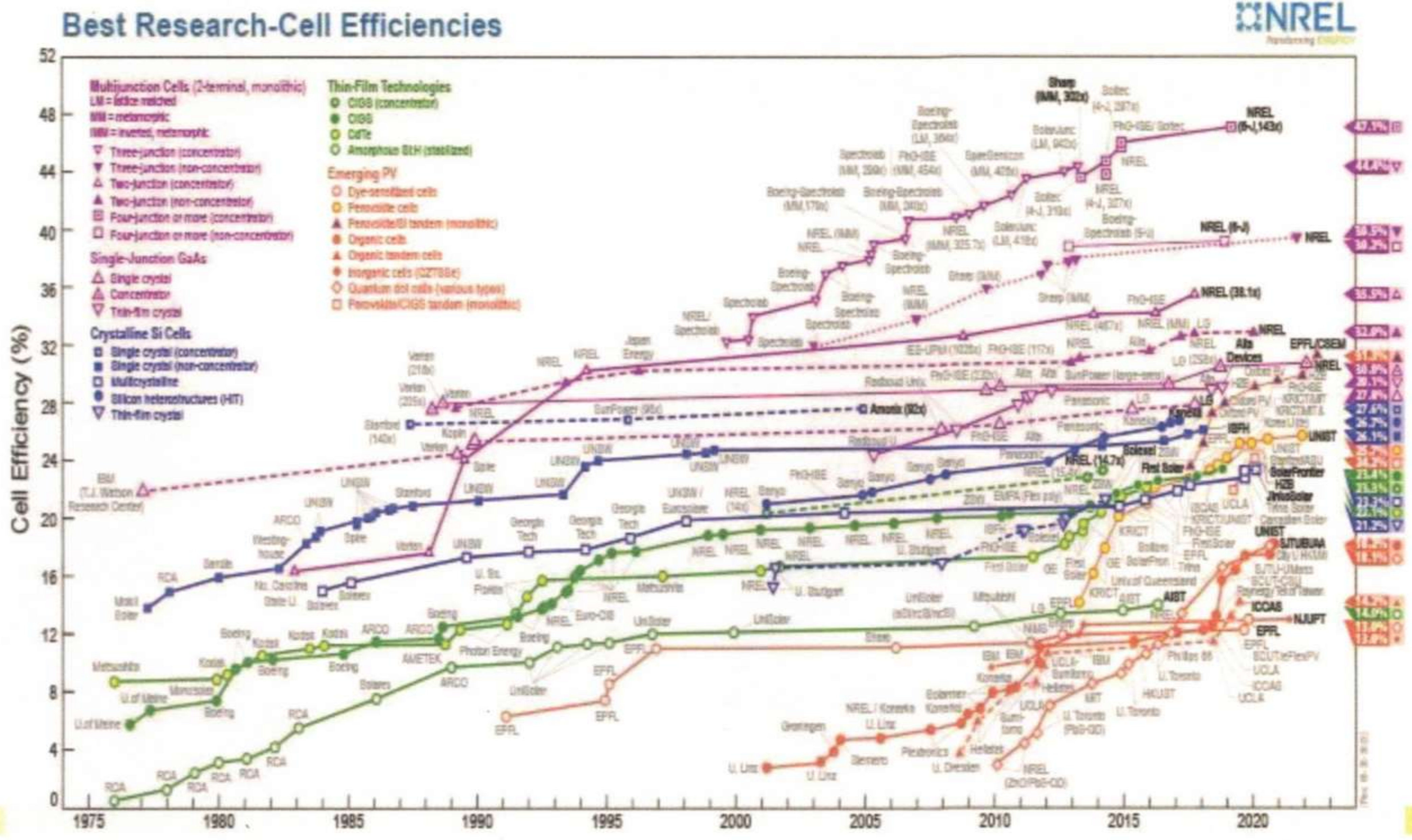




* Very Large Scale Production: Multi GW

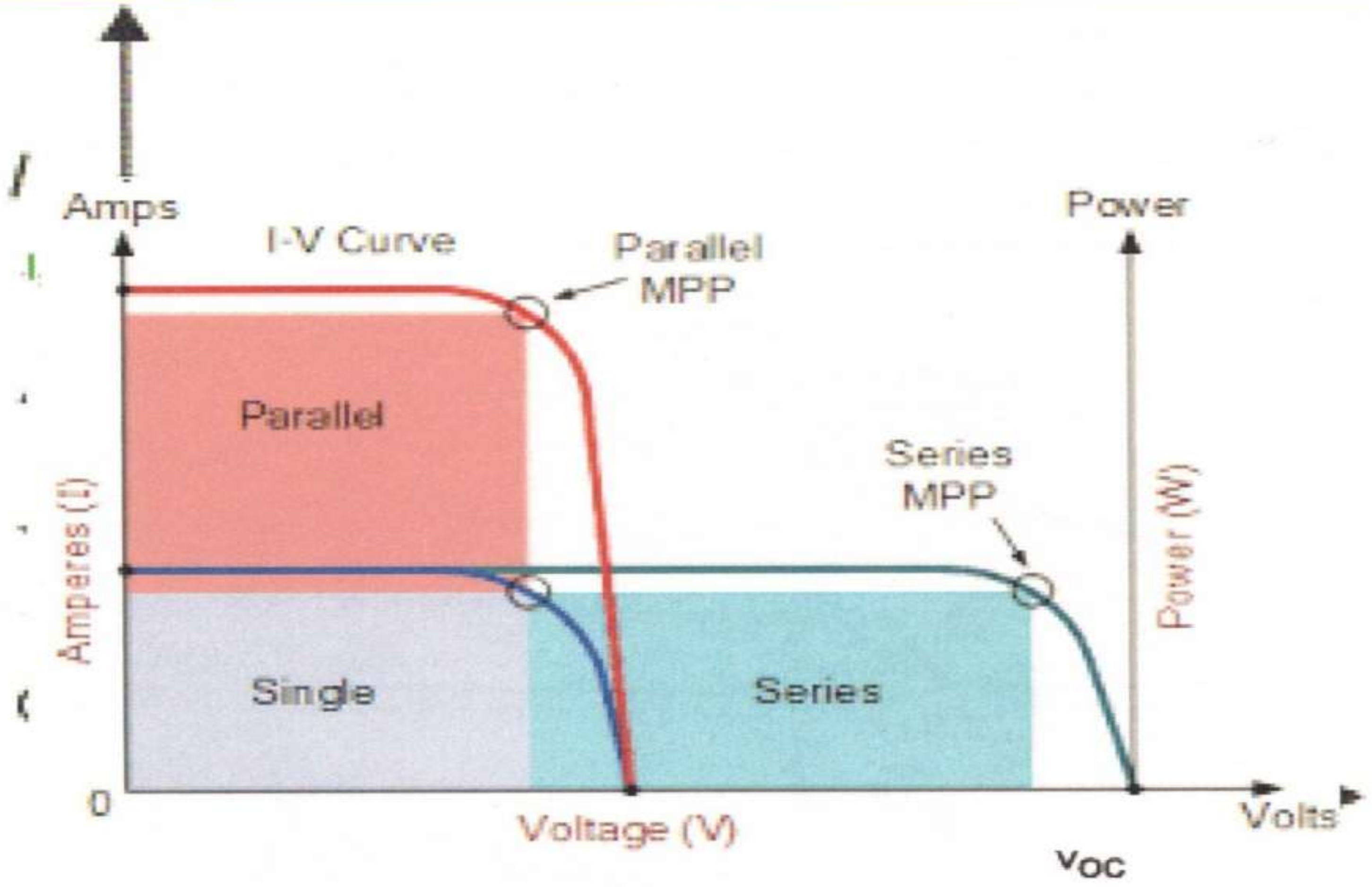
** Large Scale Production: 1 GW

*** Small Scale Production: ~ MW



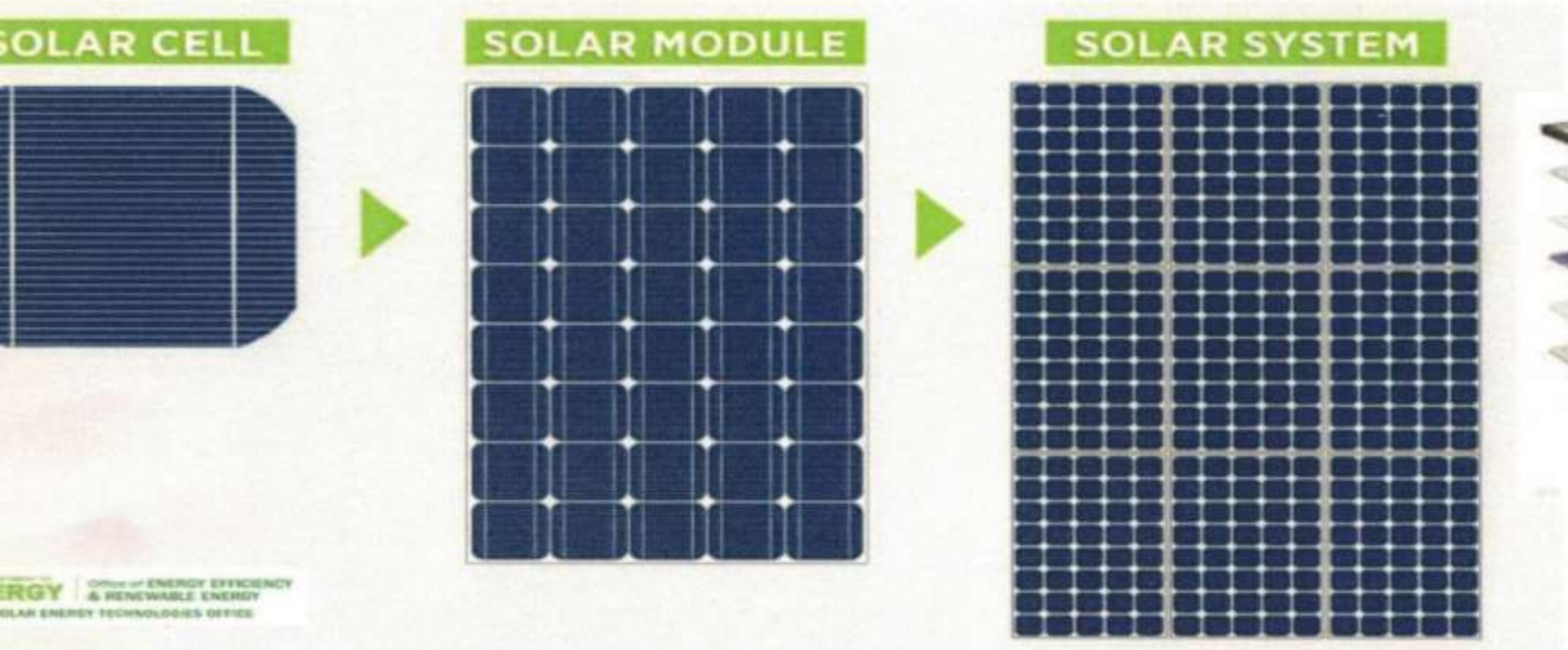
Best Research-Cell Efficiencies
NREL
Cell Efficiency (%)
Multijunction Cells (2-terminal, monolithic)
Thin-Film Technologies
Emerging PV
Single-Junction GaAs
Crystalline Si Cells

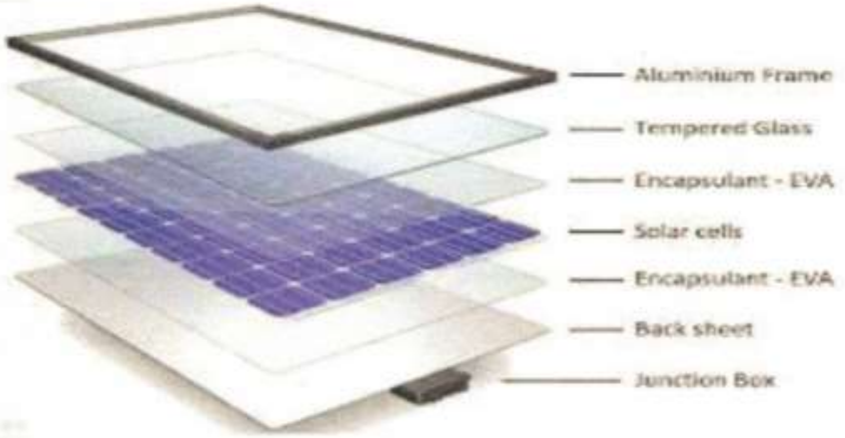
GRAPH



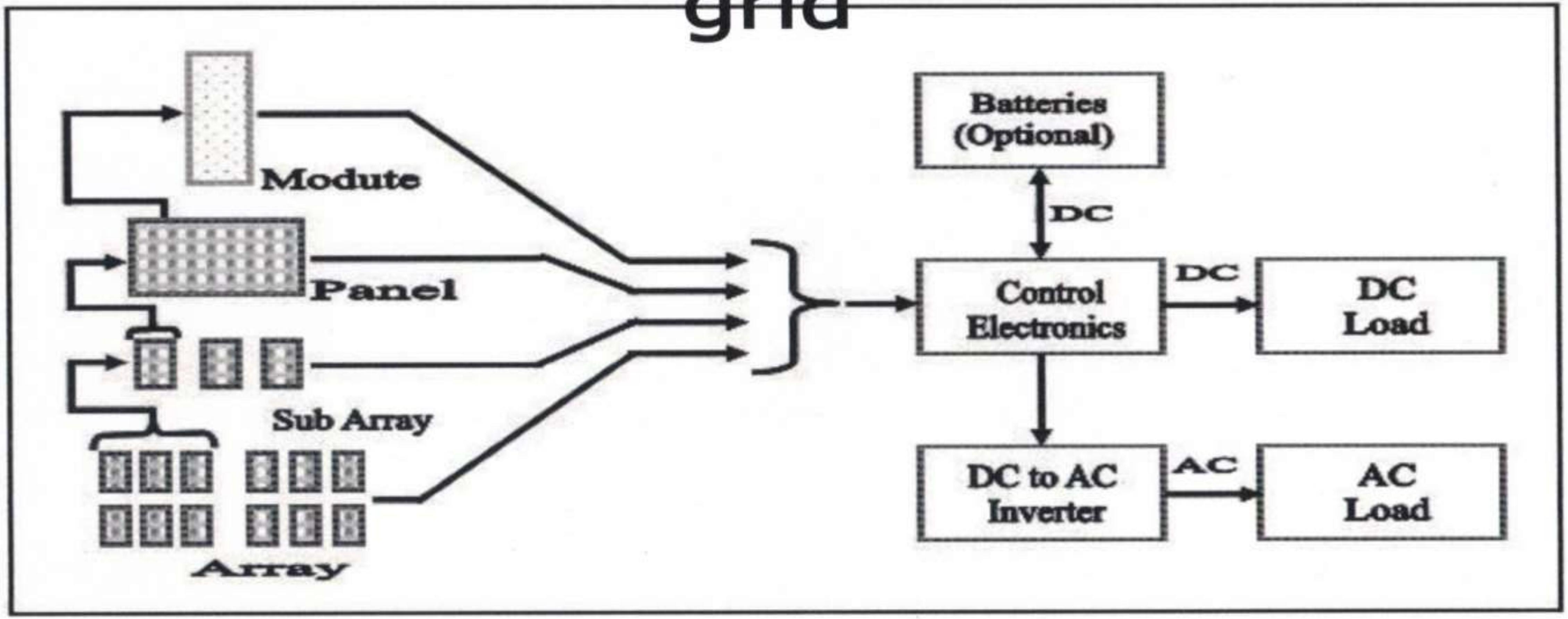
I
Amps
I-V Curve
Parallel
MPP
Power
Parallel
Series
MPP
Amperes (I)
Power (W)
Single
Series
0
Voltage (V)
Volts
VOC

