

# Renewable Energy and Distributed Generations

## Lecture 3

### Introduction on Renewable Energy (RE)Technology

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## ***Lecture learning outcomes:***

At the end of this lecture, you will be able to:

- i. Define the Renewable Energy Generation
- ii. Understand the global Trends in Renewable energy
- iii. Identify the Way Forwards for Energy Transitions

# Outlines

## 1. Introduction

### 1.1 Global energy Trends

### 1.2 Energy and Climate

### 1.3 Alternative energy solution

### 1.4 Way Forewords to net-zero carbon emission

### 1.5 Higher institutions (HI) motivation towards RE Transitions

## Summary

# 1. Introduction: Renewable Energy & Distributed Generations

- Energy is what makes you able to work. It's the driving force for modern industrial applications
- Energy is one of the most crucial elements of the economic infrastructure.
- The two categories of energy sources based on the rate at which they can be replenished are:
  - i. Conventional energy resources (CER)
- CER uses fossil fuel for energy generation, which is matured type of generation with limited resources and non-renewable

# Introduction

# Cont.....

## ii. Renewable Energy Resources (RE):

- RE is derived from renewable energy resources, abundant availability and renewable
- Renewable energy is derived from *unlimited, naturally regenerating resources like the sun, tides, water, biomass and wind.*
- Distributed generation(DG): one of the RE generation, which is generating energy in small amount near to the demands
- DG is very important, especially for rural electrification and supplying customers who live in unfavorable demography

# Introduction

# Cont.....

- They often leave little to no carbon emission to the environment and are self-replenishing and natural.
- The production of electricity, heating and cooling of spaces and water, and transportation and others are done with renewable energy.
- In contrast, non-renewable energy is derived from limited resources like oil, natural gas, and coal.
- Which pollutes the environment and adversely affects our environment

# Introduction

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- ❖ By granting people access to inexpensive, safe, dependable, and clean energy, renewable power generation can assist nations in achieving their SDGs.
- ❖ Nowadays, the bulk of power producing capacity additions come from renewable energy sources.
- ❖ Tens of Gig watts of wind, hydropower and solar photovoltaic capacity are installed worldwide every year in a renewable energy market that is worth more than a hundred billion USD annually.
- ❖ Other renewable power technology markets are also emerging.

# 1. 1 Global Energy Trends(GET)

- The UN-2030 agenda, Goal-7 that targets to provide clean and affordable energy to all society is on GET Starting point [1].
- Electricity generation is the driving point of modern civilization of humankind
- Thus, our modern industries, vehicles and other loads needs energy, means we need energy for sustainable development goal(SDGs).
- Currently the power generation is the largest source of carbon dioxide (CO<sub>2</sub>) emissions in the world as observe in Figure 1[2].
- *It's observed that the generation sector is contributing 41.5GT CO<sub>2</sub> to the environment, in 2022, which needs to be addressed*

