



COMMISSION INTERNATIONALE
DES GRANDS BARRAGES

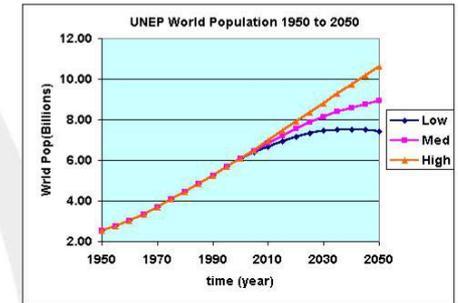
INTERNATIONAL COMMISSION
ON LARGE DAMS

HYDROPOWER CHALLENGES FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

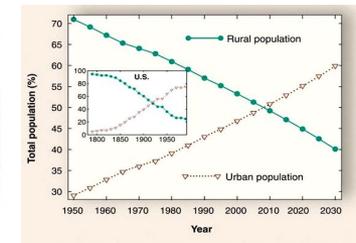


GLOBAL CHANGES

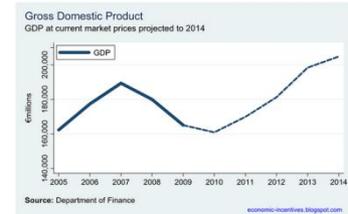
POPULATION GROWTH



URBANIZATION

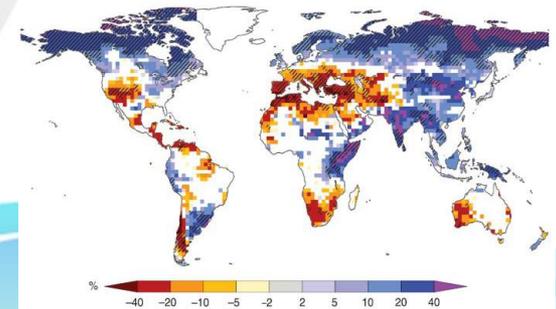


SOCIO-ECONOMIC DEVELOPMENT



CLIMATE VARIABILITY

CLIMATE CHANGE





Key mitigation technologies and practices currently commercially available.

- Improved supply and distribution efficiency
- Fuel switching from coal to gas
- Nuclear power
- **RENEWABLE energies** (Hydropower, solar, wind, geothermal and bioenergy)
- Combined heat and power
- Early applications of carbon dioxide capture



United Nations
Climate Change

**UNFCCC says hydropower can
“help climate action”**

**The sector has a key role to play in the
implementation of the Paris Agreement**

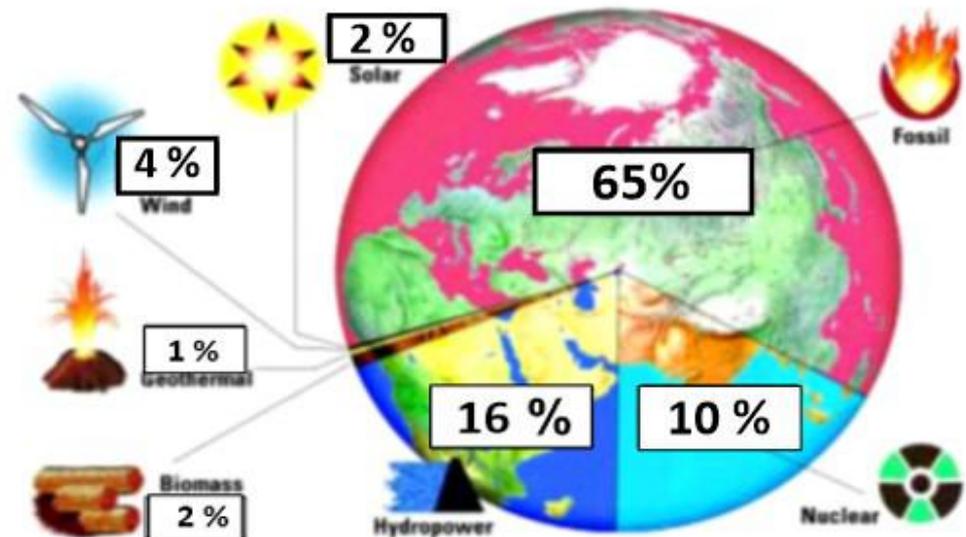


2018. ELECTRICITY GENERATION: 26.614 TWh/y

HYDROPOWER: 4.200 TWh/y

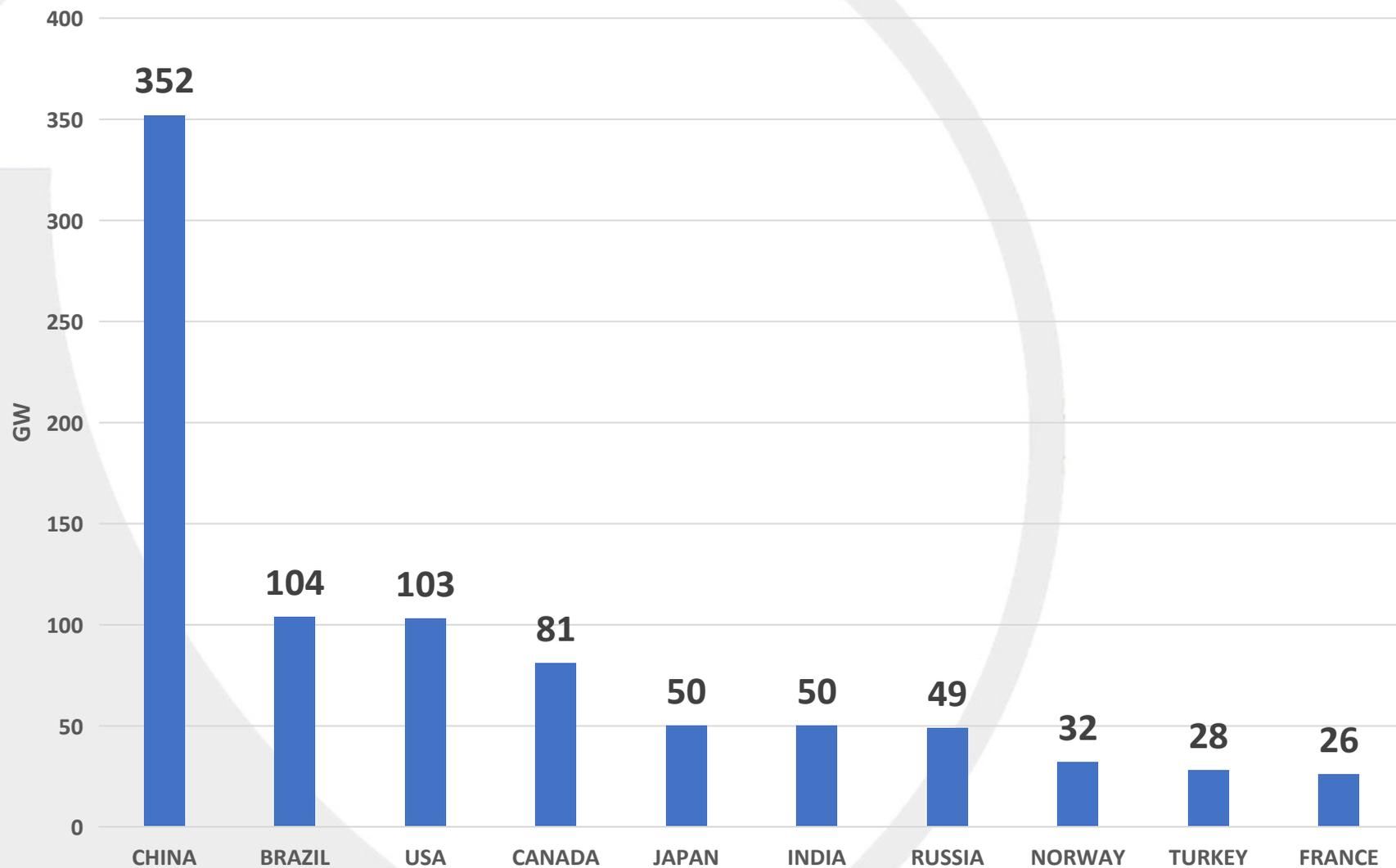
≈ 16% ELECTRICITY. 65 % RENEWABLES.