Panel to Module





Solar PV connection to the grid



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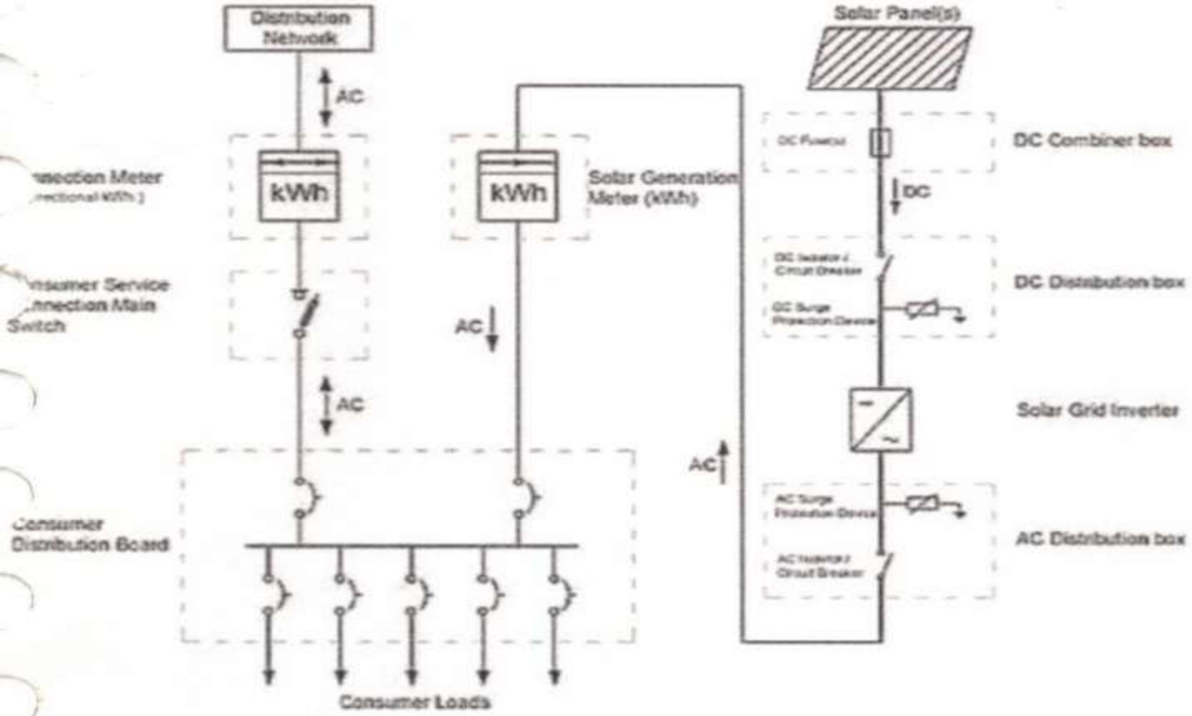


Distribution Network
AC
kWh
kWh
Solar Generation Meter (kWh)
Switch
AC
AC
Consumer Distribution Board
Consumer Loads
AC
Solar Panel(s)
DC Combiner box
DC
DC Distribution box
Solar Grid Inverter
AC Distribution box

Solar Panels
Mounting System
Utility Grid
DC
AC
Inverter

Stats:

Global electricity power generation capacity	849.5 GW (2021)
Global electricity power generation capacity annual growth rate	26% (2012-2021)
Share of global electricity generation	2% (2018)
Levelized cost per megawatt hour	Utility-scale photovoltaics: USD 38.343 (2019)
Primary technologies	Photovoltaics, concentrated solar power, solar thermal collector
Other energy applications	Water heating; heating, ventilation, and air conditioning (HVAC); cooking; process heat; water treatment

Solar Photovolatics in India

- Begun as far back as in the mid 70's solar photovoltics programme of the Government of India is one of the largest in the World
- Reliefs offered by government on SPV manufacturers and users of SPV based products :

* 100% depreciation in the first year of installation of the systems
* No excise duty for manufacturers
* Low import tariff for several raw materials and components
* Soft loans to users, intermediaries and manufacturers.

Postage Stamp published By India Government

Cont'd

Solar Photovolatics in India (cont'd)

Promoting use of PV technology to Provide Lighting in Villages in the form of :

Systems	Capacity	Uses
Community lighting systems	1KW to 2.5 KW	Small household lighting system
Portable solar lanterns	10Wp SPV module	lighting 7 W CFL lamp for 3 hours a day
Street lights	75Wp SPV module	Charging 100-130AH battery to run a 11W CFL lamp for dusk to dawn operation
Fixed home lighting systems	35-50Wp SPV module	powering two CFLs -- 9 or 11W , work 4-5 hours /day, run a small TV set or a fan
Water Pumping	1KW DC motor	shallow pumping

Cont'd

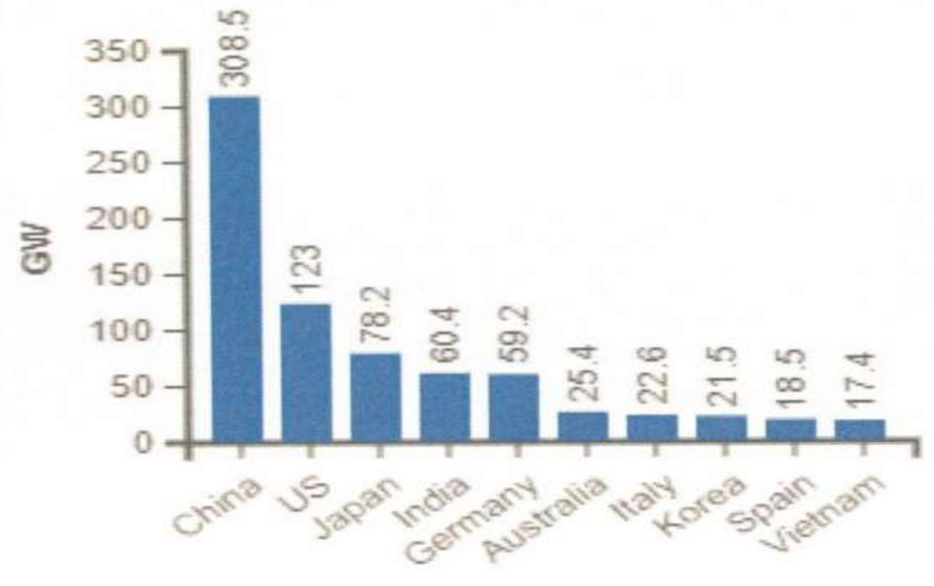
Some Statistics:

The average solar intensity received in India is about 200 MW/km2. With a geographical area of 3.287 million km2, this could lead up to an annual generation of 657.4 TW, enough to satisfy all of our energy needs

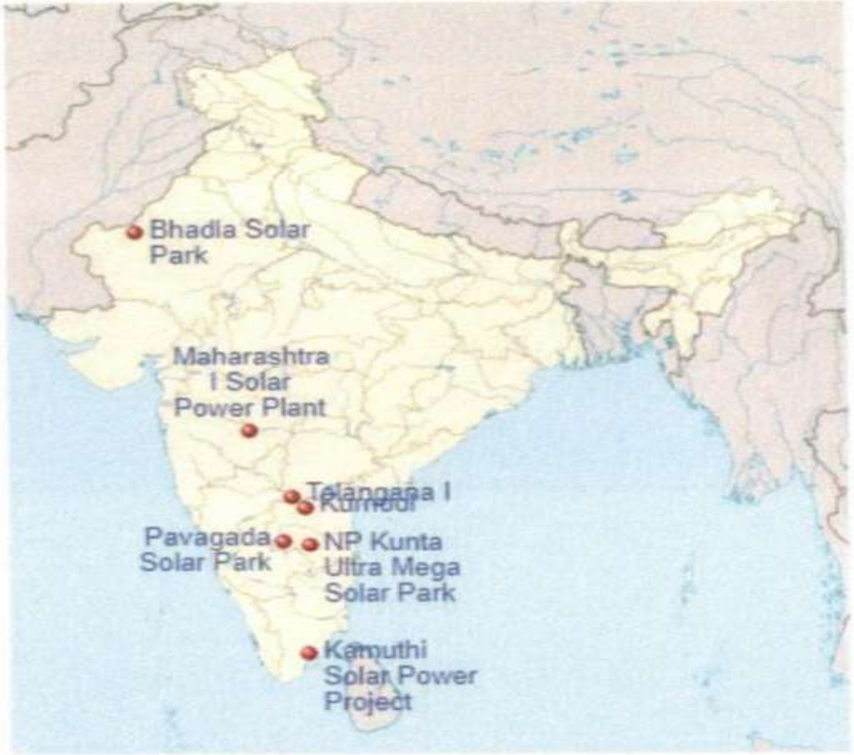
According to the National Solar Mission, India is set to install 100 GW of solar power by 2022. Out of which 40 MW will be from rooftop, solar power plants and 60 MW will be from ground solar plants.

Some Important plants:

Installed capacity in India as of 2022 is 57,705.72 MW with a growth rate of 21.65% (lowest capital cost per MW installation in the world)



Top 10 countries by cumulative solar power installed capacity in 2021[1]



Some Important plants:

Bhadla Solar Park is the world's largest solar park as of 2021 (Bhadla, Phalodi Tehsil, Jodhpur District, Rajasthan, India) Covering a total area of 5,700 hectares (14,000 acres). The total capacity of the park is 2245 MW.

SOLAR THERMAL ENERGY:

- **Solar thermal energy** (**STE**) is a form of energy and a technology for harnessing solar energy to generate thermal energy for use in industry, and in the residential and commercial sectors.

Israel harnessing sunshine with world's tallest solar tower

Ashalim project in the Negev desert aims to boost renewable energy supplies by providing enough power for 130,000 households.

Solar towers of the Ivanpah **facility,** the world's **largest solar thermal power station** in the Mojave Desert, southeastern California.

Current Technologies for STE plants (I)

Central Receiver Technology

"3rd SFERA Summer School" 21 Almeria (Spain), June 27-28, 2012

CSP In the world Projection.

Time	Annual Investment	Cumulative Capacity
2015	21 billion Euros a year	420 Mega- Watts
2050	174 billion Euros a year	1500 Giga-Watts

Steam for Hospitality applications like Laundry, Cooking, Bathing
ITC Maurya Hotel, New Delhi

Delivery	8 bar (g) and 175˚C
Capacity	80 – 100 kW_{th} per dish
Dish numbers	2 dishes
Commissioning	Nov 2009

Steam for Comfort Cooling
NTPC – Greater Noida

Delivery	10 bar and 180˚C
Capacity	80 – 100 kW_{th} per dish
Dish numbers	2 dishes
Commissioning	July 2012

Steam Generation for Milk Pasteurization
Chitale Dairy, Maharashtra

Delivery	5 bar and 152°C
Capacity	80 – 100 kW_{th} per dish
Dish numbers	2 dishes
Commissioning	October 2009

Pressurized Hot Water for Comfort Cooling
TVS Group, Chennai

Delivery	15 bar and 180°C
Capacity	80 – 100 kW_{th} per dish
Dish numbers	2 dish
Commissioning	March 2011




Temperature requirement in domestic and commercial sector

Application	Temperature
Bathing	40-50 C
Kitchen	50- 300 C
Space heating	50-80 C
Washing	50-80 C

Temperature requirement in industrial sector

Industry	Working Fluids	Temperature Range
Pharmaceutical Industry	Steam, Air	80° C - 230° C
Textile industry	Water, Steam	60° C - 150° C
Chemical Industry	Steam, Air	80° C - 320° C
Pulp & Paper Industry	Steam	Up to185° C
Food Industry	Steam, Air	80° C - 280° C
Mechanical Industry	Water, Steam	60° C - 150° C
Automobile Industry	Water, Steam	60° C - 200° C

Solar thermal collectors are classified by the United States Energy Information Administration as low-, medium-, or high-temperature collectors. Low-temperature collectors are generally unglazed and used to heat swimming pools or to heat ventilation air. Medium-temperature collectors are also usually flat plates but are used for heating water or air for residential and commercial use.

High-temperature collectors concentrate sunlight using mirrors or lenses and are generally used for fulfilling heat requirements up to 300 deg C / 20 bar pressure in industries, and for electric power production. Two categories include Concentrated Solar Thermal (CST) for fulfilling heat requirements in industries, and Concentrated Solar Power (CSP) when the heat collected is used for electric power generation. CST and CSP are not replaceable in terms of application.

Low Temperature:

- The low temperature systems are systems which operate from room temperature to 80-85 degree centigrade.
- These include systems for : Boiler feed pre-heating, drying, heating of chemical baths, textiles etc.
- The basic solar device used for these systems are the water heating collectors, namely the **Flat Plate Collector** and the **Evacuated Tube Collector**.
- Drying systems utilise the Air-heating collectors.
- Drying systems can also be used for **Effluent Evaporation**.

Medium Temperature:

- These processes are carried out from 90/95 upto 200 degree centigrade.
- These include:
- A. Chemical industries.
- B. Dairy applications.
- C. Textile industries.
- D. Pharmaceutical industries.
- E. Food processing.
- F. Cooling requirements (VAM based air-conditioning)

  to name a few.

- These temperature requirements can be met with the use of **Solar Concentrators**.
- Solar Concentrators are devices through which high concentration of the Sun's rays is achieved resulting in high temperatures.
- Solar Concentrators are also categorised as medium temperature concentrators and high temperature concentrators.