# Energy Sector Emissions by Source, 2021-2022

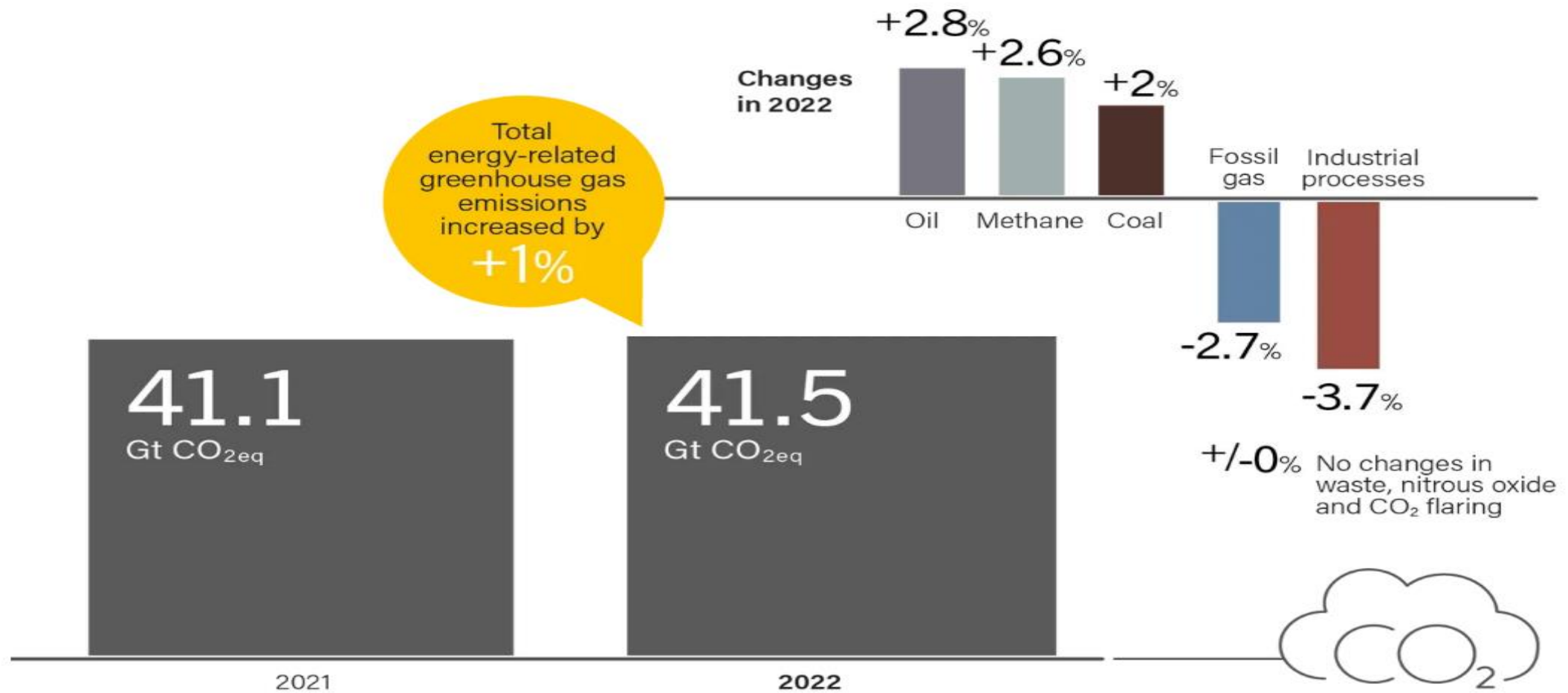


Figure1. The CO2 emissions in the world. Source: REN21. 2023



Figure 1. Carbon dioxide (CO<sub>2</sub>) emissions from fossil fuels and industry. Land-use change is not included[3]. *Source: <https://ourworldindata.org>*

- In contrast, the transition to net zero emissions by 2050 G.C based on Paris agreement has contributed the rapid growth in RE sectors[4].
- Expansion of renewable energy sources such as solar , wind power , hydro and others are needed to come up with the carbon emission free environment by 2050.
- The global electricity generation review of 2023 based on data from 78 countries( contributes 93% of global energy demand& top 10 CO<sub>2</sub> emitting that accounts 80% global CO<sub>2</sub> emission ) indicates there is significant improvement in renewable energy generation.

# GET

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- The total energy generation of 2023 report indicates that there are 28,430 TWh of generation from different energy shares[5] as indicated in Fig.2