- World hydro **generation** **4.200 TWh/year**
- Hydro **capacity** is **1.292 GW**
- Increase **3 % annual rate**, in the last 5 years.
- **130 GW hydro** under construction, and about **500 GW** planned



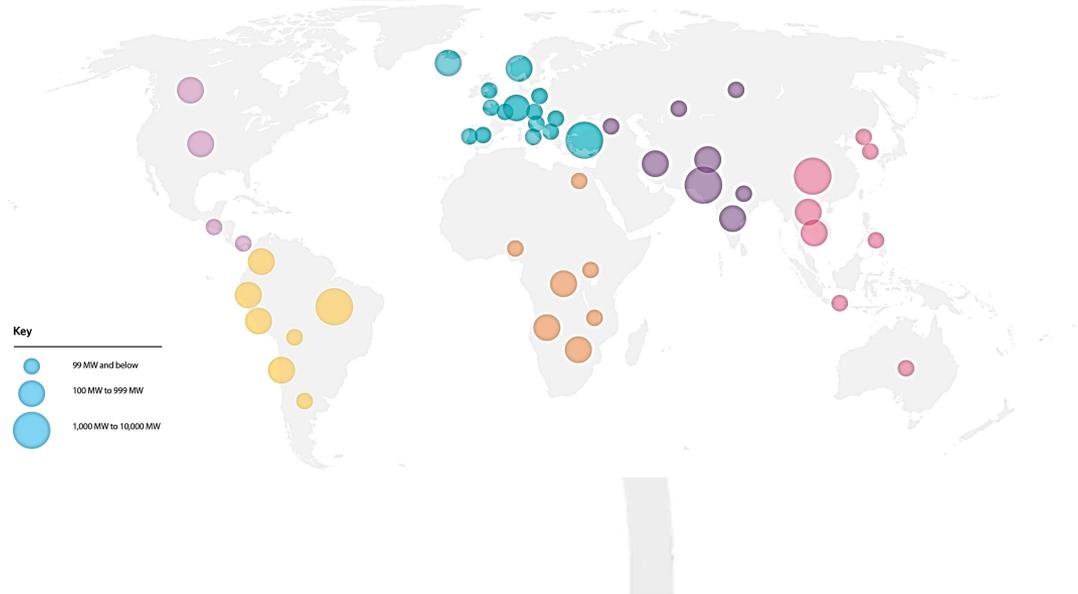


HYDROPOWER. INSTALED CAPACITY GW.2018





2018.HYDROPOWER ADDED CAPACITY. + 22 GW



NEW INSTALLED CAPACITY BY COUNTRY (MW)



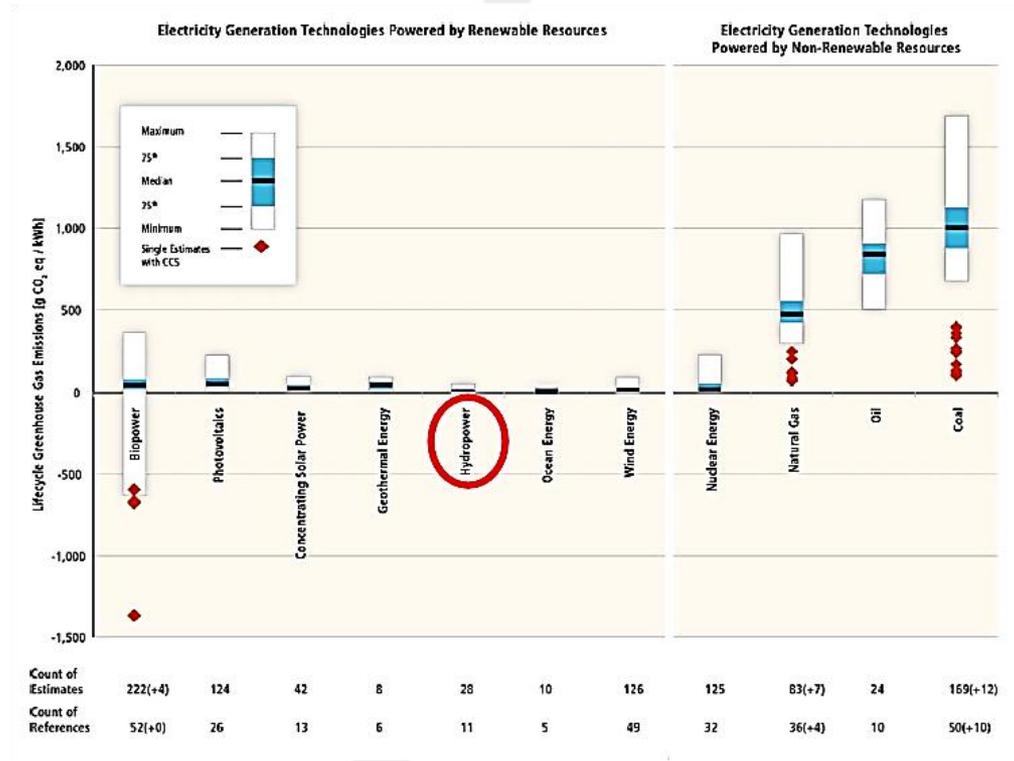


ROLE OF HYDROPOWER IN CC MITIGATION

-PREVENT EMISSION: ≈ 4 Gt CO₂/year.

-10 % OF TOTAL ANNUAL CO₂ EMISSIONS

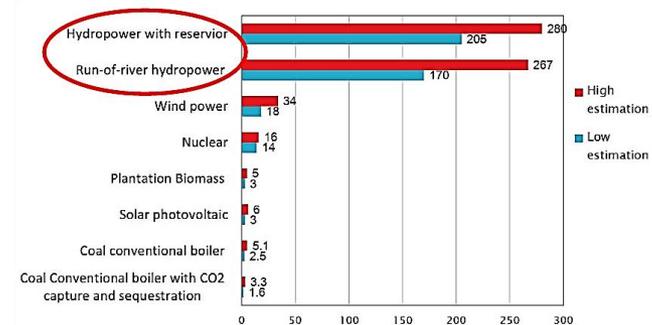
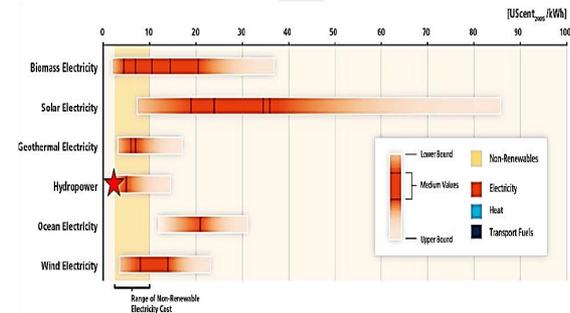
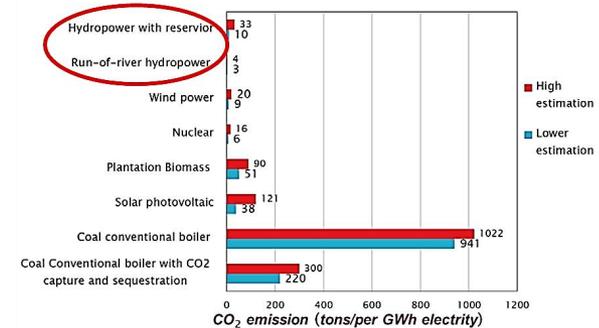
-IN GENERAL, IT IS A SOURCE OF ENERGY PRODUCING FEW GREENHOUSE EMISSIONS





HYDROPOWER ADVANTAJES

- Few CO₂ emissions
- Cheapest RE
- Efficient. Water to wire
- Highest Payback ratio
- Size variety (Small to Big)
- High reliability
- Flexibility