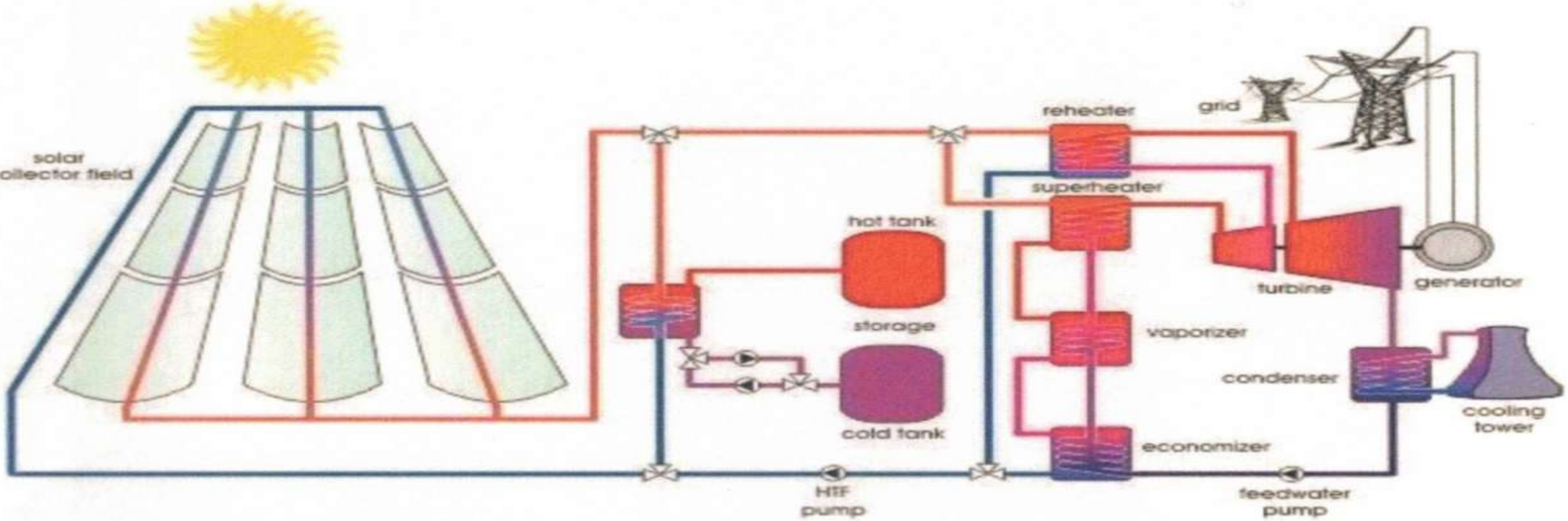
High Temperature:

- These applications lie in the range of 200-450 degree centigrade.
- The concentrators required for these applications are the Parabolic Trough Collectors (PTC's) and the ARUN paraboloid dish.
- These Concentrators are capable of producing very high temperatures and pressures and are best suited to cater to this segment.

Some important examples:

- The largest facilities are located in the American Mojave Desert of California and Nevada. These plants employ a variety of different technologies.
- The largest examples include, Ouarzazate Solar Power Station in Morocco (510 MW),
- Ivanpah Solar Power Facility (377 MW),
- Solar Energy Generating Systems installation (354 MW), and
- Crescent Dunes (110 MW).
- Spain is the other major developer of solar thermal power plants.
- The largest examples include, Solnova Solar Power Station (150 MW), the Andasol solar power station (150 MW), and Extresol Solar Power Station (100 MW).

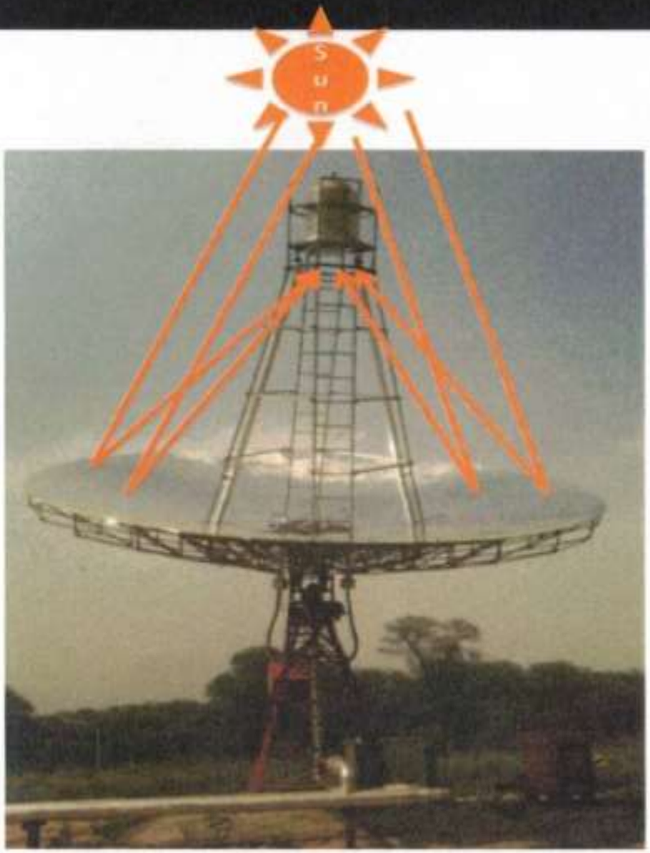
Solar thermal power plant:



Concentrated solar thermal energy technology based on parabolic dish collectors

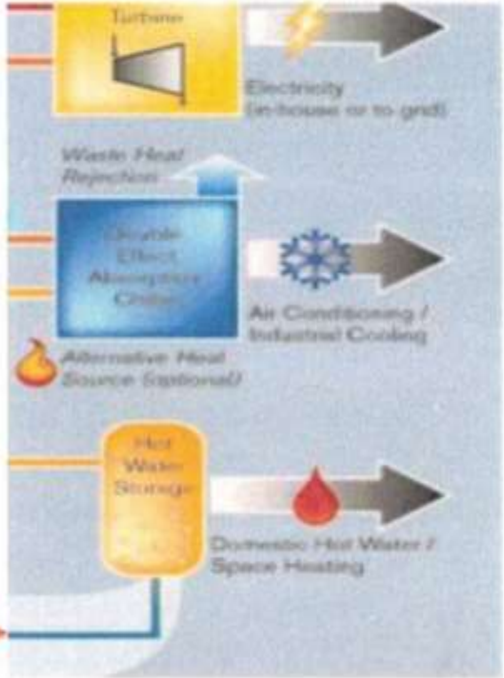
(Megawatt Solution –SEC)

Hybridization
Principle Of Operation of a Solar Dish



Sun's rays fall on dish and get concentrated on a receiver at all times throughout the year

This concentrated solar energy heats up a cold fluid upto very high temperatures (400degC)



The solar heat at high temperatures can be used as process heat in Industries, for power generation and for refrigeration /cooling

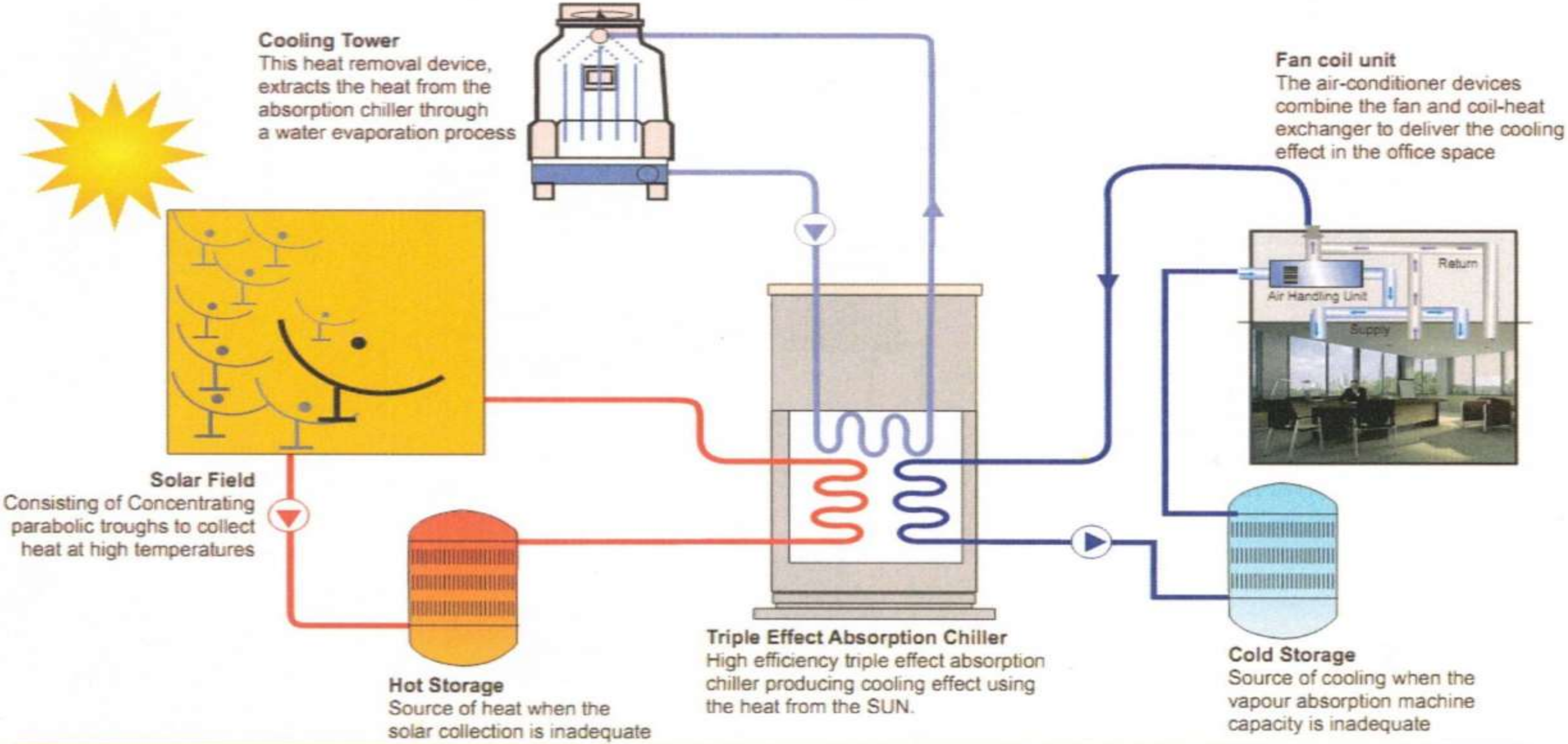
100 kW Solar Cooling System

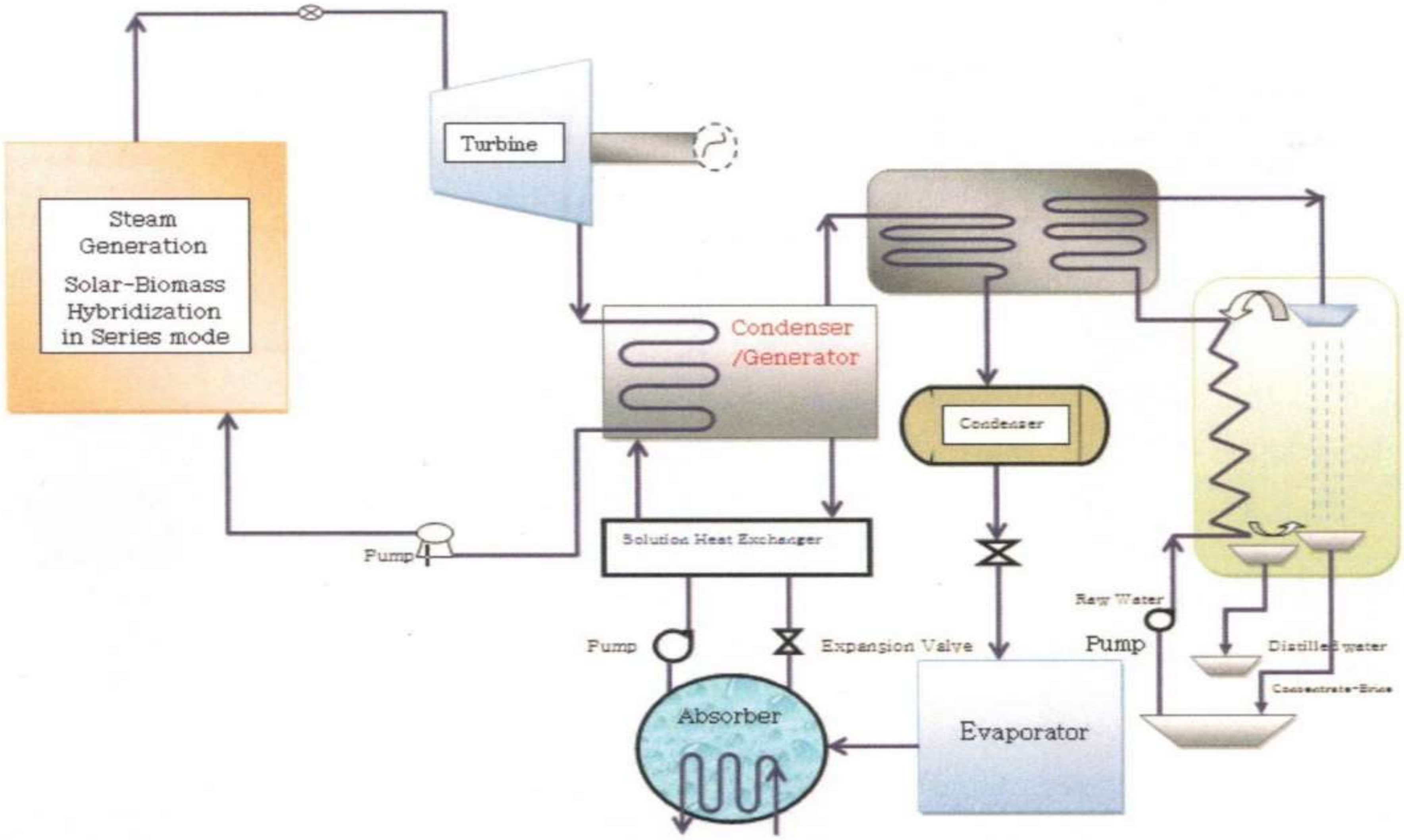
Thermax and SEC

- **Heat source : Hot water from solar collectors**
- **Hot water temperature : 210°C**
- **Cooling capacity : 100 kW**
- **Chilled water Temperature: 12 / 7 Deg C.**
- **Cooling water inlet Temperature : 32 Deg C**
- **COP of cooling system : 1.7**
- **Thermal storage : Chilled water / Hot water / PCM for short duration**