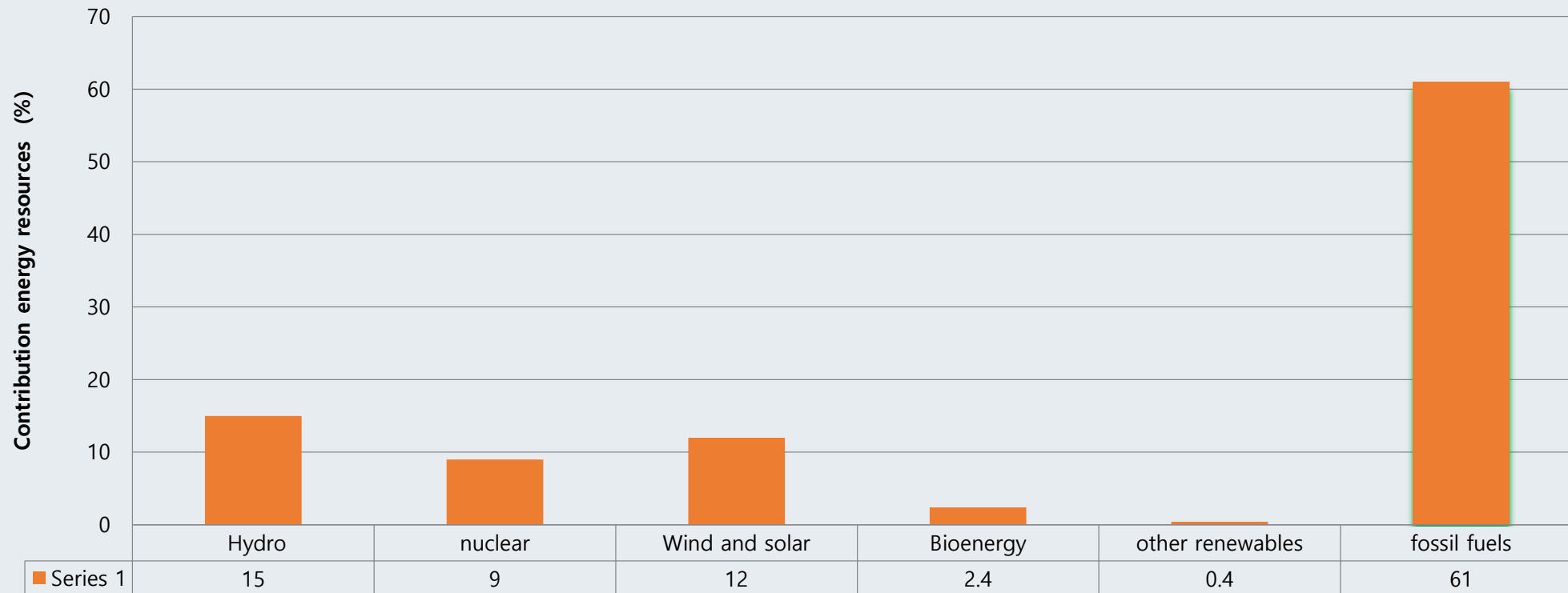
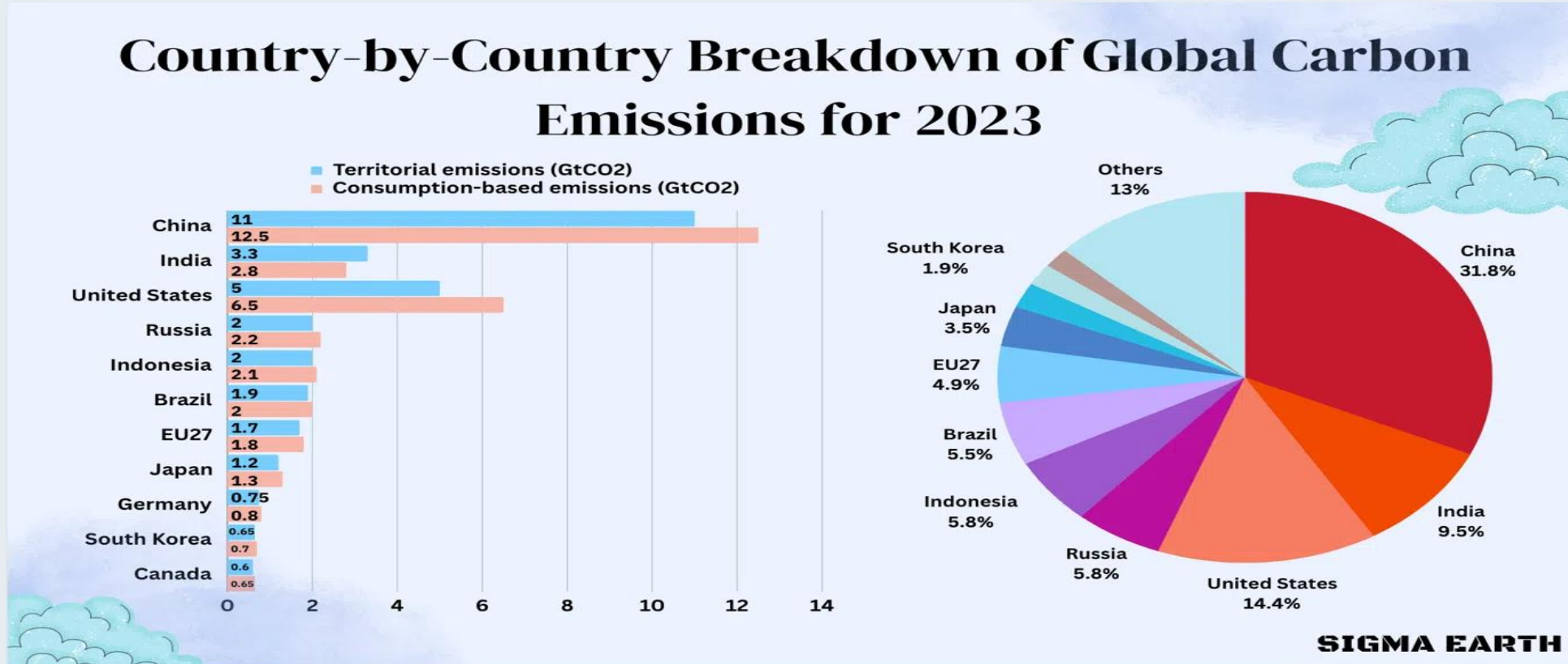