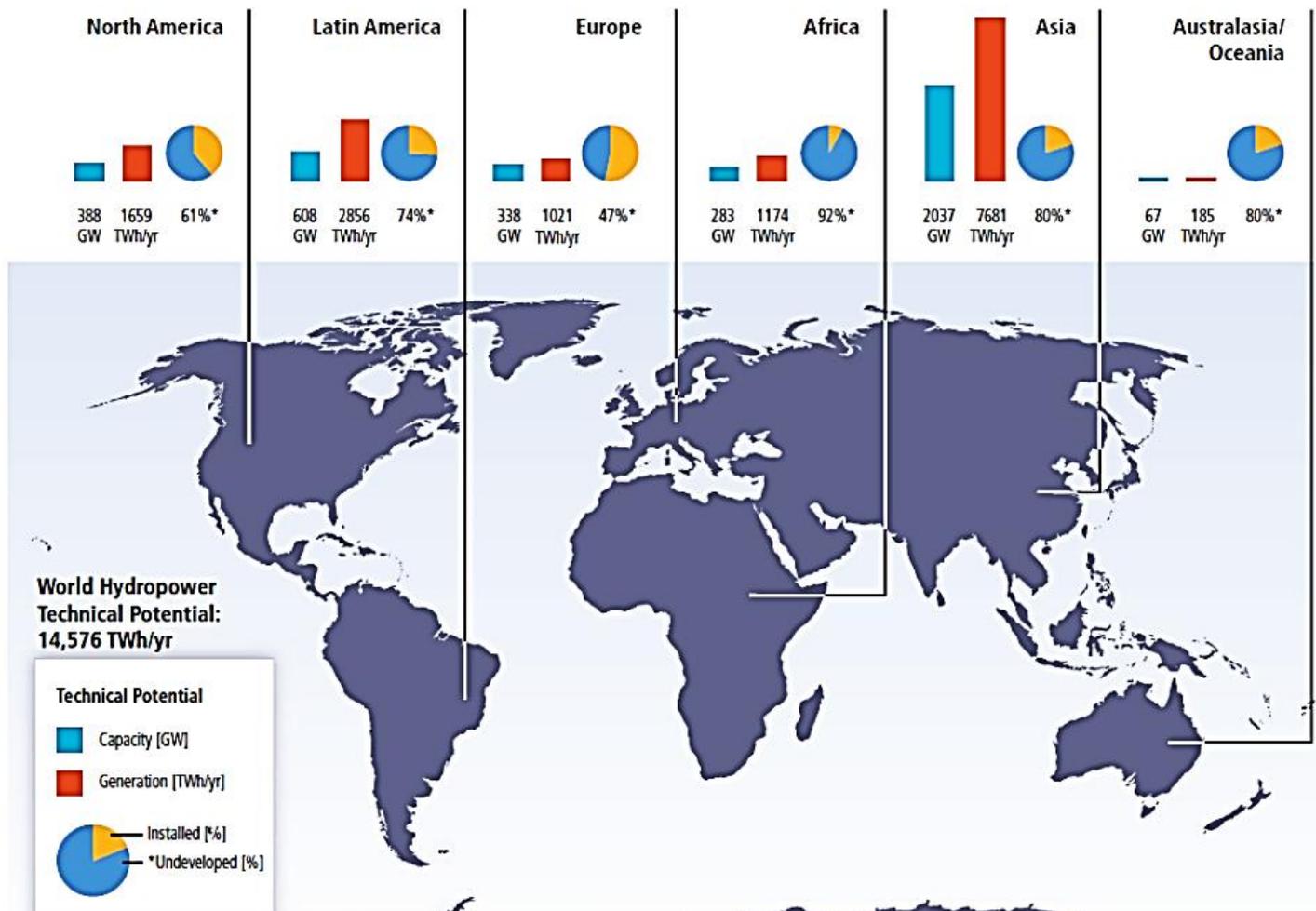




Technically Potential 14.576 TWh/y. 3.721 GW

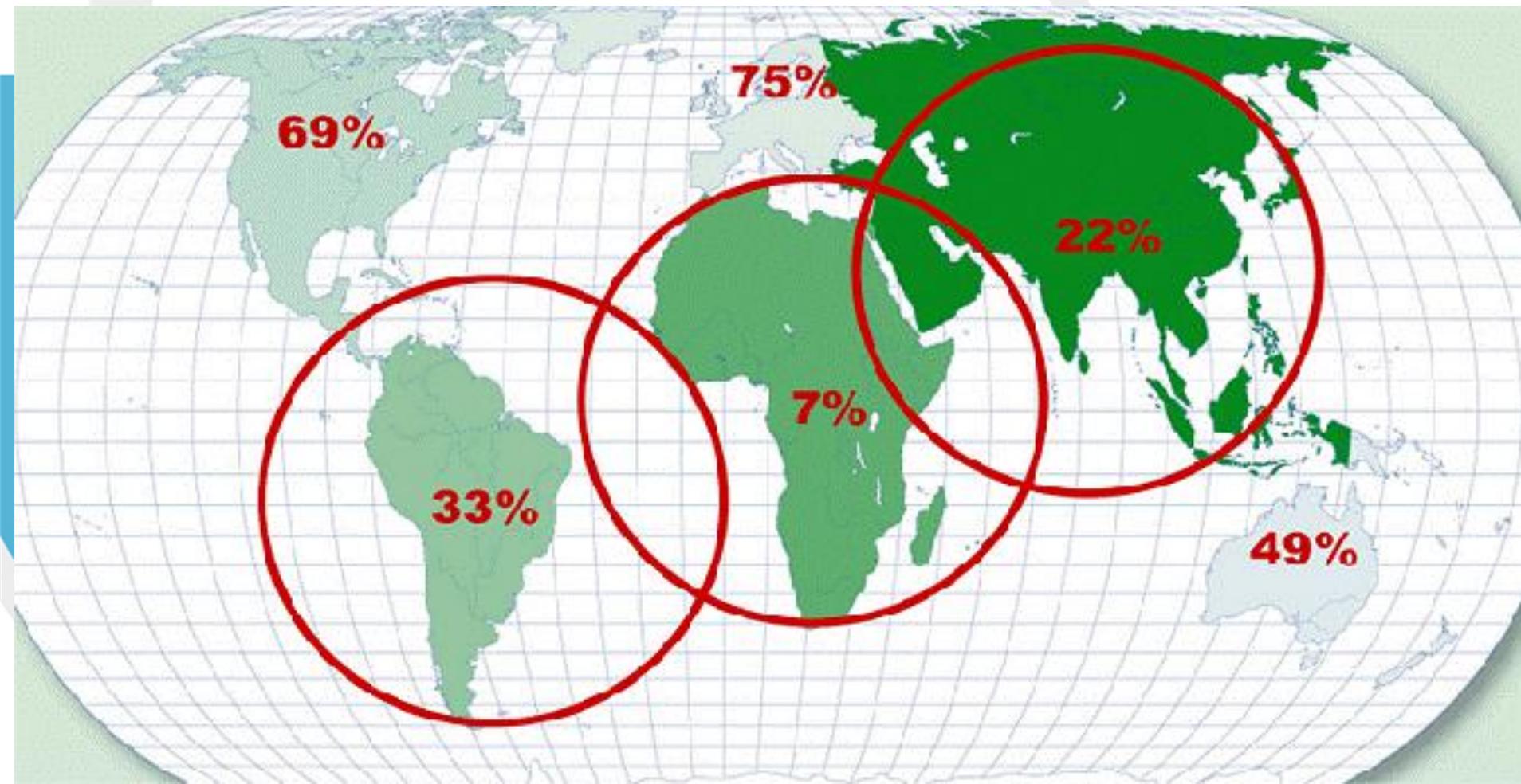
2018. Developed : 4.200 TWh/y. (28%)