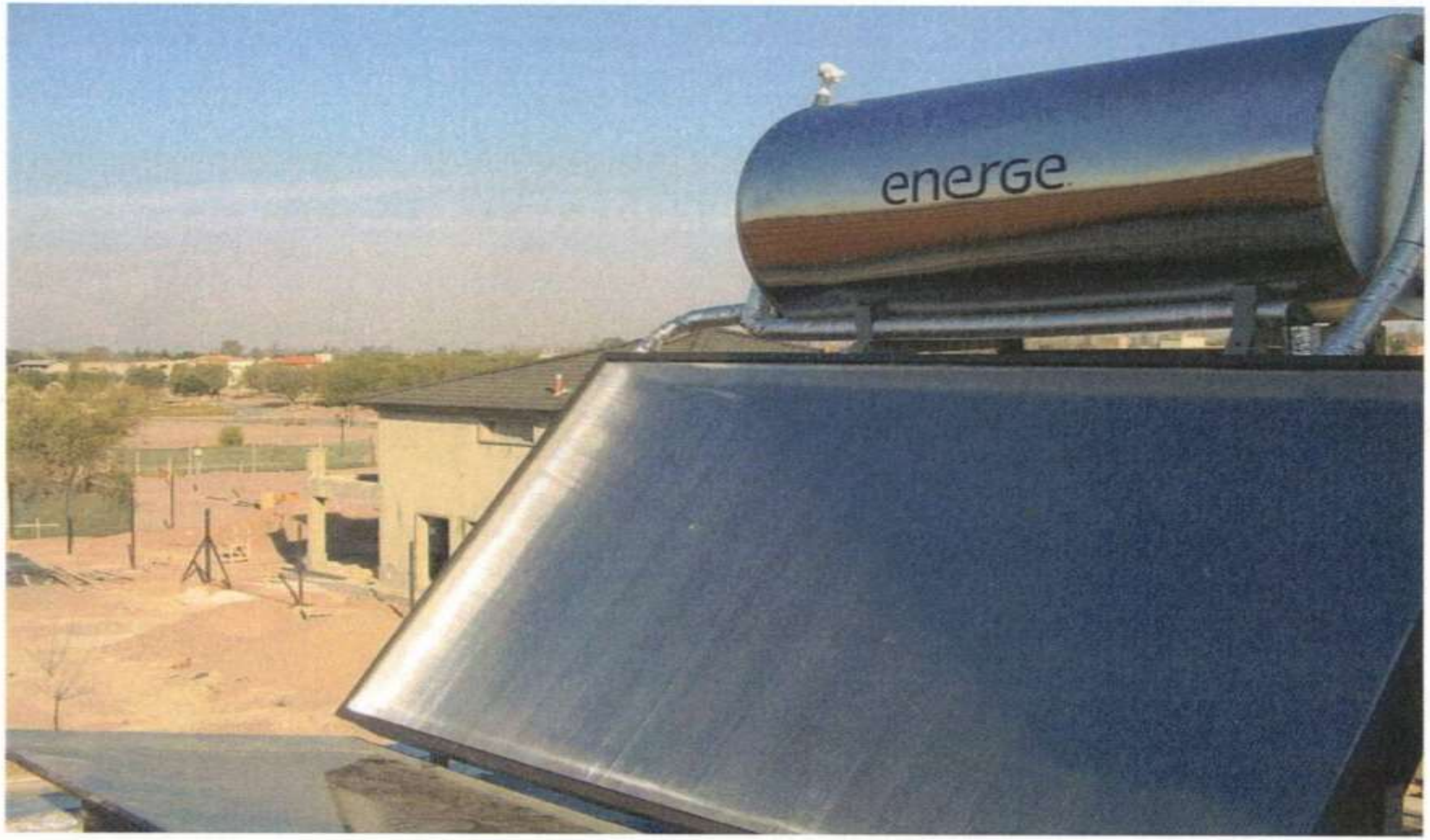
100 kW Solar Cooling System

Schematic layout of the system




Turbine
Steam
Generation
Solar-Biomass
Hybridization
in Series mode
Condenser
/Generator
Condenser
Pump
Solution Heat Exchanger
Pump
Expansion Valve
Absorber
Evaporator
Raw Water
Pump
Distilled water

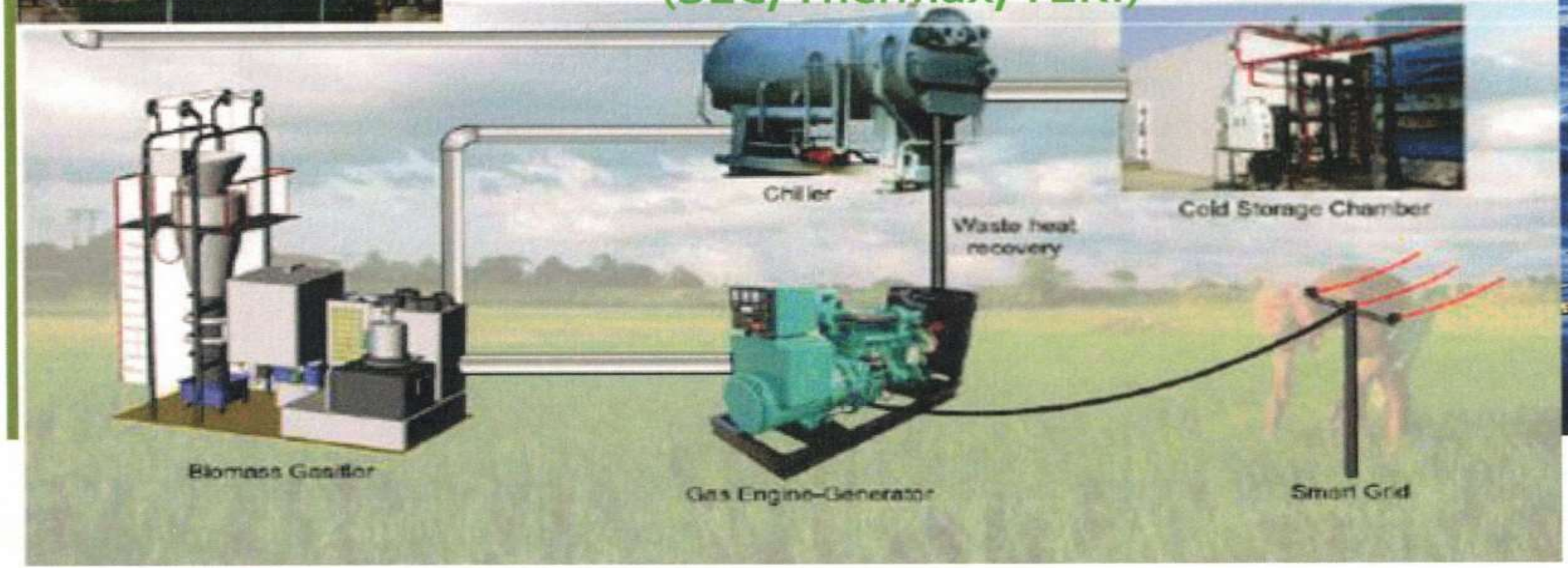
Roof top solar heating:



Electricity & Cold Storage for Remote Rural Applications

- Electricity from biomass gasifier
- Cooling from engine exhaust
- Solar concentrators during solar hours

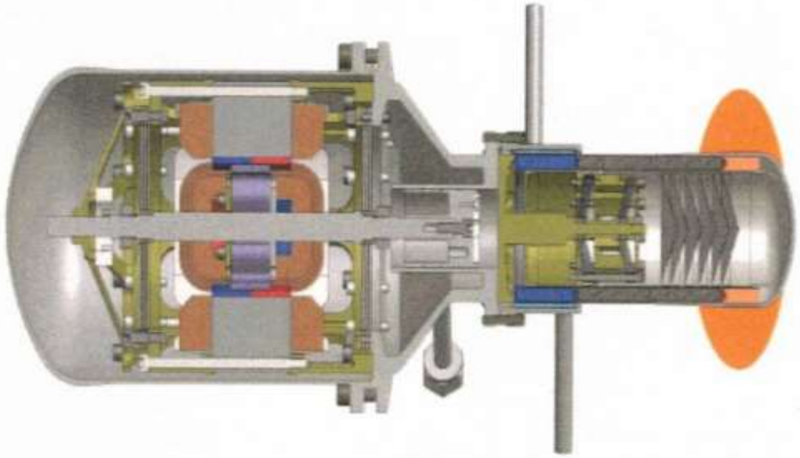
(SEC, Thermax, TERI)

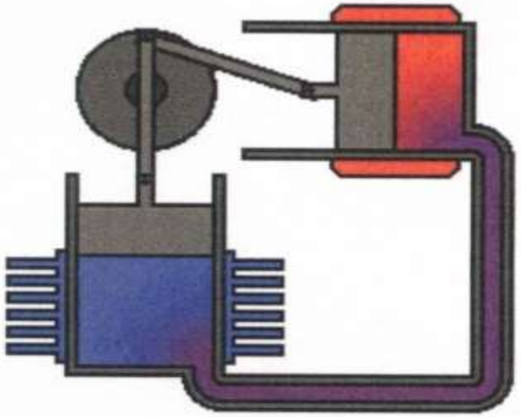


Project Specifications

▣ Cooling Capacity	: 15 kW
▣ Cold storage Temperature	: 0 to 5°C
▣ Gas Engine capacity	: 50 kWe
▣ Biomass consumption	: 70 kg/hr
▣ Storage Capacity	: 20 Tons
▣ Heat source for VAM	
During solar hours	: Solar and producer gas engine exhaust.
During non solar hours	: Producer gas engine exhaust/ auxiliary firing.

Stiriling Engine

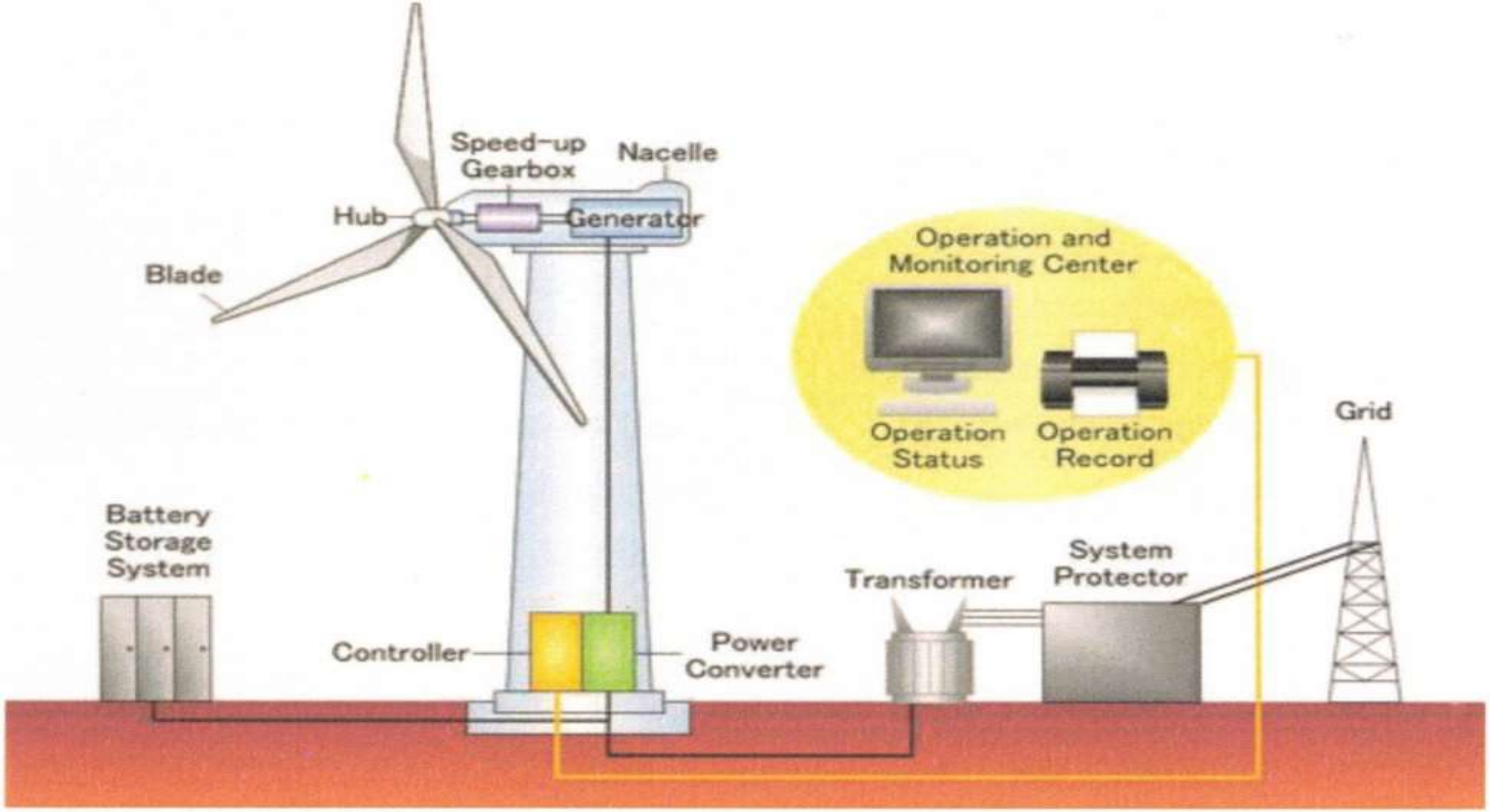




- External combustion engine
  - can work with any fuel
- High power conversion efficiency
- Can be used for distributive power generation

3kWp Solar Dish Stirling Installed at SEC
(with ONGC Research Centre)