Figure 2. Global Electricity Trends 2023. *Source: ember-climate.org*

- As indicated in the global electricity trends, the global electricity demand is 28,510 TWh.
- The developed countries are the one who consumes most.
- On average worldwide, the per capita demand was 3.6 MWh.
- This necessitates, working towards achieving the exponential growth demand as per the UN-Agenda 2030 and Paris Agreement for better SDGs.

# 1.2 Energy and climate (E&C)

- Limiting global warming to 1.5°C requires cutting carbon dioxide (CO<sub>2</sub>) emissions by around 40 Giga-tonnes (Gt) from 2022 levels and achieving net-zero emissions in the energy sector by 2050.

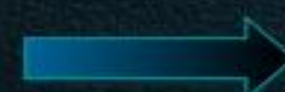


Source: [sigmaearth.com](https://sigmaearth.com)

- Climate Change – Major problem of the century
- Sustainable Development



**TEMPERATURE INCREASE**



**NEGATIVE  
EFFECTS**

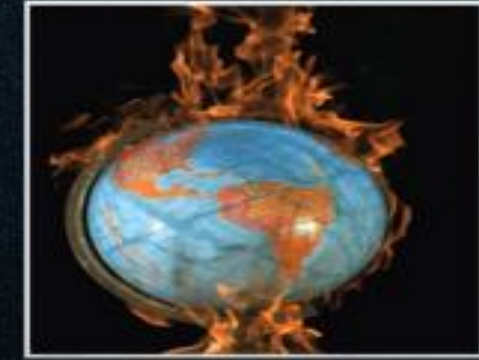


Figure 3. Emissions Gap Report 2023[6]. *Source: www.unep.org*

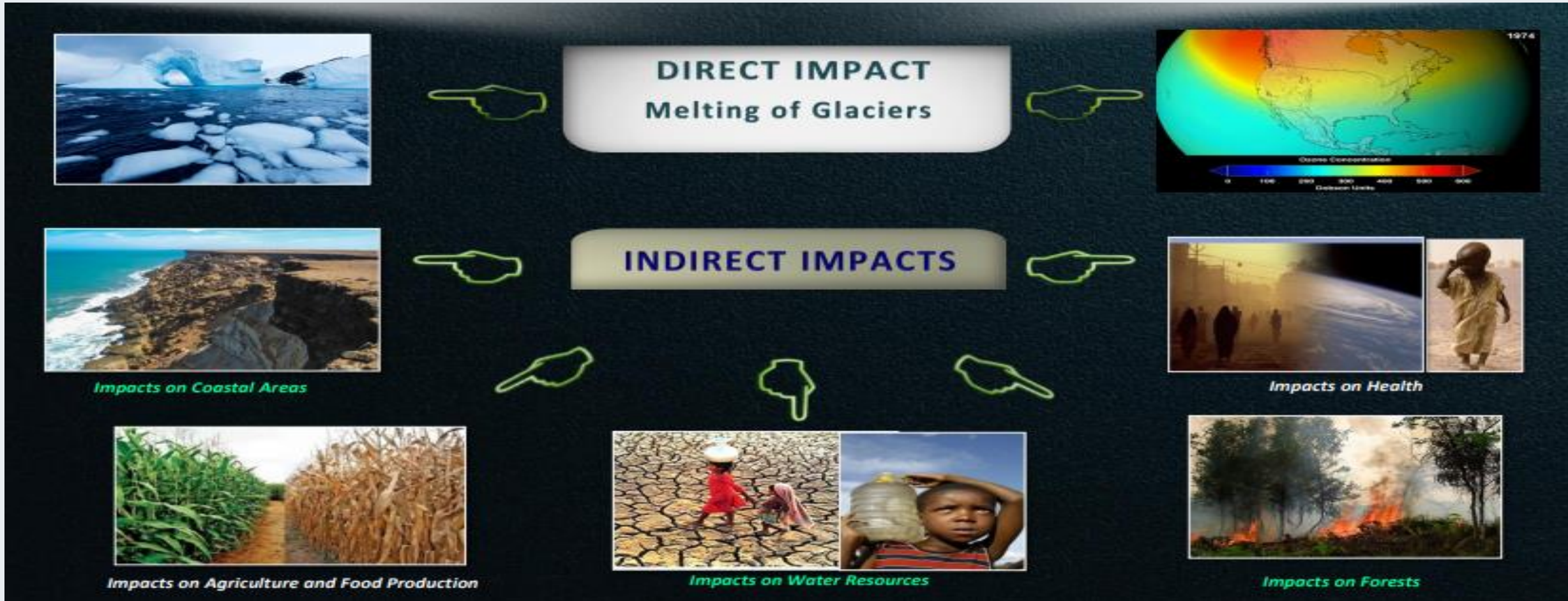


Figure 4. Climate impact on environment. *Source: europeansting.com*

# 1.3 Alternative energy solution(AES)

- To avoid the worst impacts of climate change, emissions needs to be reduced by almost half by 2030 and reach net-zero by 2050.
- To mitigate the CO<sub>2</sub> emission to our environment and hence to achieve the sustainable development goal , it's advisable to use RE technologies
- Renewable energy sources are the **least expensive** options in boosting electricity access, reducing air pollution and cutting carbon dioxide emissions worldwide
- It includes natural gas and renewable energy sources such as wind, solar, geothermal, and hydropower

**Five** reasons why accelerating the transition to clean energy is needed;

- i. Renewable energy sources are available all over the world
  - 80% of the world population lives (>6 B peoples) in countries that are net-importers of fossil fuels.