IPCC.SREX. 2012



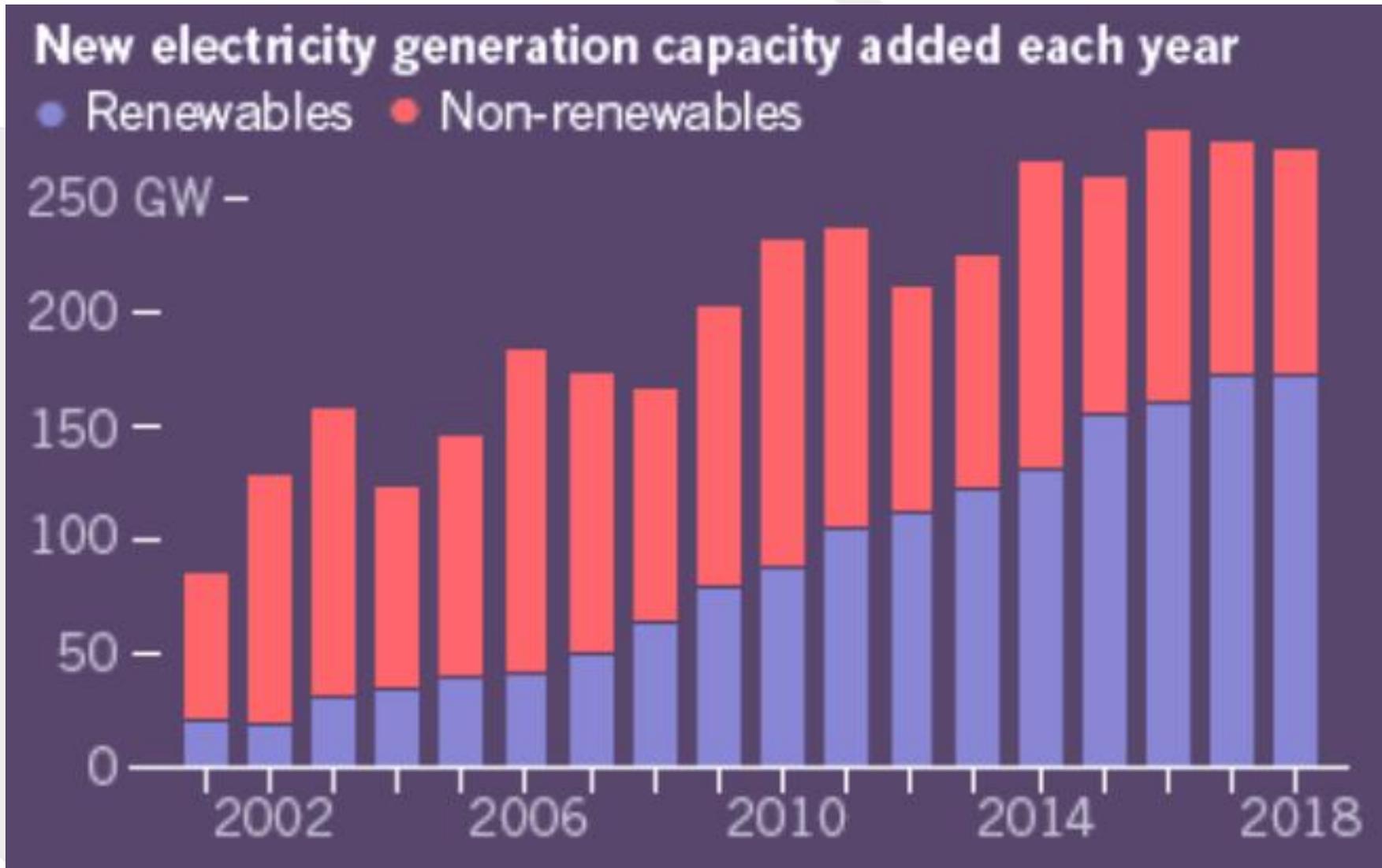


HYDROPOWER DEVELOPED TECHNICAL POTENTIAL





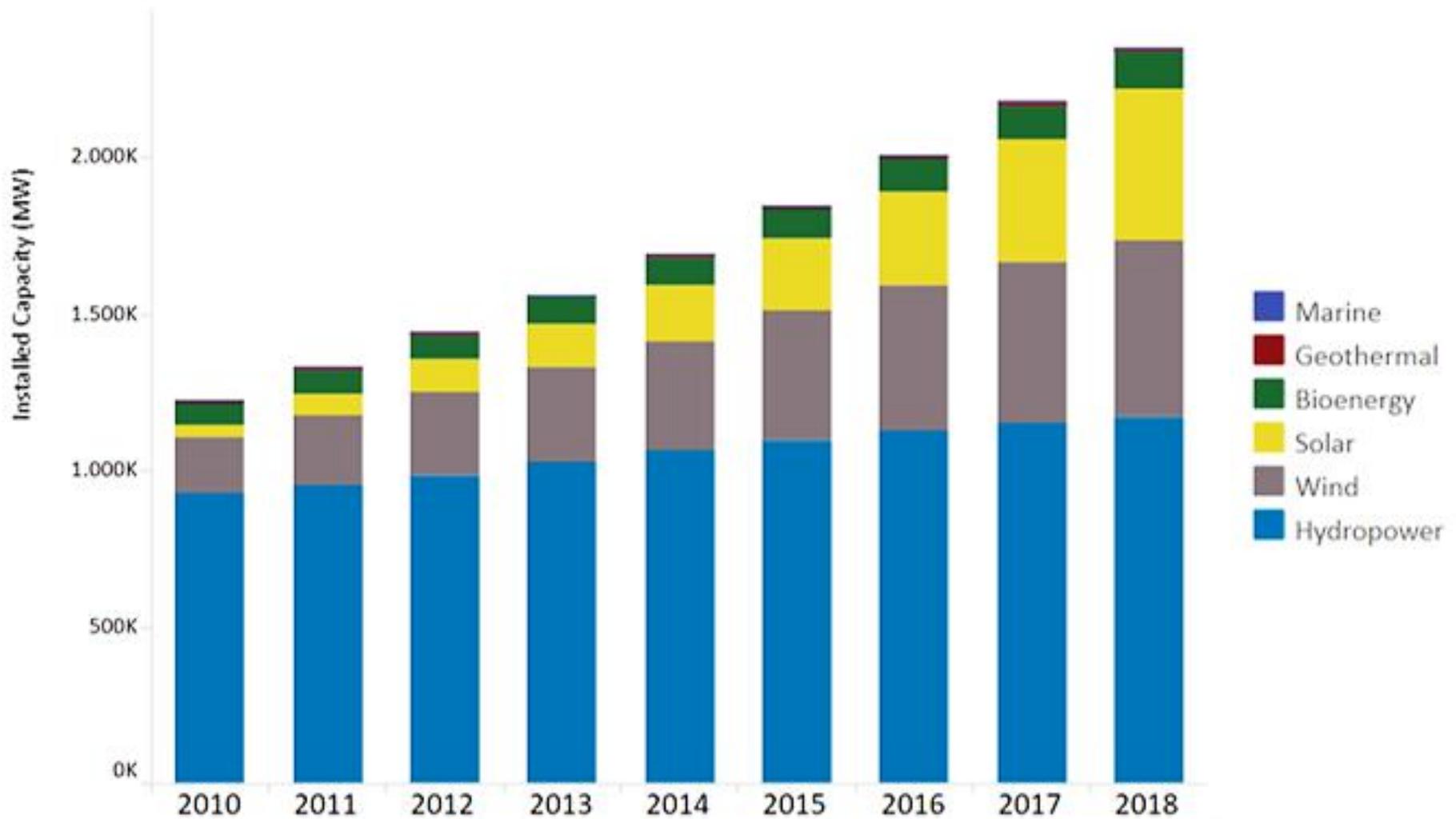
NEW ELECTRICITY GENERATION ADDED EACH YEAR.GW 2001-2018





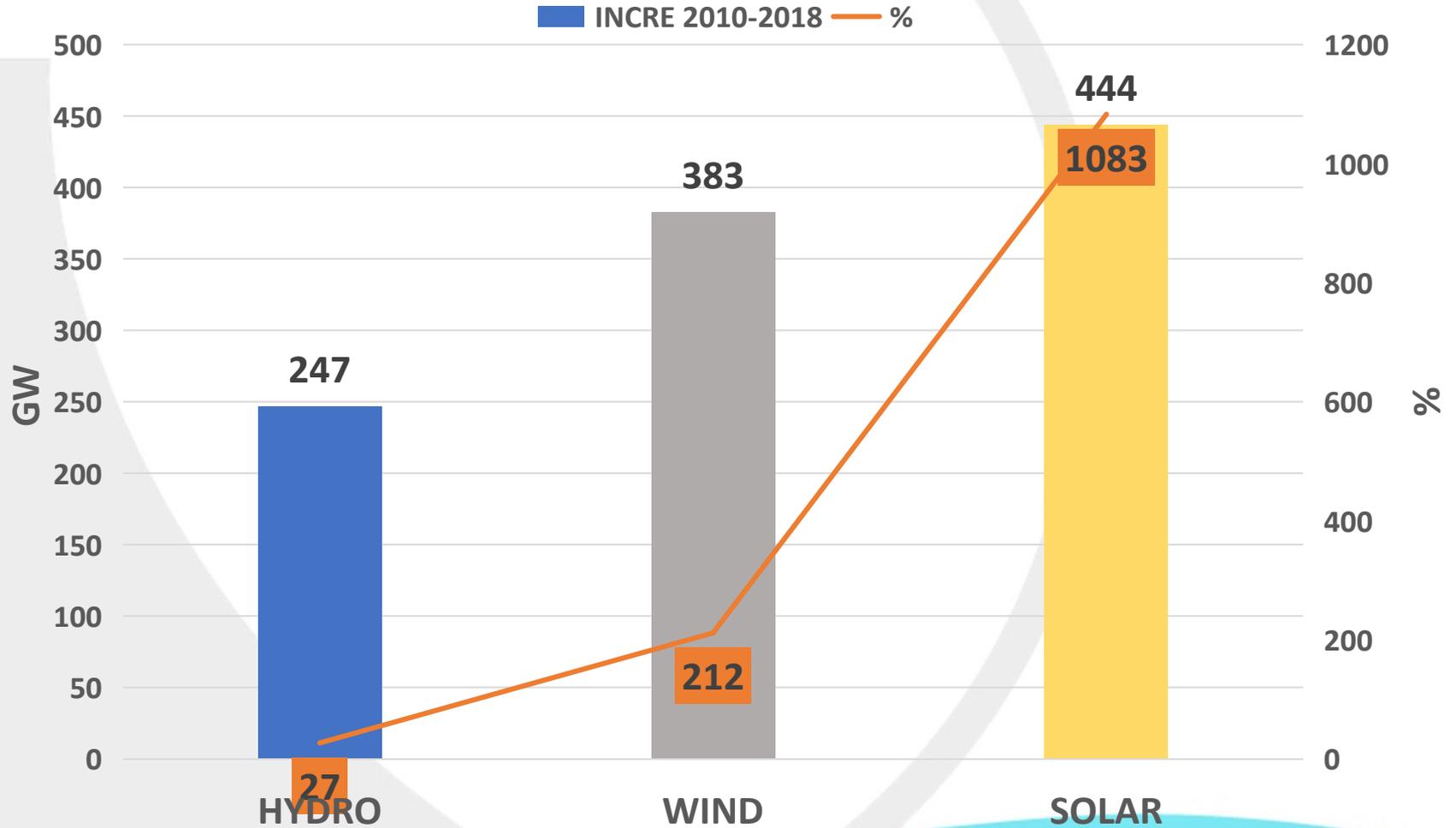
TRENDS RENEWABLE CAPACITY. 2010-2018.

MW





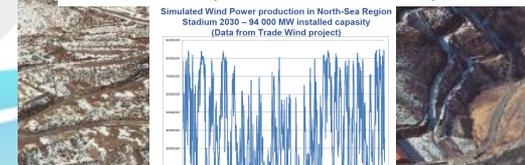
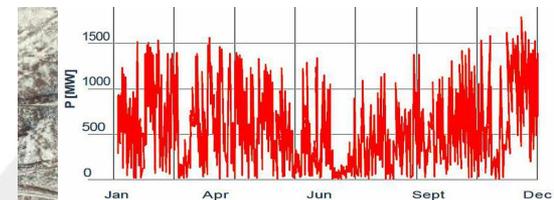
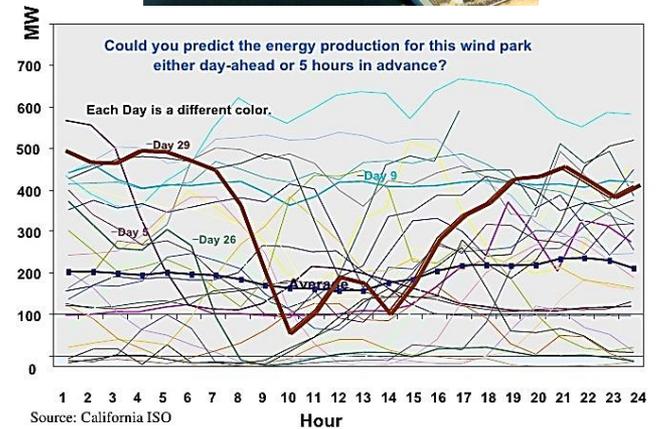
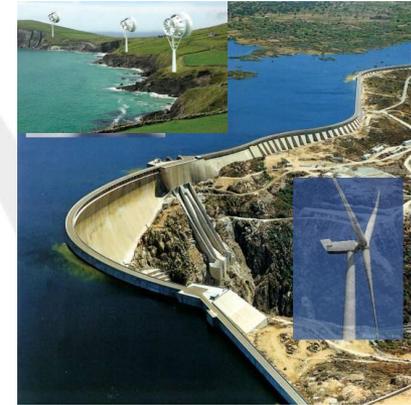
INCREASE RENEWABLE CAPACITY 2010-2018