বায়ু শক্তি

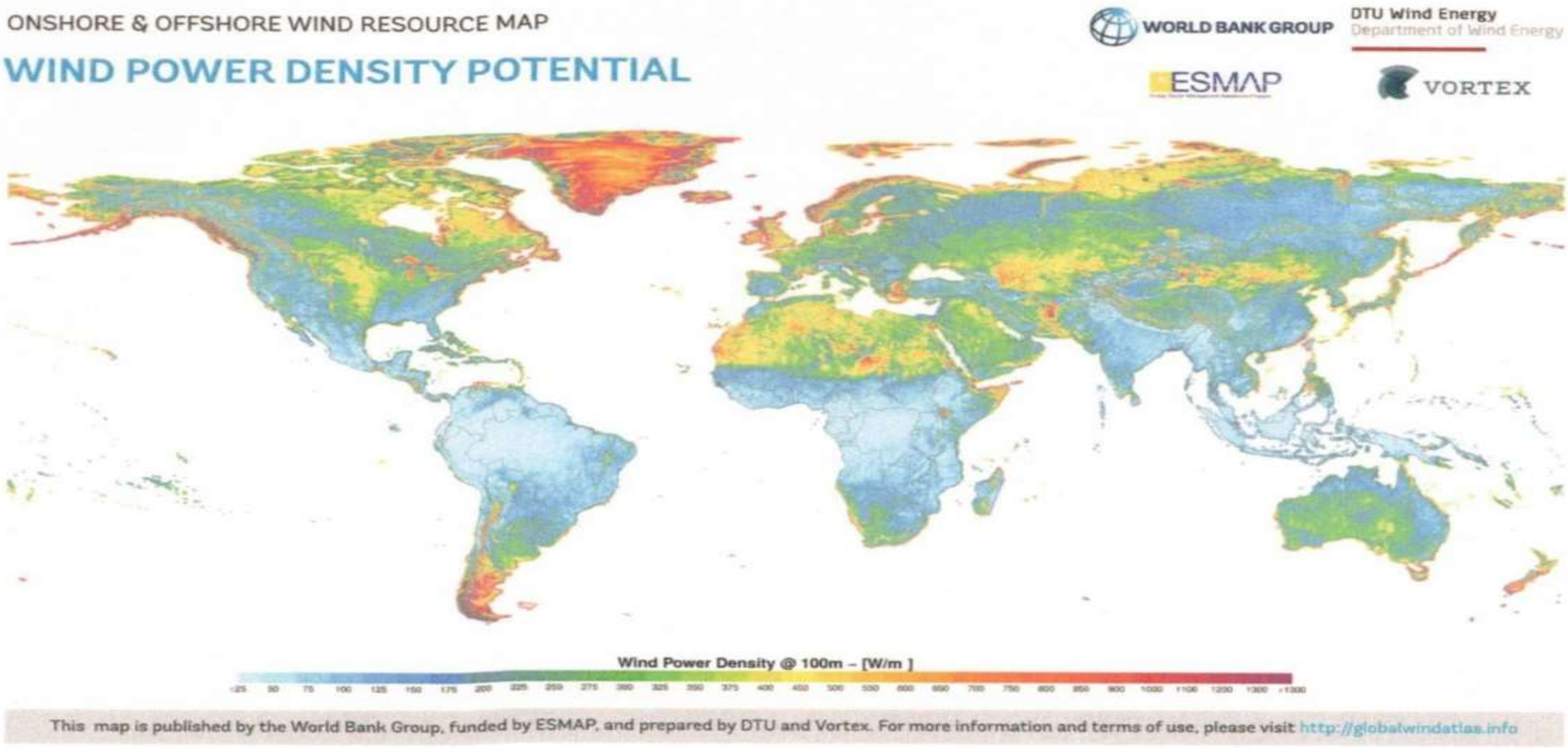


Speed-up Gearbox
Nacelle
Hub
Generator
Blade
Operation and Monitoring Center
Operation Status
Operation Record
Grid
Battery Storage System
System Protector
Transformer
Controller
Power Converter

কিছু পরিসংখ্যান

Global electricity power generation capacity	824.9 GW (2021)
Global electricity power generation capacity annual growth rate	13% (2012-2021)
Share of global electricity generation	5% (2018)
Levelized cost per megawatt hour	Land-based wind: USD 30.165 (2019)
Primary technology	Wind turbine
Other energy applications	Windmill, windpump

বিশ্ব ব্যাপী বায়ুপ্রবাহের তীব্রতা

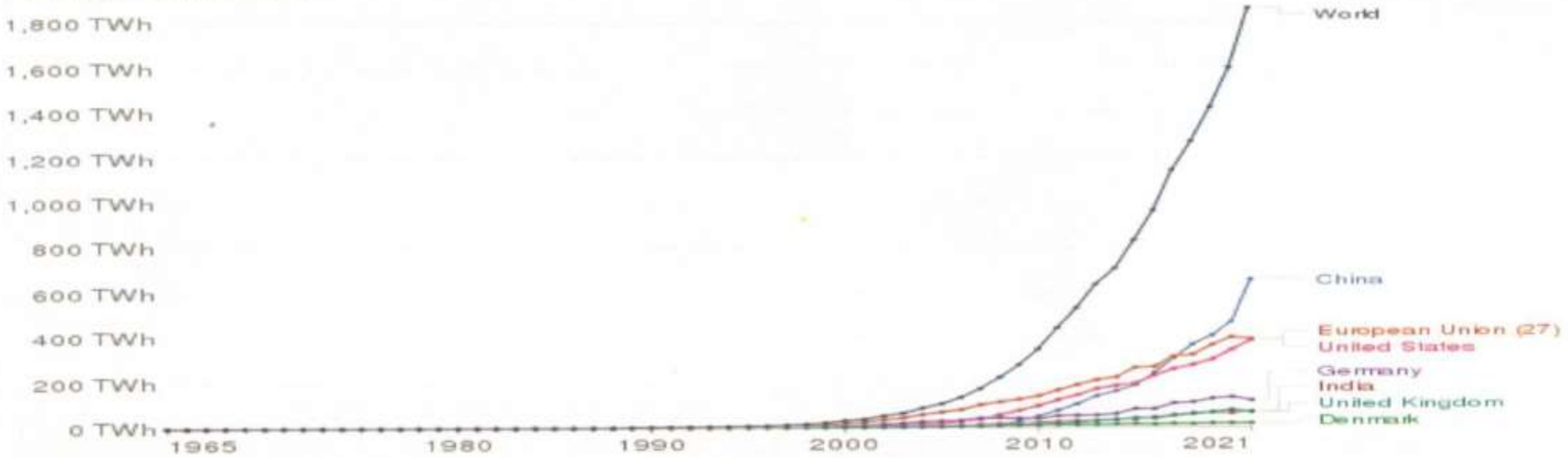


কিছু পরিসংখ্যান - ভারত - বর্তমান

31 জুলাই 2022 পর্যন্ত, মোট ইনস্টল করা বায়ু শক্তির ক্ষমতা ছিল 40.893 GW, যা বিশ্বের চতুর্থ বৃহত্তম ইনস্টল
(প্রধানত দক্ষিন, পশ্চিম এবং উত্তর পশ্চিম অঞ্চল)

Wind power generation

Annual electricity generation from wind is measured in terawatt-hours (TWh) per year. This includes both onshore and offshore wind sources.

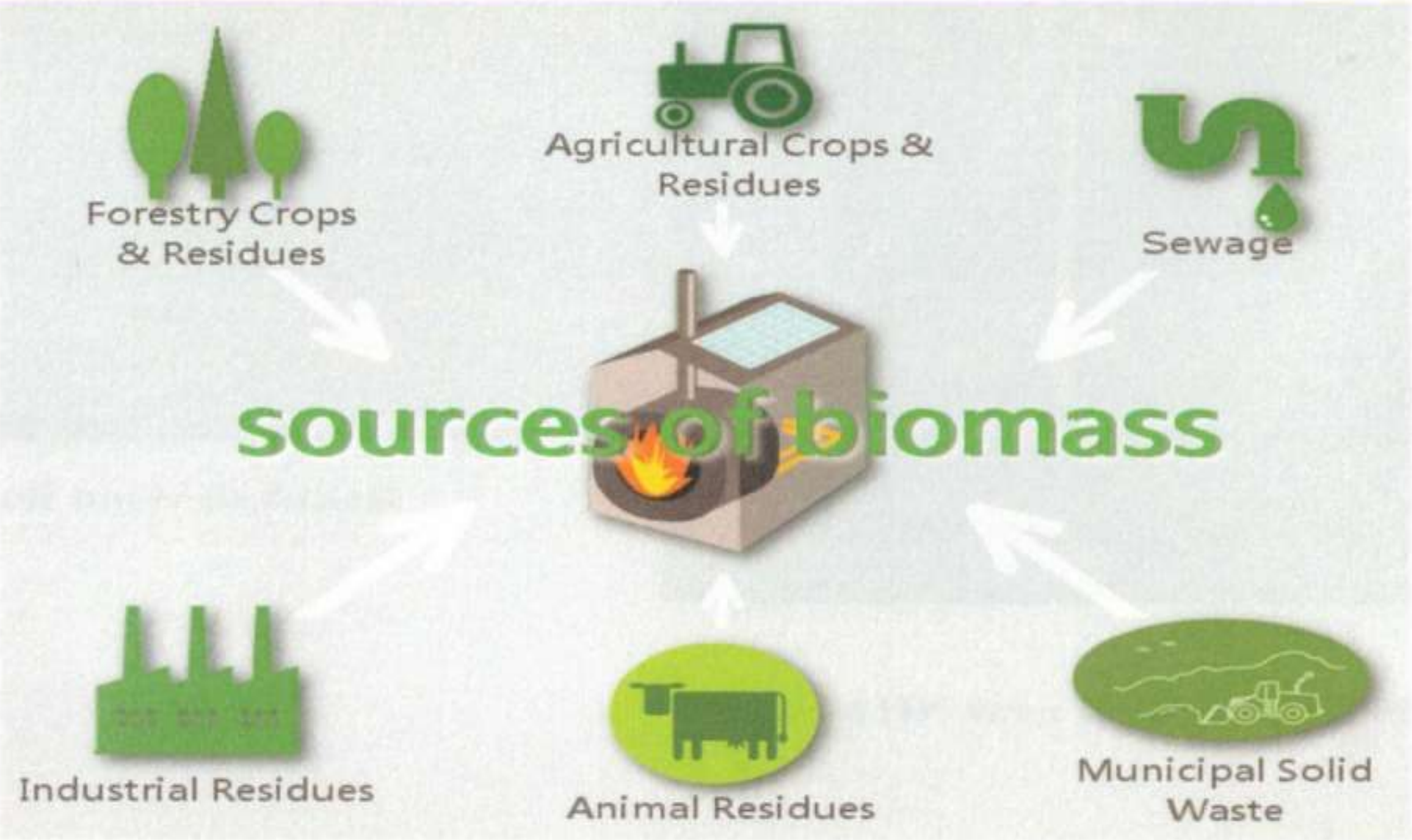


Source: Our World in Data based on BP Statistical Review of World Energy (2022) ; Our World in Data based on Ember's Global Electricity Review (2022). ; Our World in Data based on Ember's European Electricity Review (2022).

Bakkhali Wind farm

Muppandal Wind farm near NH44 1.5GW

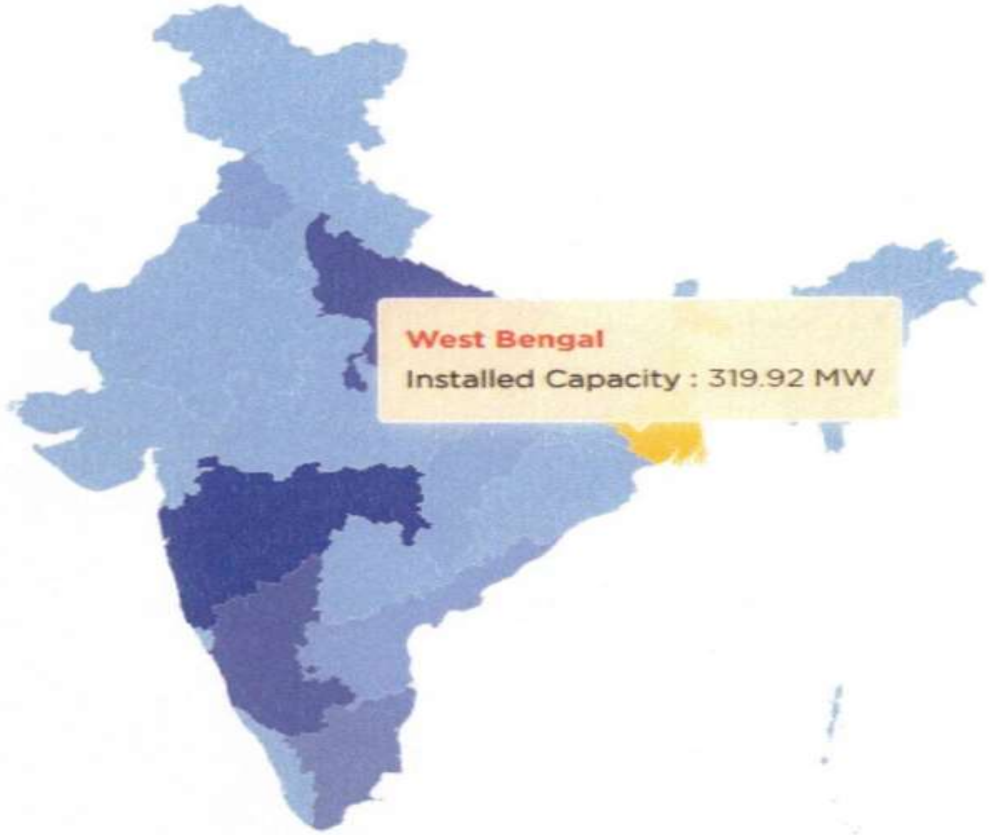
জৈব শক্তি


Forestry Crops
& Residues
Agricultural Crops &
Residues
Sewage
sources of biomass
Industrial Residues
Animal Residues
Municipal Solid
Waste

কিছু পরিসংখ্যান

Global electricity power generation capacity	143.4 GW (2021)[89]
Global electricity power generation capacity annual growth rate	7.1% (2012-2021)[90]
Share of global electricity generation	2% (2018)[56]
Levelized cost per megawatt hour	USD 118.908 (2019)[91]
Primary technologies	Biomass, biofuel
Other energy applications	Heating, cooking, transportation fuels