  - By contrast, renewables are available in all countries, offering a way out of import dependency and allowing them to enhance their economies through natural gifts[7]
- ii. Reduced price/ cheaper : The cost of electricity from solar power fell by 85 percent between 2010 and 2020.
  - Costs of onshore and offshore wind energy fell by 56 percent and 48 percent respectively.

iii. RE is very friendly for the society or healthier

- According to WHO, around 99% of people in the world breathe air that exceeds air quality limits and more than 13 million deaths around the world each year are due to avoidable environmental causes, including air pollution[8].

iv. RE creates job opportunity

- Three times as many jobs are produced a single dollar invested in renewable energy as in the fossil fuel sector.
- By 2030, it's predicted that the production of fossil fuels would lose 5 million jobs, while the clean energy sector would add 14 million jobs, for a net increase of 9 million.

Till now, 13.7 million people were employed both directly and indirectly by the worldwide RE sector [9].

## V. Economic stability [10]

- In 2022, subsidies for fossil fuels were worth \$7 trillion globally. Its negative effects on the environment and human health that were not factored in.
- This expense results from the restricted supply of fossil fuels throughout the majority of the nation.
- However, in order to achieve net-zero emissions by 2050, over \$4 trillion must be invested annually in renewable energy sources until 2030.
- By 2030, the world may save up to \$4.2 trillion only by reducing pollution and the effects of climate change.

# AES

# Cont.....

**Globally, 77 countries 10 regions** and more than 100 cities announced their commitment to net-zero carbon emission by 2050 considering the following advantage:

- Clean environment
- Unlimited supply
- Zero GHG emission
- Decentralization
- provides rural and island electrification
- Employment opportunity
- Societal impact