HYDRO SYNERGIES AND INTEGRATION

- Hydro, wind and solar present important **synergies**, as wind and solar energies are **intermittent** and very variable, while hydropower is able to balance out variability and supply the peak load.
- These three renewable resources should be contemplated in an **integrated way, with a holistic vision, within the future electric mix.**



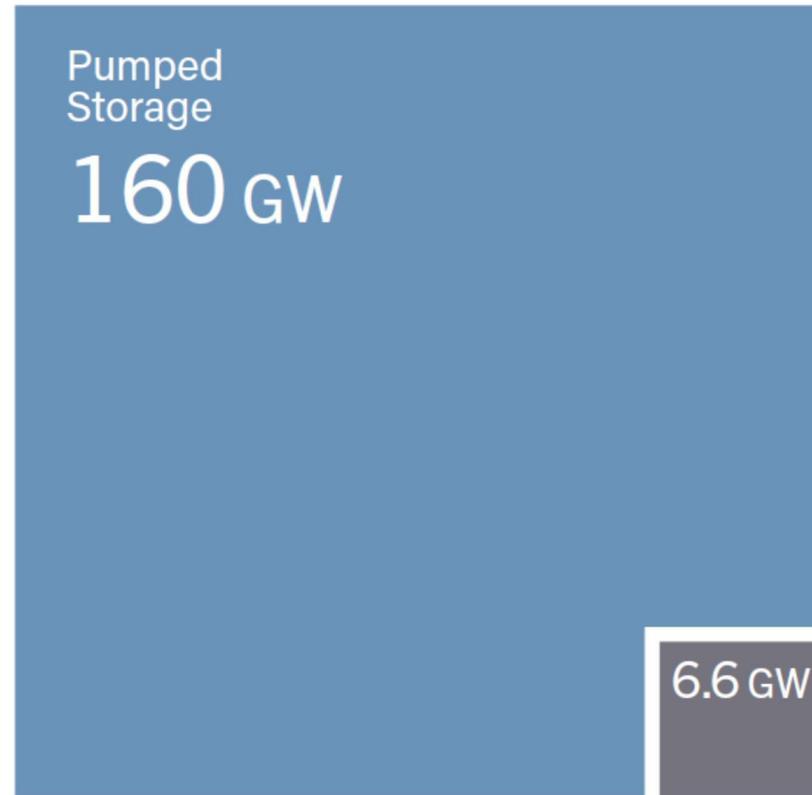


ENERGY STORAGE

PUMPED STORAGE “WATER BATTERY”

An essential and critical component for energy transition

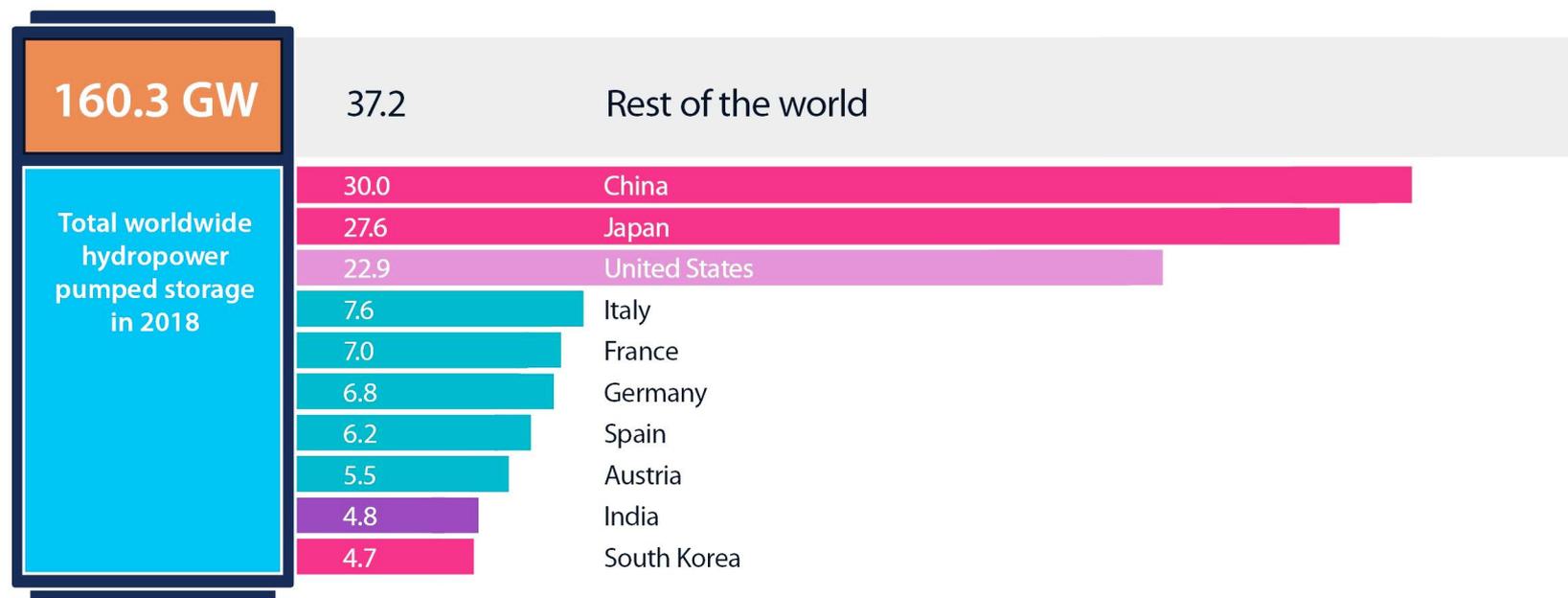
- In addition, hydropower is the only system that currently exists to **store energy in a significant and effective way**, in the form of pumped storage power plants, which make up **95% of global energy storage** in the electricity networks.





PUMPED STORAGE. 160 GW.2018

PUMPED HYDROPOWER STORAGE WORLDWIDE



Pumped hydro power storage capacity (GW) of top 10 countries and rest of the world in 2018.
Source: IHA 2018.