কিছু পরিসংখ্যান

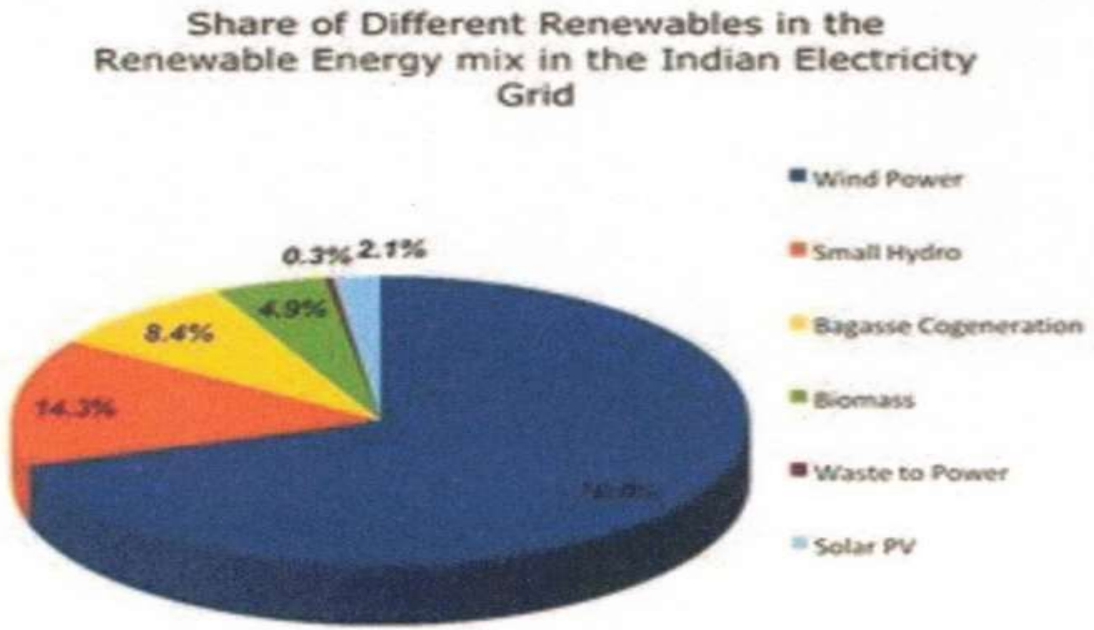

West Bengal
Installed Capacity : 319.92 MW


Overall Target(In GW)
Installed Capacity (In GW)
0
1
2
3
4
5
6
7
8
9
10

ফিরোজপুর পাঞ্জাব

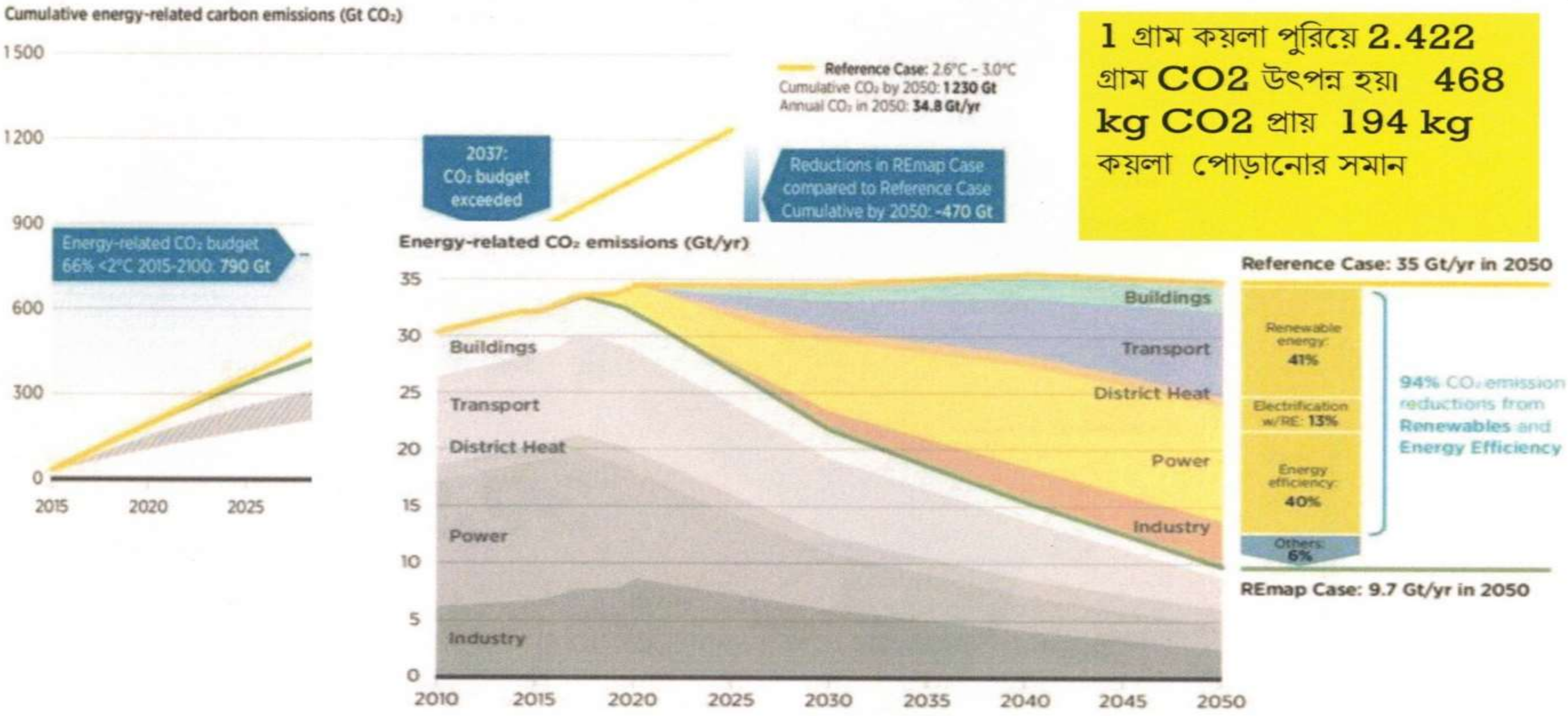
অন্যান্য নবায়ন যোগ্য উৎস

geothermal energy - ভূ শক্তি
tidal wave energy - জোয়ার তরঙ্গ শক্তি
small hydro power - ক্ষুদ্র জলবিদ্যুৎ প্রকল্প

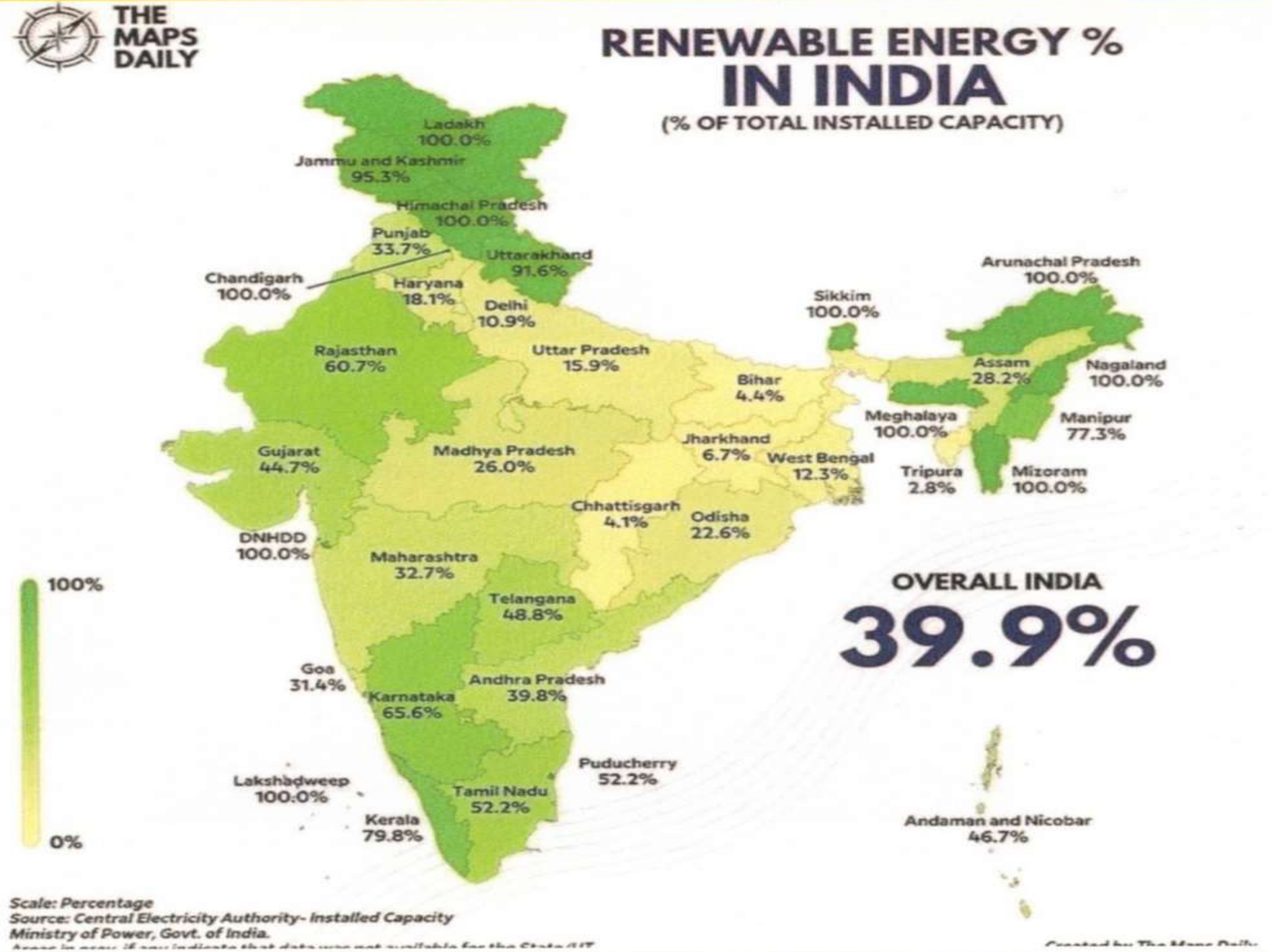


উপযোগিতা

1 গ্রাম কয়লা পুরিয়ে 2.422 গ্রাম CO_2 উৎপন্ন হয়। 468 kg CO_2 প্রায় 194 kg কয়লা পোড়ানোর সমান



ভারতে প্রদেশভিত্তিক বন্টন



শক্তির চাহিদা মেটানোর চেয়ে শক্তির চাহিদা কমানো:

- গার্হস্থ্য শক্তি প্রয়োজন নিয়ন্ত্রণ সোলার কুকার/বায়ো গ্যাস। সরকার ইনসেনটিভ সহায়ক হতে পারে
- সবুজ শাকসবজি/ কম প্রক্রিয়াজাত খাবার। খাদ্য শিল্পের শক্তির চাহিদা অটোমোবাইলের চেয়ে বেশি এবং বেশি গ্যাস নির্গমন
- সৌর আলো
- কম শক্তি ব্যবহার করার অভ্যাস করা -
- সাইকেল চালানো

2. *Proper transition into* **EV, Solar vehicles.**

3. **Green hydrogen** *cultivation.*

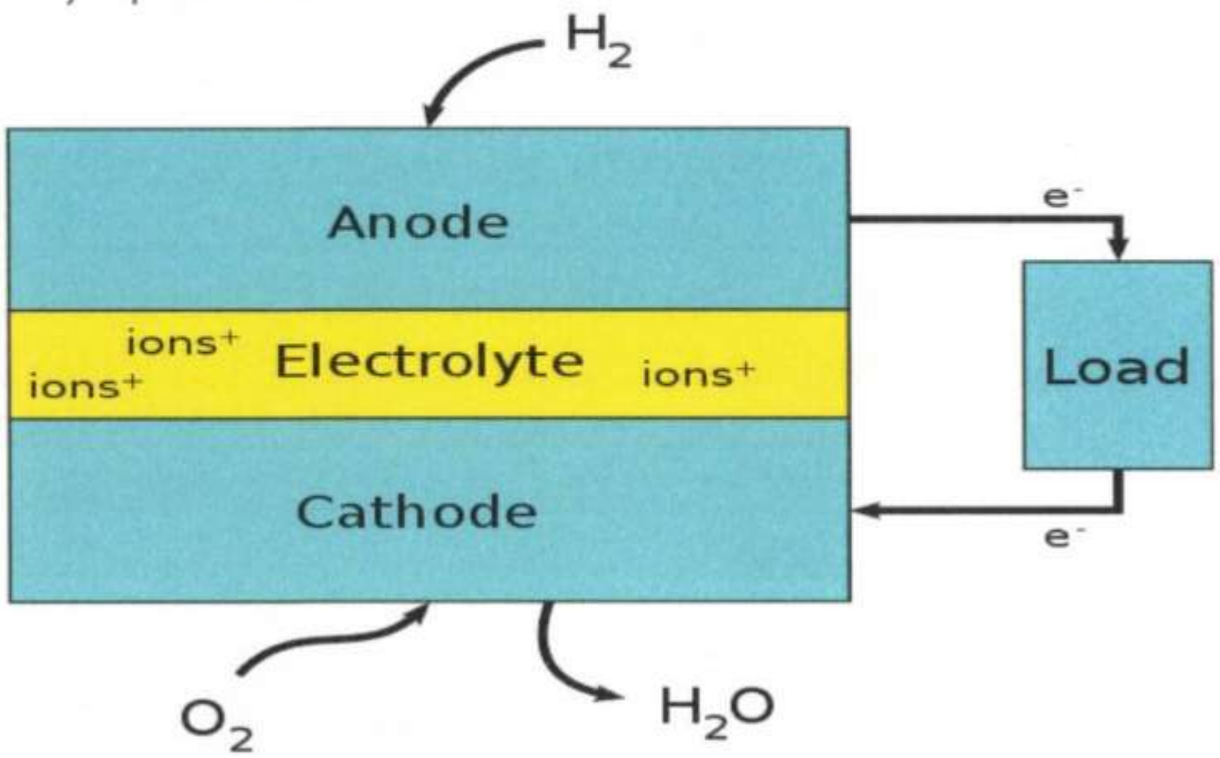
বৈদ্যুতিন যানবাহন

Electric vehicle charging

Solar TOTO developed at IIEST Shibpur

Energy Storage Elements:

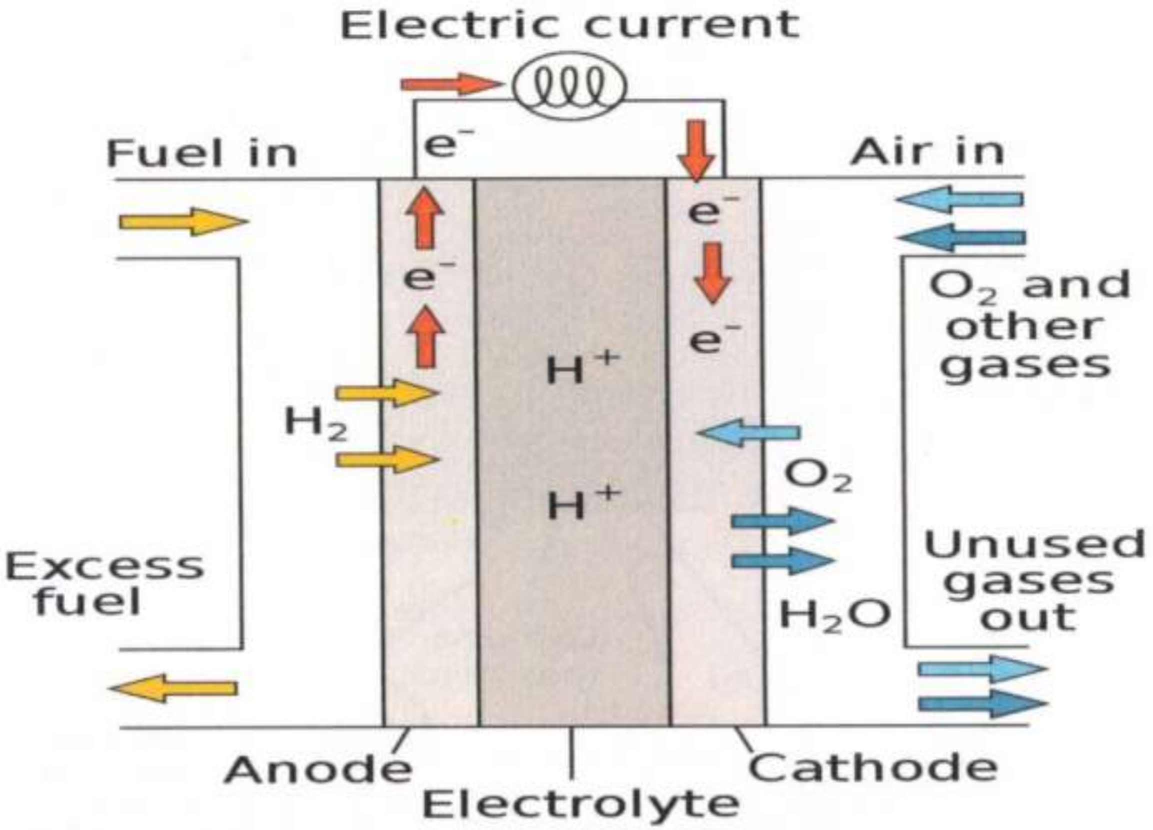
- Generation and distribution is not always possible
- Storing is required:
- Traditional batteries
- Fuel cells.