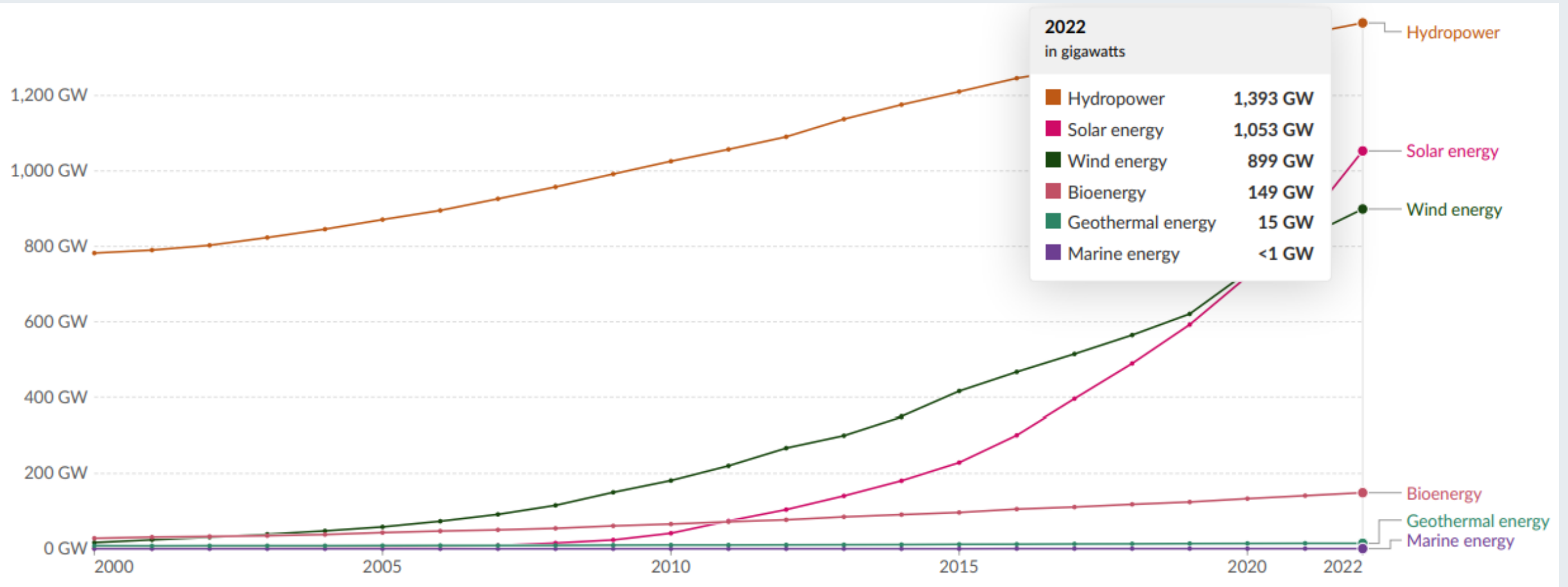


Figure 4. Global RE installed capacity in 2022

**Source :** International Renewable Energy Agency (2023)

# Energy consumption will be doubled between 2015-2050

- Energy consumption will be doubled between 2020 to 2050 as presented in Fig. 5[11],