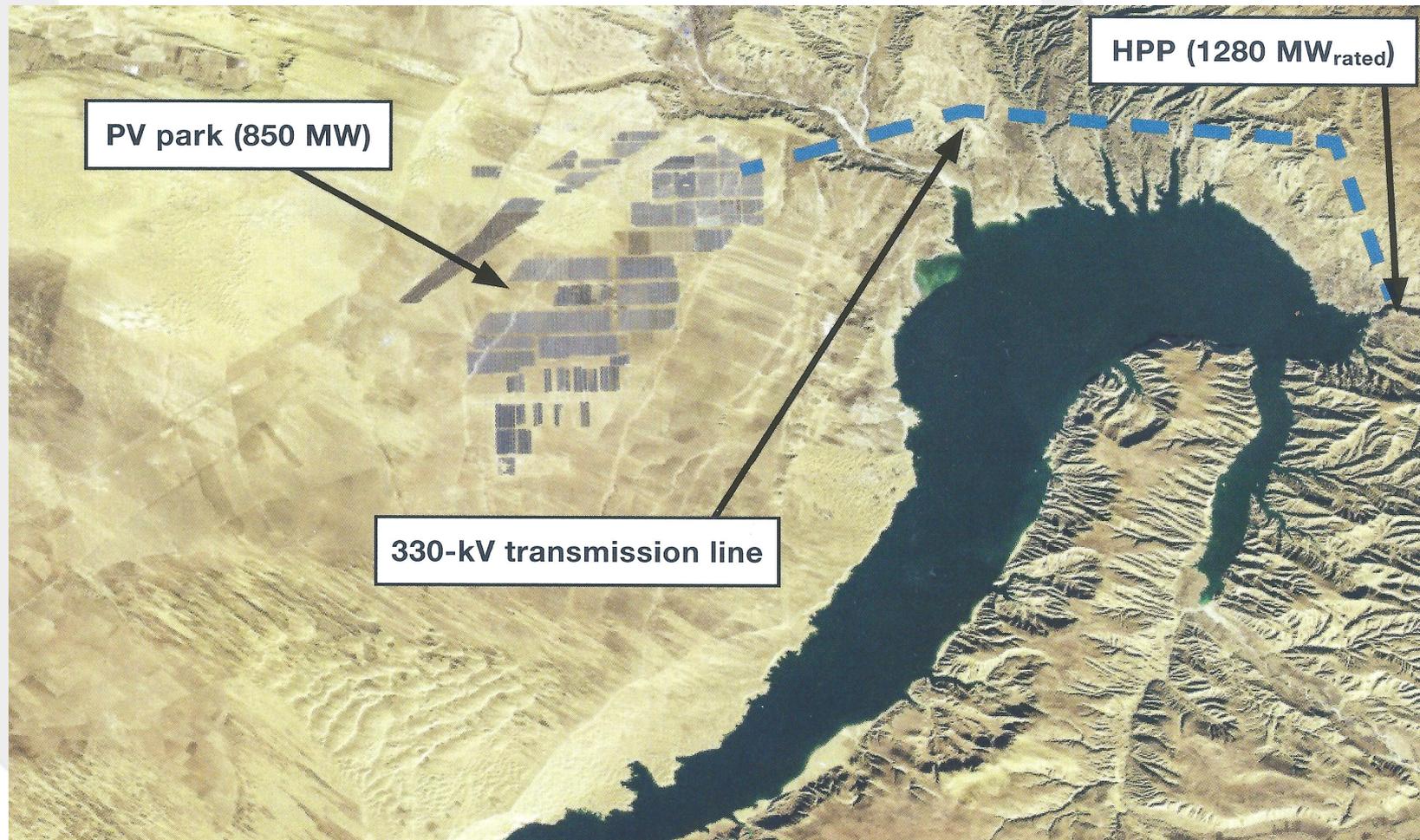
INNOVATIONS

**HYBRID POWER PLANTS
HY-SOLAR AND /OR WIND**

FLOATING SOLAR PV



Longyangxia upper yellow river .China Hybrid : HPP and PV photovoltaics 1st world large scale HPP and large solar





LONGYANGXIA SOLAR-HYDRO UPPER YELLOW RIVER .CHINA.

Hybrid : HPP and PV photovoltaics. 1st world large scale HPP and large solar

It became the largest in the world when the second phase was connected in 2014 by China Power Investment

HPP. **Arch gravity. Height : 178 m.**

Reservoir storage 24.7 billion m³

Reservoir area 383 Km².

Multipurpose dam: Hydro, irrigation, flood and ice control. Operation 1992. Visit 1987, under construction.

The power plant has 4 single 320 MW units, the **total installed capacity is 1.280 MW**. The annual energy output is 6 TWh. First in hydro cascade upper yellow river.





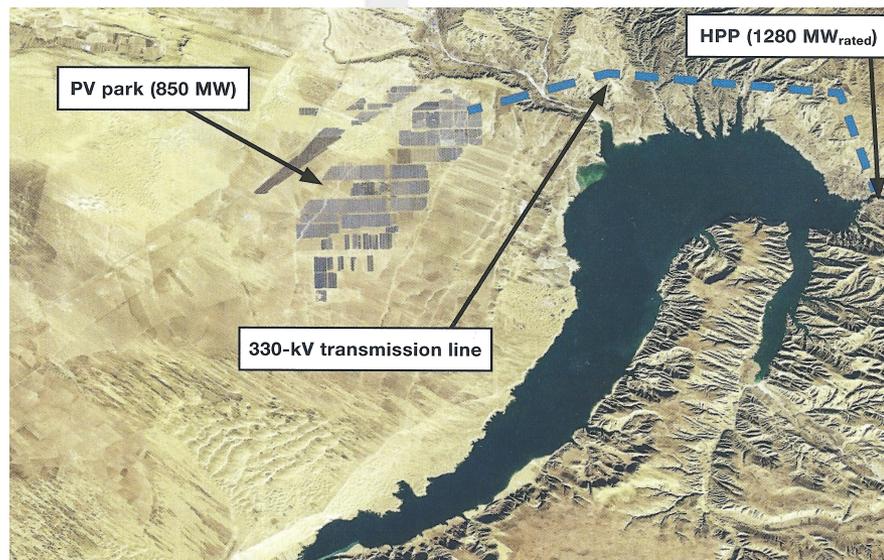
LONGYANGXIA UPPER YELLOW RIVER .CHINA.

HYBRID : HPP and PV photovoltaics. 1st world large scale HPP and large solar

PV. 2015. **850 MW**. One of the largest photovoltaic power stations in the world 4 million solar panels. . **27 Km²**

Electricity transferred 330 KV transmission line to the HPP.

The **park is coupled to one of the hydroelectric turbines**, which automatically regulate the output to balance the variable generation from solar before dispatching power to the grid. **Cheap battery for electricity PV**



FLOATING SOLAR PV

Hydropower reservoirs has a potential to **host 4,400 GW of floating photovoltaic (PV)**



Megawatts

1,500

Annual additions

Previous year's capacity

1,200

900

600

300

0

2014

2015

2016

2017

2018

11

68

169

678

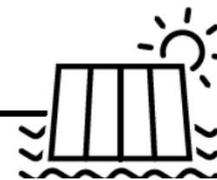
Installed capacity
1,314 Megawatts

73%
China

16%
Japan

6%
Republic
of Korea

Chinese Taipei 2%
United Kingdom 1%
Others 2%

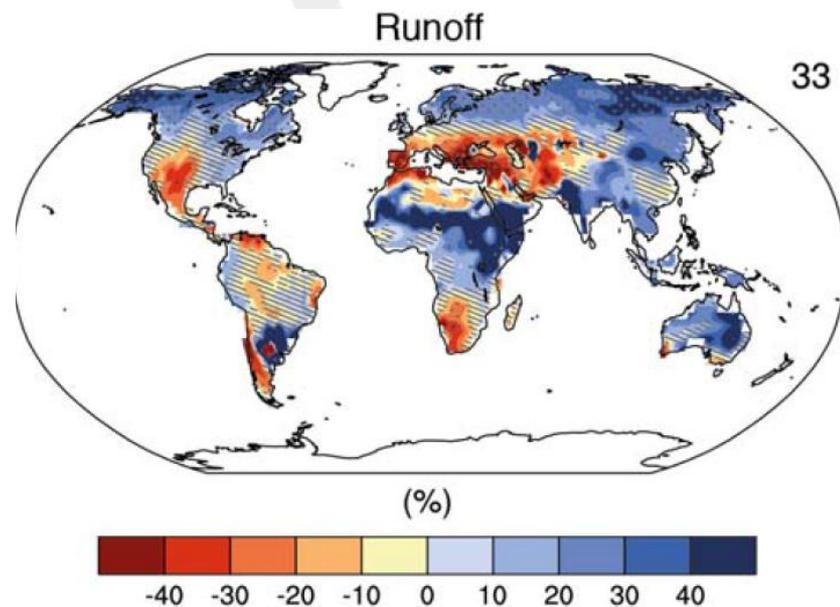




WATER RESOURCES

PROJECTED CHANGES.IPCC AR 5. 2014

- MAJOR TIME **IRREGULARITY**
- **UNEVEN GEOGRAPHICAL DISTRIBUTION ON WATER RESOURCES**
- INCREASING THE CURRENT TEMPORAL VARIABILITY AND THE STRESS ON WATER RESOURCES