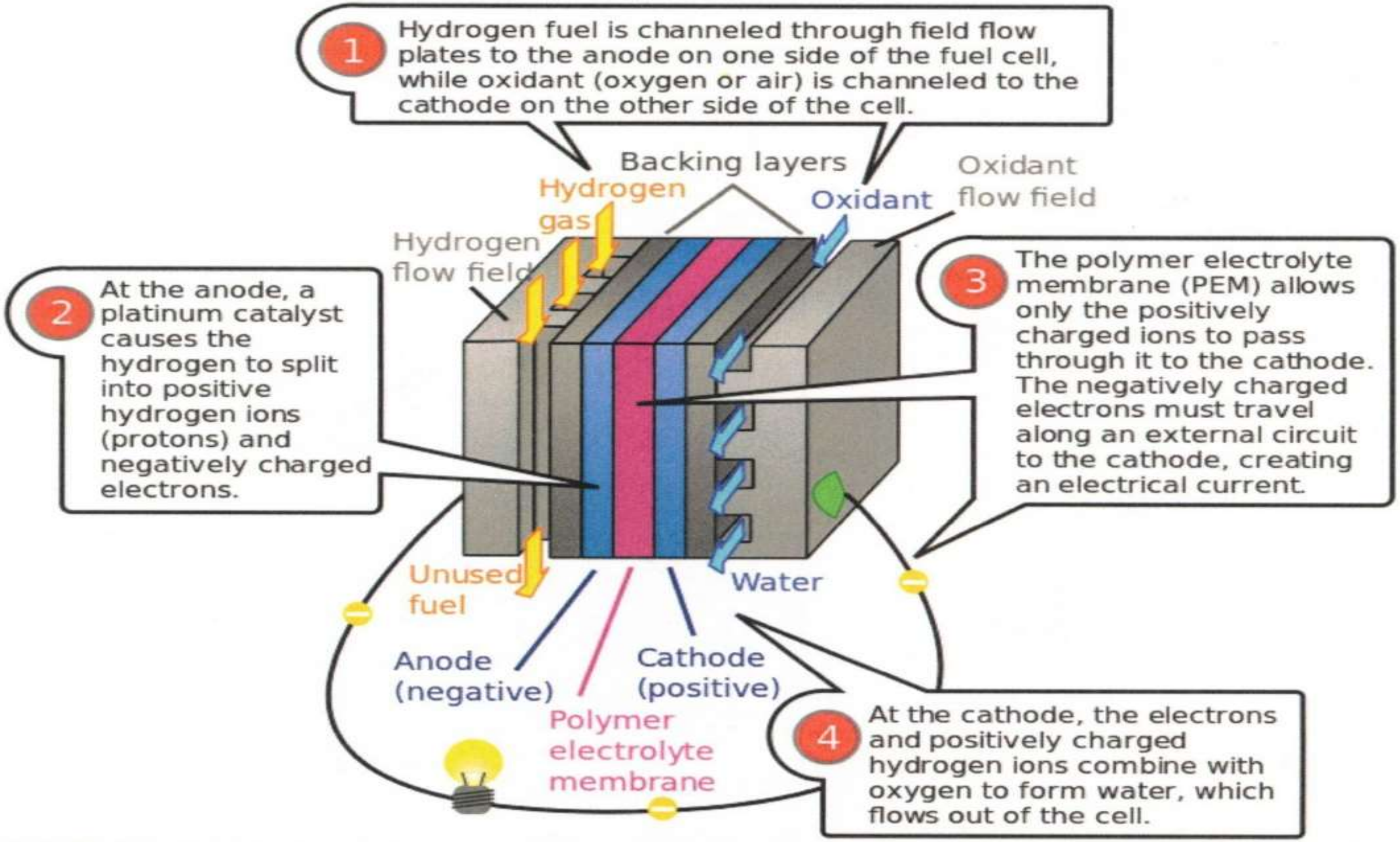
Fuel cell vs battery:

- A **fuel cell** is an electrochemical cell that converts the chemical energy of a fuel (often hydrogen) and an oxidizing agent (often oxygen) into electricity through a pair of redox reactions.
- **Fuel cells are different from most batteries in requiring a continuous source of fuel and oxygen (usually from air) to sustain the chemical reaction, whereas in a battery the chemical energy usually comes from substances that are already present in the battery.[3] Fuel cells can produce electricity continuously for as long as fuel and oxygen are supplied.**

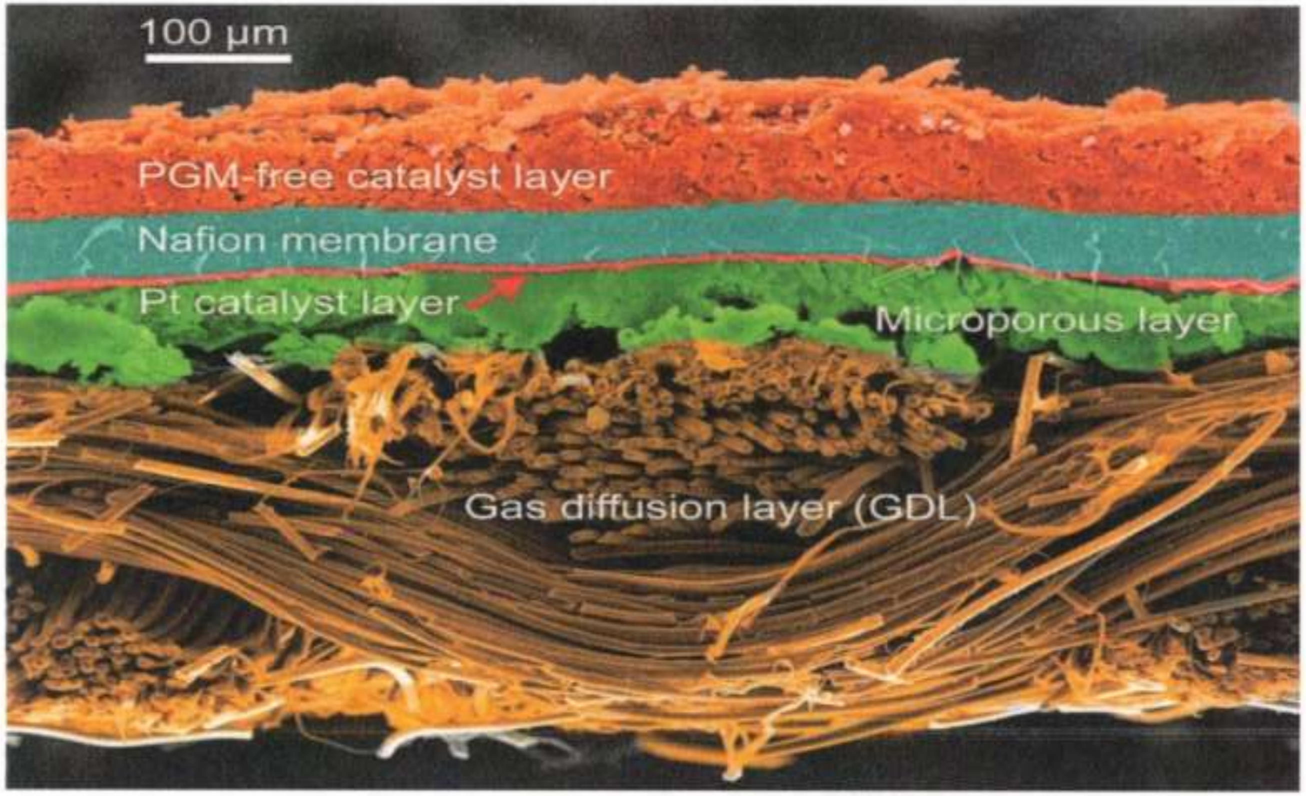
Schematic of a typical PEM Fuel cell:



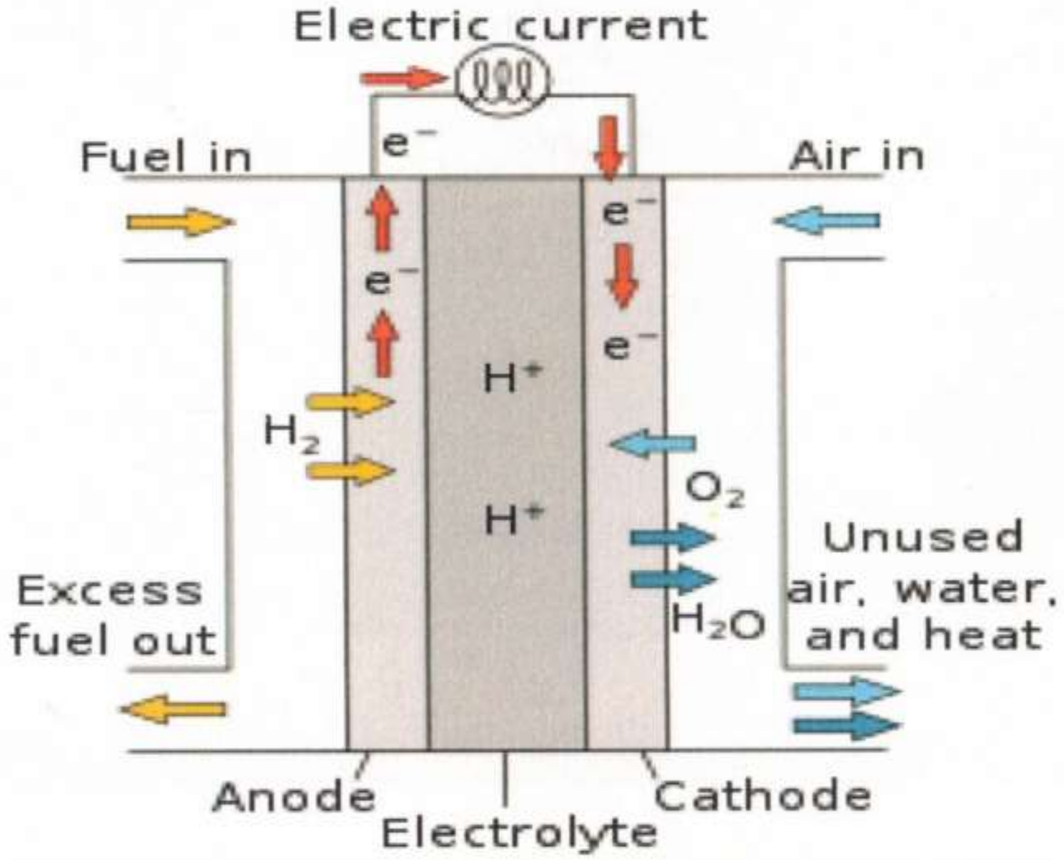
Proton exchange membrane fuel cell



Microscopic image:



Schematic of a typical phosphoric acid Fuel cell:



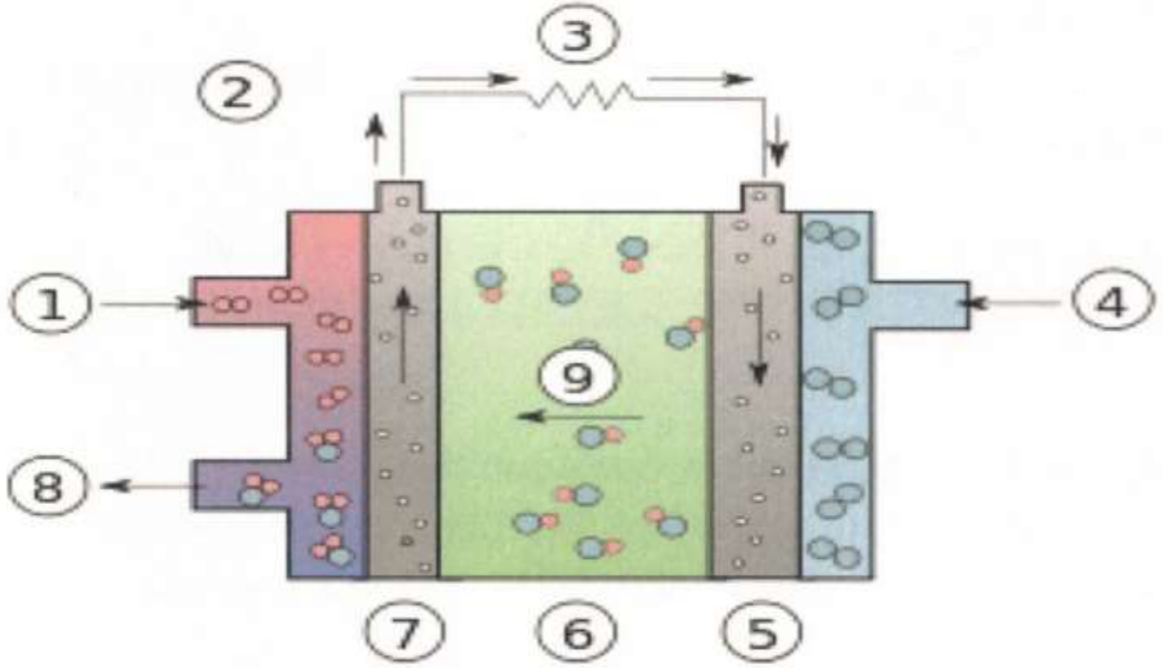
Details of a typical Phosphoric acid Fuel cell:

- ***Electrode Reactions:***
- Hydrogen gas is channeled to the anode, where it is split into protons and electrons. Protons travel through the solid acid electrolyte to reach the Cathode, while electrons travel to the cathode through an external circuit, generating electricity. At the cathode, protons and electrons recombine along with oxygen to produce water that is then removed from the system.
- **Anode**: $H_2 \rightarrow 2H^+ + 2e^-$
- **Cathode**: $\frac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O$
- **Overall**: $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$
- The operation of SAFCs at mid-range temperatures allows them to utilize materials that would otherwise be damaged at high temperatures, such as standard metal components and flexible polymers. These temperatures also make SAFCs tolerant to impurities in their hydrogen source of fuel, such as carbon monoxide or sulfur components. For example, SAFCs can utilize hydrogen gas extracted from propane, natural gas, diesel, and other hydrocarbons.