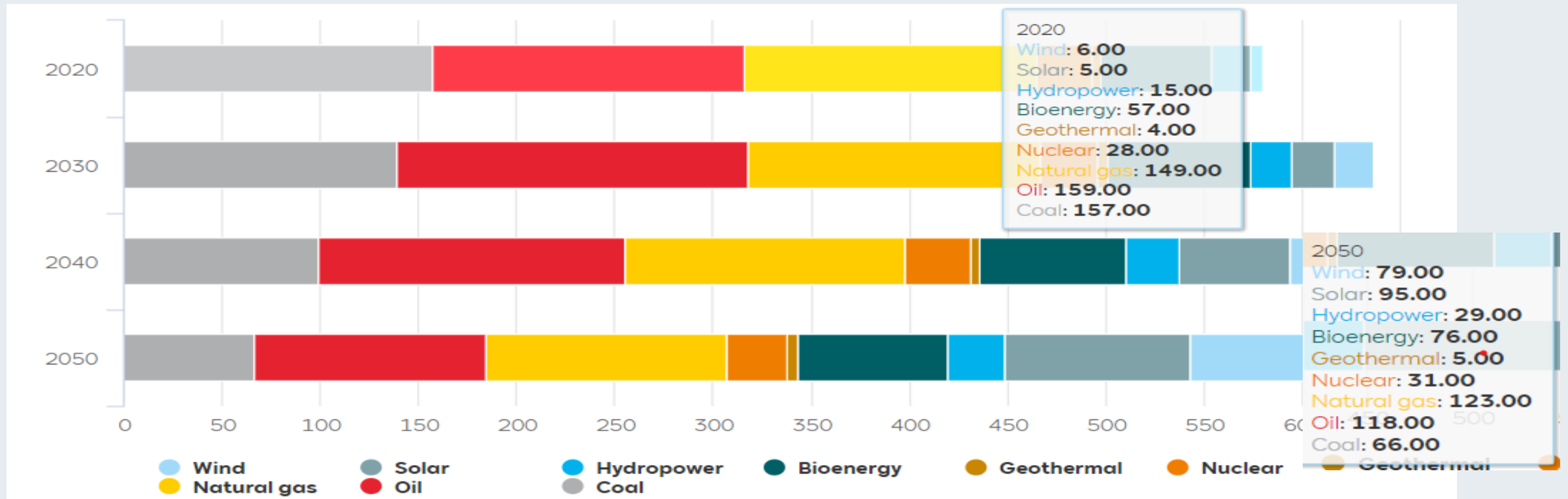


Fig.5 World primary energy supply by source in 2020 until 2050in EJ/yr. Source: DNV

# 1.4 Way Forewords to net-zero carbon emission

a. The governments and Policy makers has to actively participate in the transitions[11]

- In order to implement cohesive, **transnational policies**, governments need to work together in a productive and rewarding manner.
- To scale up clean technology, national markets must be connected through international standard creation, coordination, and innovation acceleration.
- It will be more difficult and costly for many wealthy countries to reach net-zero emissions without international cooperation.
- Many emerging nations are unsure about how to reach net zero without assistance from other nations.
- Technical and financial support are needed to ensure the deployment of crucial

# Way forewords

# Cont.....

- The amount of RE capacity added globally reached 473 GW in 2023, an estimated 36% increase[12].
- Thirty-one countries promised to double the yearly pace of energy efficiency improvements by 2030.
- USA initiated more than 250 clean energy manufacturing projects, and EU introduced the first phase of the Carbon Border Adjustment Mechanism and the Net-Zero Industry Act in 2023.
- About 13.7 million jobs in the renewables industry in 2022, an 8% growth in employment.
- Globally people without access to electricity decreased from 756 million in 2022 to 745 million in 2023

# Way forewords

# Cont.....

b. Private sectors should involve

- Financing the green energy transition
- Decarbonizing the industries
- Digitizing industries

c. Higher institutes should highly involve on working towards the SDGs:

- Through researches
- Innovation
- Policy creation
- Doing feasibility analysis, constructing power plants and consultant of energy generation
- The higher institution (HI) or researchers should do motivation towards the transition of RE & DGs as follows:

# 1.5 HI motivation towards RE Transitions

- ***The first motivation:*** promoting and teaching the stockholders regarding the RE as
- It is clean energy , free from emission and can be harnessed in MW
- Generation in large GW is possible
- Reduce the dependence on oil/fuel in energy sector that lead to economic inflations

- **2<sup>nd</sup> motivation is reduction in cost: that the recent years have** seen dramatic reductions in renewable energy technologies' costs as a result of R&D and accelerated deployment.
- However , the **policy-makers** are often not aware of the latest cost data.
- International Renewable Energy Agency (IRENA) Member Countries have asked for **better and cost effective design and installation of renewable energy technologies.**