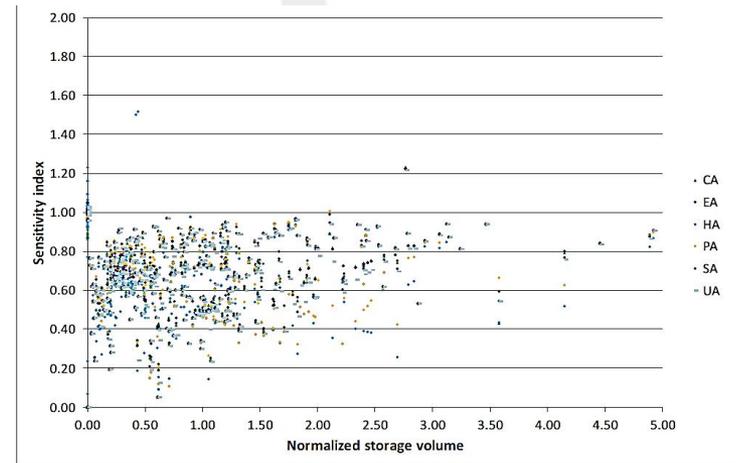




STORAGE AND AVAILABILITY OF WATER RESOURCES

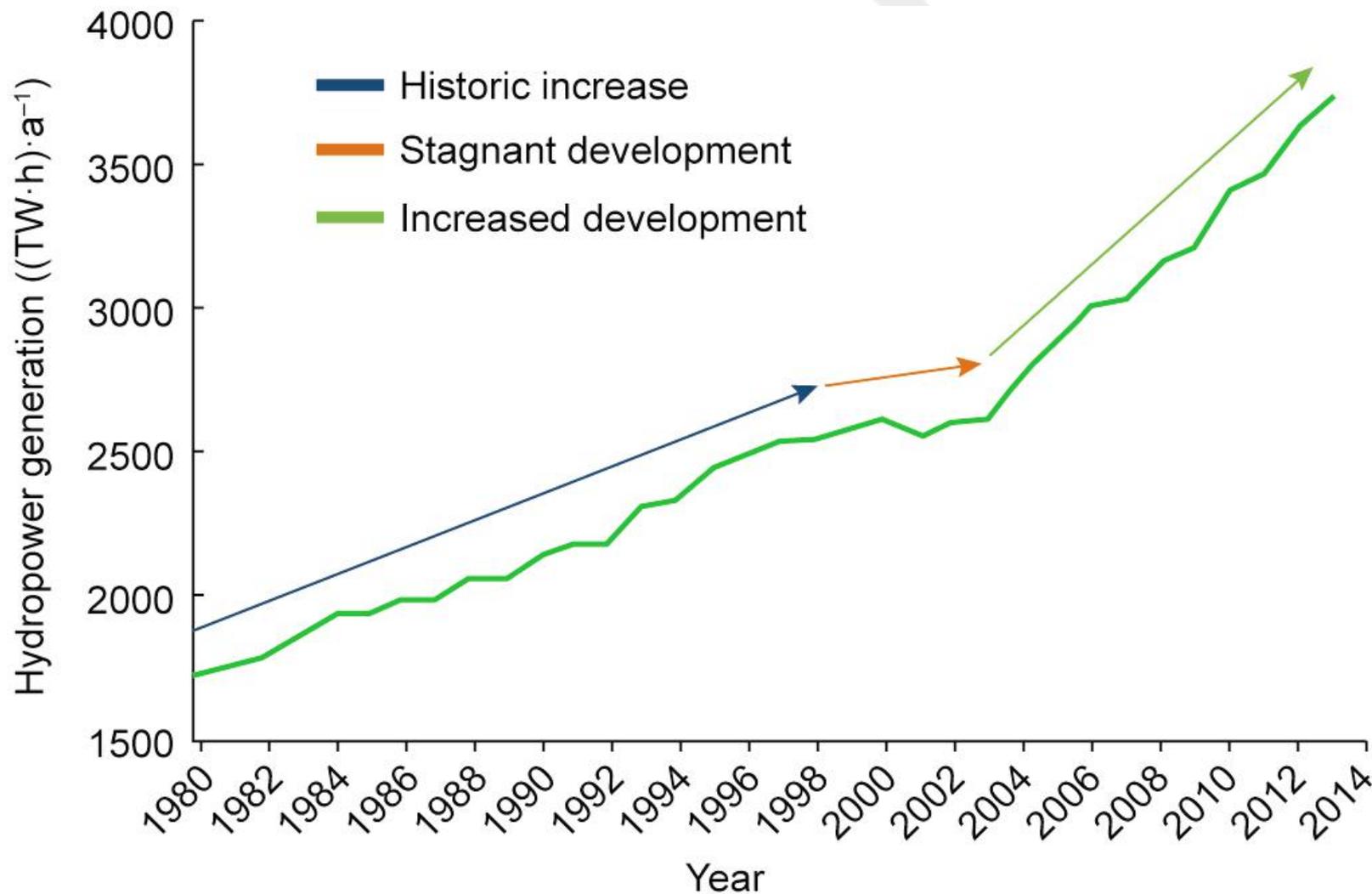
BASINS WITH HIGH STORAGE CAPACITY:

- MORE **RESILIENT** TO WATER RESOURCE CHANGES
- LESS **VULNERABLE** TO CLIMATE CHANGE
- STORAGE ACTS AS A **BUFFER** AGAINST CLIMATE CHANGE.





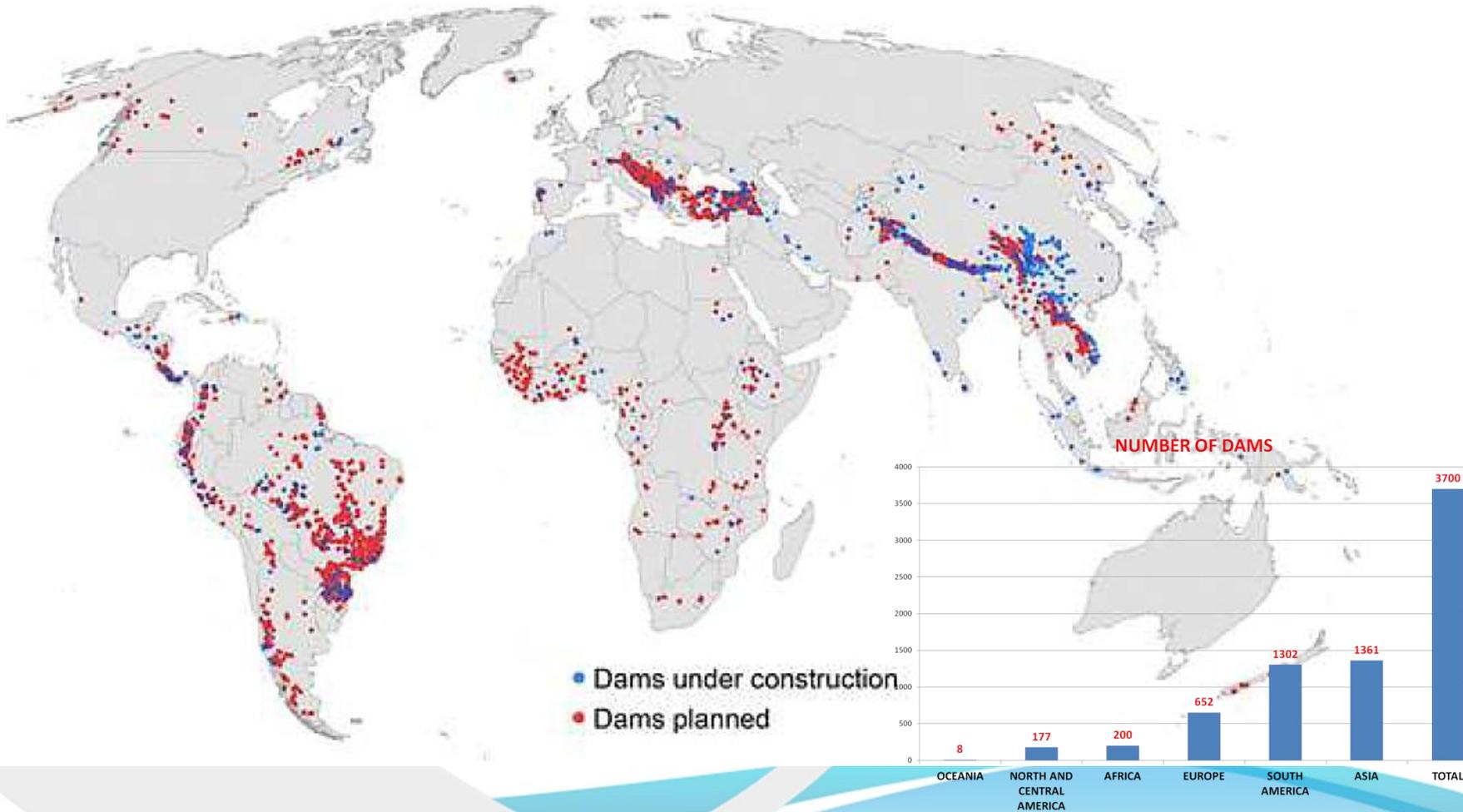
TRENDS IN HYDROPOWER DEVELOPMENT





PROJECTION OF THE NUMBER OF HYDROPOWER >1 MW 2030

Total 3.700 (102 Countries). U.C.= 629(17%) + P= 3071 (83%)





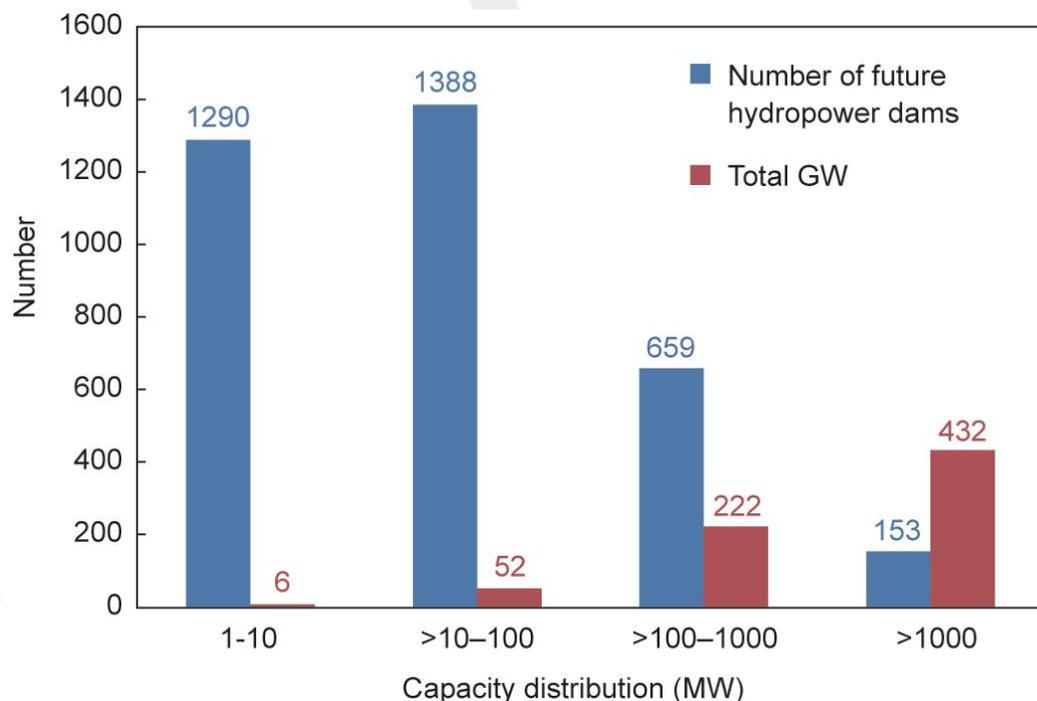
HYDROPOWER >1 MW . 2030

The total new installed capacity of these hydropower projects will reach about **700 GW**.