Description solid acid fuel cell:

- ***Electrode reactions***
- Anode reaction: $2H_2(g) \longrightarrow 4H^+ + 4e^-$
- Cathode reaction: $O_2(g) + 4H^+ + 4e^- \longrightarrow 2H_2O$
- Overall cell reaction: $2\ H_2 + O_2 \longrightarrow 2H_2O$
- ***Advantages and disadvantages.***
- At an operating range of 150 to 200 °C, the expelled water can be converted to steam for air and water heating (combined heat and power). This potentially allows efficiency increases of up to 70%. PAFCs are CO_2-tolerant and can tolerate a CO concentration of about 1.5%, which broadens the choice of fuels they can use. If gasoline is used, the sulfur must be removed.At lower temperatures phosphoric acid is a poor ionic conductor, and CO poisoning of the platinum electro-catalyst in the anode becomes severe.However, they are much less sensitive to CO than proton-exchange membrane fuel cells (PEMFC) and alkaline fuel cells (AFC).
- Disadvantages include rather low power density and chemically aggressive electrolyte

Alkaline fuel cell:



1. Hydrogen
2. Electron flow
3. Load
4. Oxygen
5. Cathode
6. Electrolyte
7. Anode
8. Water
9. Hydroxide Ions

Working principle:

Half Reactions:

The fuel cell produces power through a redox reaction between hydrogen and oxygen. At the anode, hydrogen is oxidized according to the reaction:

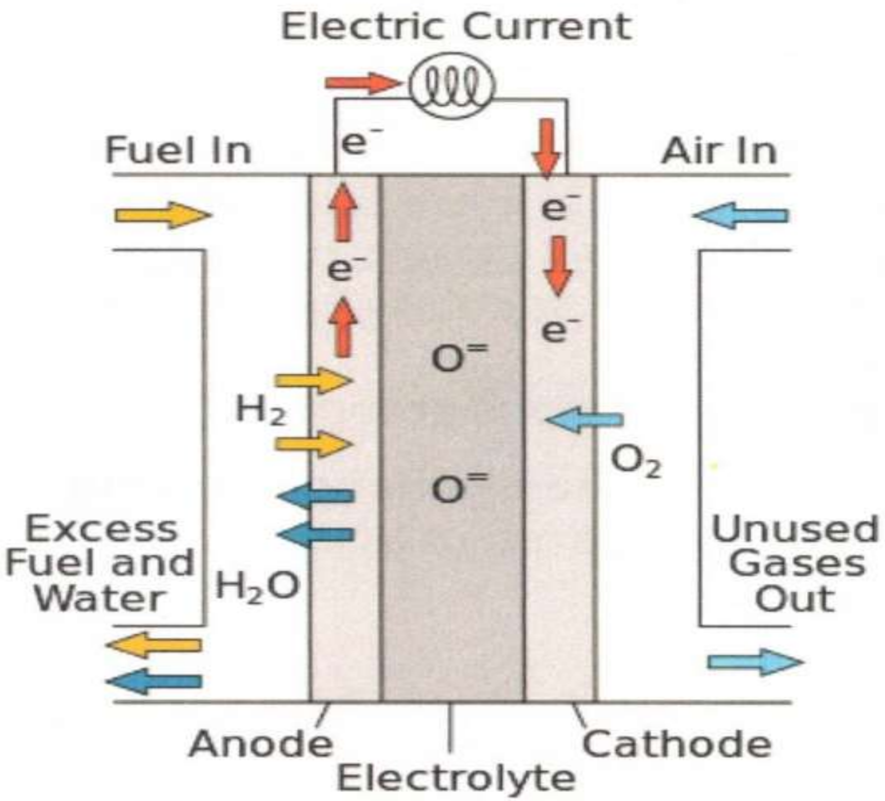
producing water and releasing electrons. The electrons flow through an external circuit and return to the cathode, reducing oxygen in the reaction:

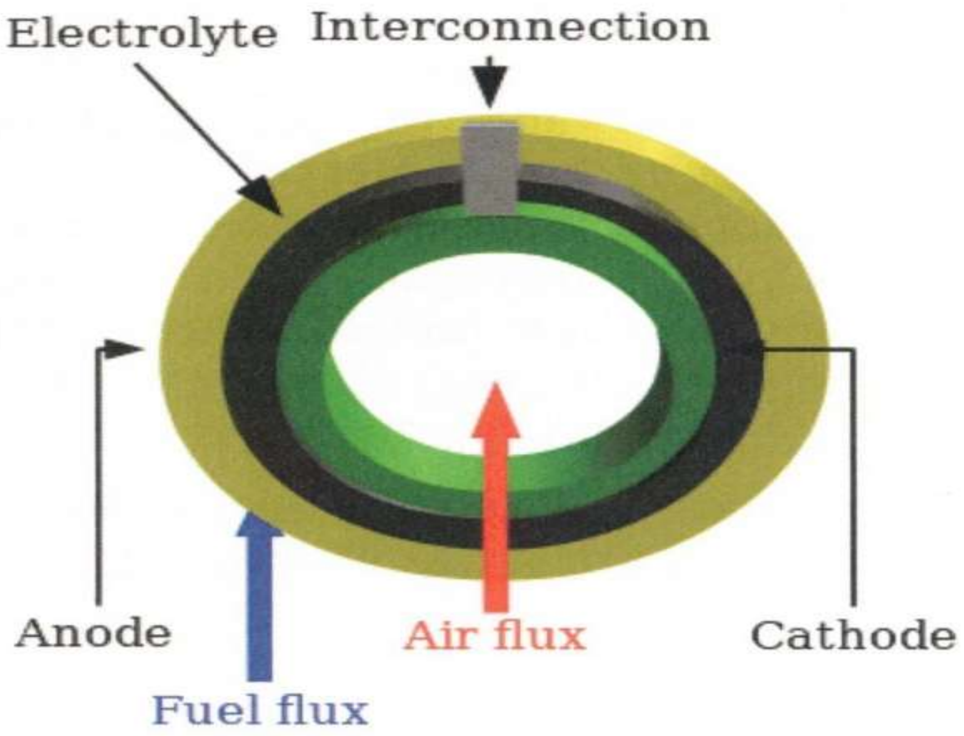
producing hydroxide ions. The net reaction consumes one oxygen molecule and two hydrogen molecules in the production of two water molecules. Electricity and heat are formed as by-products of this reaction

Advantages & disadvantages:

- Alkaline fuel cells operate between ambient temperature and 90 °C with an electrical efficiency higher than fuel cells with acidic electrolyte, such as proton exchange membrane fuel cells (PEMFC), solid oxide fuel cells, and phosphoric acid fuel cells. Because of the alkaline chemistry, oxygen reduction reaction (ORR) kinetics at the cathode are much more facile than in acidic cells, allowing use of non-noble metals, such as iron, cobalt, or nickel, at the anode (where fuel is oxidized); and cheaper catalysts such as silver or iron phthalocyanines at the cathode,[1] due to the low overpotentials associated with electrochemical reactions at high pH.
- An alkaline medium also accelerates oxidation of fuels like methanol, making them more attractive. This results in less pollution compared to acidic fuel cells.
- Apollo 11

Schematic of solid oxide fuel cell:





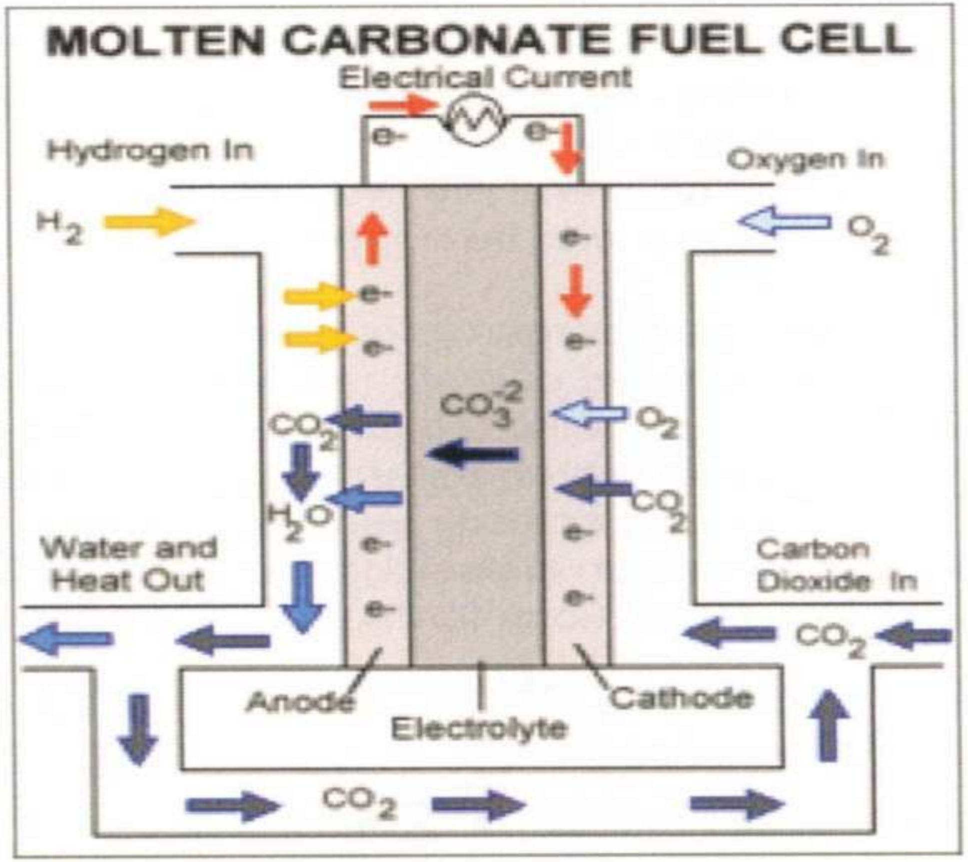
Operation details:

Solid oxide fuel cells (SOFCs) use a solid material, most commonly a ceramic material called yttria-stabilized zirconia (YSZ), as the electrolyte. Because SOFCs are made entirely of solid materials, they are not limited to the flat plane configuration of other types of fuel cells and are often designed as rolled tubes. They require high operating temperatures (800–1000 °C) and can be run on a variety of fuels including natural gas.

SOFCs are unique because negatively charged oxygen ions travel from the cathode (positive side of the fuel cell) to the anode (negative side of the fuel cell) instead of protons travelling vice versa (i.e., from the anode to the cathode), as is the case in all other types of fuel cells. Oxygen gas is fed through the cathode, where it absorbs electrons to create oxygen ions. The oxygen ions then travel through the electrolyte to react with hydrogen gas at the anode. The reaction at the anode produces electricity and water as by-products. Carbon dioxide may also be a by-product depending on the fuel, but the carbon emissions from an SOFC system are less than those from a fossil fuel combustion plant.[45] The chemical reactions for the SOFC system can be expressed as follows:

Anode reaction: $2H_2 + 2O^{2-} \rightarrow 2H_2O + 4e^-$
Cathode reaction: $O_2 + 4e^- \rightarrow 2O^{2-}$
Overall cell reaction: $2H_2 + O_2 \rightarrow 2H_2O$

Molten Carbonate fuel cell:



Reactions :

lten carbonate fuel cells (MCFCs) require a high operating temperature, 650 °C (1,200 °F), similar to SOFCs. MCFCs use lithium potassium carbonate salt as an electrolyte, and this salt liquefies at high temperatures, owing for the movement of charge within the cell – in this case, negative carbonate ions.
Like SOFCs, MCFCs are capable of converting fossil fuel to a hydrogen-rich gas in the anode, eliminating the ed to produce hydrogen externally. The reforming process creates CO_2 emissions. MCFC-compatible fuels include natural gas, biogas and gas produced from coal. The hydrogen in the gas reacts with carbonate ions m the electrolyte to produce water, carbon dioxide, electrons and small amounts of other chemicals. The electrons travel through an external circuit creating electricity and return to the cathode. There, oxygen from the and carbon dioxide recycled from the anode react with the electrons to form carbonate ions that replenish the electrolyte, completing the circuit. The chemical reactions for an MCFC system can be expressed as follows

Internal Reformer:

$$CH_4 + H_2O = 3H_2 + CO$$

Anode:

$$H_2 + CO_3^{2-} = H_2O + CO_2 + 2e^-$$

Cathode:

$$\frac{1}{2}O_2 + CO_2 + 2e^- = CO_3^{2-}$$

Cell:

$$H_2 + \frac{1}{2}O_2 = H_2O$$

Advantages & disadvantages:

- As with SOFCs, MCFC disadvantages include slow start-up times because of their high operating temperature. This makes MCFC systems not suitable for mobile applications, and this technology will most likely be used for stationary fuel cell purposes. The main challenge of MCFC technology is the cells' short life span. The high-temperature and carbonate electrolyte lead to corrosion of the anode and cathode. These factors accelerate the degradation of MCFC components, decreasing the durability and cell life. Researchers are addressing this problem by exploring corrosion-resistant materials for components as well as fuel cell designs that may increase cell life without decreasing performance.
- MCFCs hold several advantages over other fuel cell technologies, including their resistance to impurities. They are not prone to "carbon coking", which refers to carbon build-up on the anode that results in reduced performance by slowing down the internal fuel reforming process. Therefore, carbon-rich fuels like gases made from coal are compatible with the system. The United States Department of Energy claims that coal, itself, might even be a fuel option in the future, assuming the system can be made resistant to impurities such as sulfur and particulates that result from converting coal into hydrogen.MCFCs also have relatively high efficiencies. They can reach a fuel-to-electricity efficiency of 50%, considerably higher than the 37–42% efficiency of a phosphoric acid fuel cell plant. Efficiencies can be as high as 65% when the fuel cell is paired with a turbine, and 85% if heat is captured and used in a combined heat and power (CHP) system.
- FuelCell Energy, a Connecticut-based fuel cell manufacturer, develops and sells MCFC fuel cells. The company says that their MCFC products range from 300 kW to 2.8 MW systems that achieve 47% electrical efficiency and can utilize CHP technology to obtain higher overall efficiencies. One product, the DFC-ERG, is combined with a gas turbine and, according to the company, it achieves an electrical efficiency of 65%