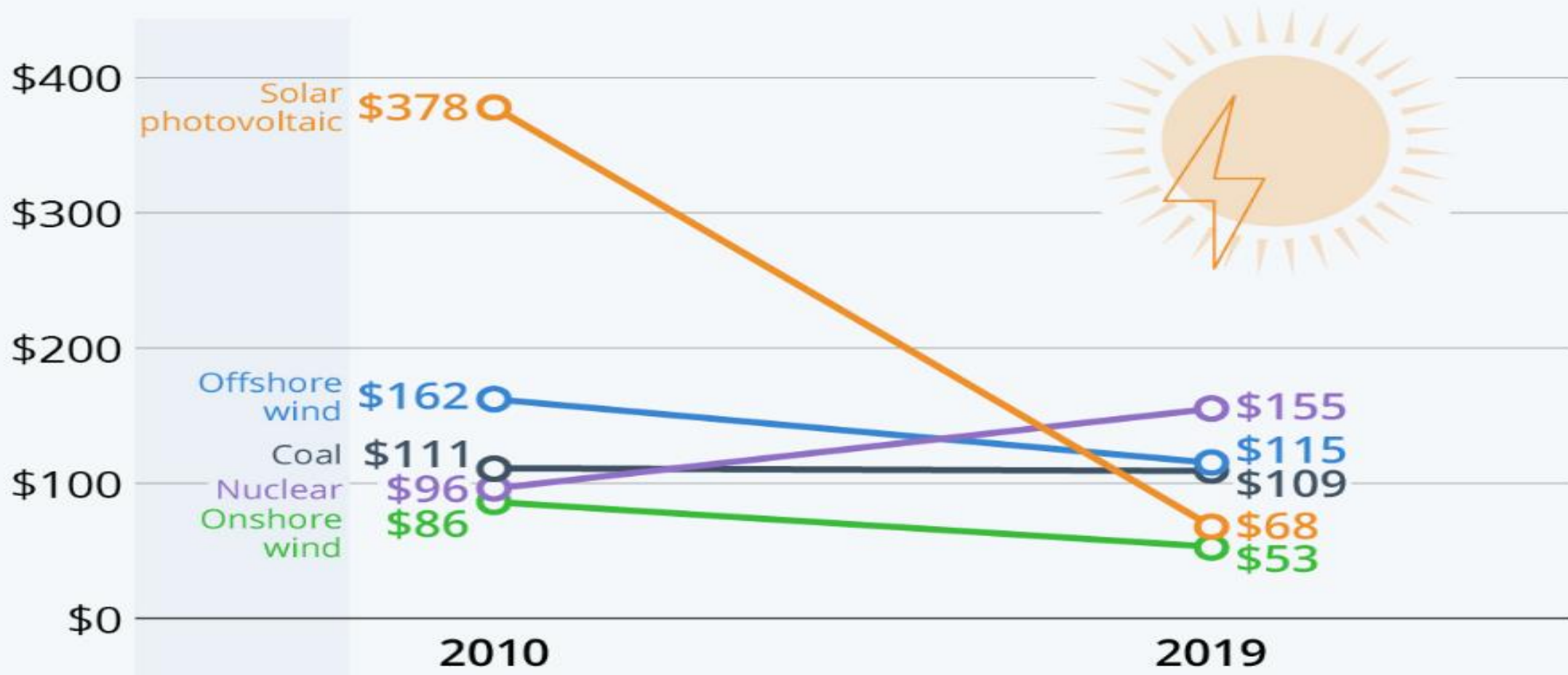


Figure 4. Generation cost per megawatt by sources [13]. Source: OurWorldindata.org

# HI contribution to RE

# Cont....

## 3rd Motivation: Abundance of RE.

- The sun radiate  $1,5 * 10^{18} \times 10^{18}$  kWh energy to the Earth for per year
- **2%** of this solar energy is converted into flow of energy
- The total energy demand of people:  $91 * 10^{12} \times 10^{12}$  kWh for a year
- **0,006%** of the radiated energy would be enough

# HI contribution to RE

# Cont....

- Worldwide wind energy potential =  $30 * 10^{15} \times 10^{15}$  kWh
- But, useable only about 3% (Heights, Distances between units 10-40 times the rotor radius) =  $0,9 * 10^{15} \times 10^{15}$  kWh
- Most of the countries have also an ample resources in other RE like hydro, biomass, geothermal etc
-

4<sup>th</sup> Motivation: the integration concern with other energy sources based on:

- Variable Power
- Uncertain Power
- Geographic Diversity,
- Size, and Distance from Load
- Standardized Power Purchase Agreement with Guaranteed Interconnection and Priority Dispatch
- Wind Turbine Generators

**RE integration to grid needs some critical analysis in terms of:**

- Planning
- Physical Connection, grid integration
- System Operation
- Therefore, the planning of RE generations(wind, solar, hydro, biomass), operation and grid integration scenarios has to be addressed.

# Summary

- In conclusion, the renewable energy generation over conventional energy is needed to achieve net-zero carbon emission transition by 2050.
- The climate change due to the conventional energy resources, which is due to exponential increasing carbon emission needs to be mitigated.
- Clean energy resources like wind, solar and hydro should be built to provide affordable and clean energy
- The policy makers, private sectors and higher institutions should enhance their contributions towards net-zero carbon mission of Paris agreement.
- Research's, knowledge transfer and importance of RE technology , and its application should be further improved

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Thank you !