The small and medium sized (1–100MW) projects are greater in number > 76%)

92% of the capacity will be in 812 large (> 100 MW) projects.

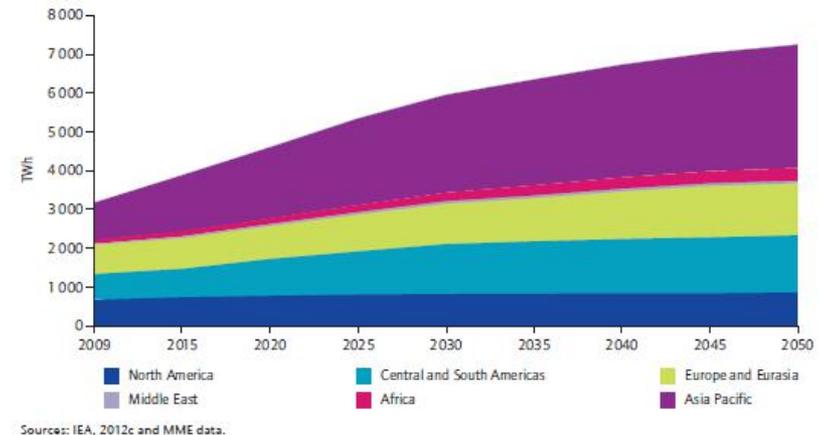
- Investments about **2000 B\$**



TRENDS IN HYDROPOWER

- **IEA.** HYDROPOWER ROADMAP 2012.
× 1.7 (2030). × 2 (2050)
- **IRENA.** REMAP 2030
Doubling the Global Share of Renewable Energy. A Roadmap to 2030. To achieve the SE4ALL targets, increase × 2.2 from 2010 to 2030.
- **2030. INCREASE OF MORE THAN 1.200 GW.**

Figure 10: Hydroelectricity generation till 2050 in the Hydropower Roadmap vision (TWh)





2015-2030

17 GOALS. 169 TARGETS



SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD

1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



5 GENDER EQUALITY



6 CLEAN WATER AND SANITATION



7 AFFORDABLE AND CLEAN ENERGY



8 DECENT WORK AND ECONOMIC GROWTH



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



10 REDUCED INEQUALITIES



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



14 LIFE BELOW WATER



15 LIFE ON LAND



16 PEACE, JUSTICE AND STRONG INSTITUTIONS



17 PARTNERSHIPS FOR THE GOALS



SUSTAINABLE DEVELOPMENT GOALS



SDG: FOOD, WATER, ENERGY, CLIMATE CHANGE

2 NO HUNGER



- **End hunger, achieve food security** and improved nutrition and promote sustainable agriculture

6 CLEAN WATER AND SANITATION



- Ensure availability and sustainable management of **water and sanitation for all**

7 AFFORDABLE AND CLEAN ENERGY



- Ensure access to affordable, reliable, sustainable and modern **energy for all**

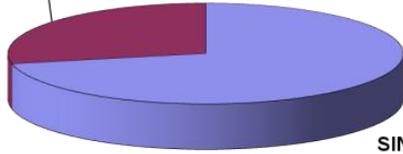
13 CLIMATE ACTION



- Take urgent action **to combat climate change and its impacts**



MULTIPURPOSE;
28,30%



SINGLE
PURPOSE;
71,70%

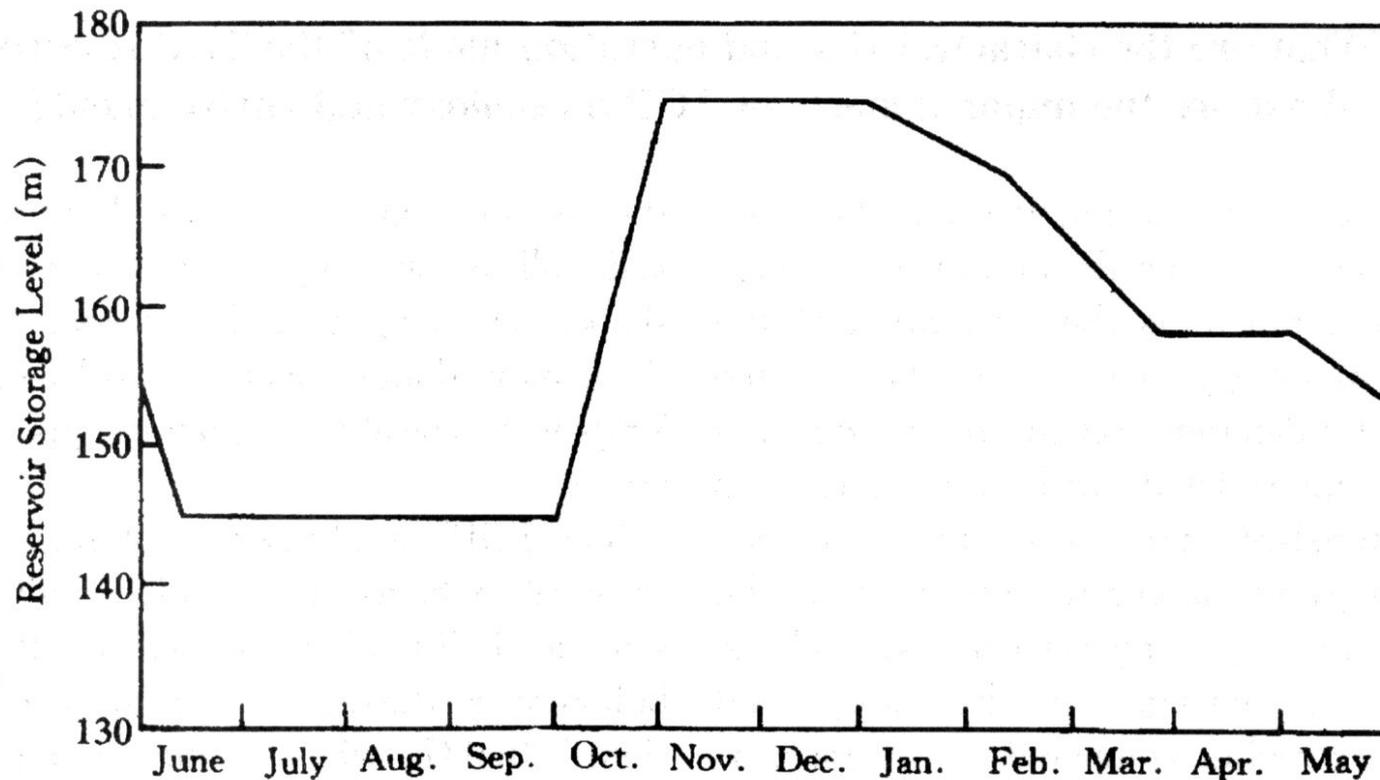
CHALLENGES OF HYDROPOWER AND WATER MULTIPURPOSE STORAGE

- To promote **multipurpose dams** and better planning tools for multipurpose water projects.
- Hydro storage capacity can provide **security** for irrigation, drinking water supply, flood control and navigation services.
- Multipurpose hydropower projects may have an enabling role beyond the electricity sector as **a financing** instrument for multipurpose reservoirs.
- Hydropower storage in multipurpose dams can contribute to **climate change adaptation** of water resources availability, and flood mitigation.



TGD (CHINA) RESERVOIR OPERATION .FLOOD ROUTING

- **FLOOD CONTROL STORAGE: 22.150 Hm³ :**
- **56 % OF THE TOTAL STORAGE**





TGD (CHINA) RESERVOIR OPERATION FLOOD MITIGATION. 2004-2018

Table 3. Statistics showing flood control operation of the TGP reservoir during 2003–2018.

Year	Peak discharge ($\text{m}^3 \cdot \text{s}^{-1}$)	Peak time	Maximum outflow discharge ($\text{m}^3 \cdot \text{s}^{-1}$)	Maximum peak discharge cutting ($\text{m}^3 \cdot \text{s}^{-1}$)	Numbers of flood control operation	Total flood storage volume (billion m^3)	Highest regulating water level (m)
2004	60,500	September 8th	56,800	3,700	1	0.5	137.77
2007	52,500	July 30th	47,400	5,100	1	1.0	146.10
2009	55,000	August 6th	39,600	16,300	2	5.7	152.89
2010	70,000	July 20th	40,900	30,000	7	26.4	161.02
2011	46,500	September 21th	29,100	25,500	5	18.8	153.84
2012	71,200	July 24th	45,800	28,200	4	22.8	163.11
2013	49,000	July 21th	35,300	14,000	5	11.8	156.04
2014	55,000	September 20th	45,000	22,900	10	17.5	164.63
2015	39,000	July 1st	31,000	8,000	3	7.5	156.11
2016	50,000	July 1st	31,000	19,000	3	9.8	158.50
2017	38,000	September 10th	22,900	20,000	3	10.4	157.10
2018	60,000	July 14th	42,000	18,000	3	11.8	156.83
Total	/				47	144.0	/



TGD FLOOD MITIGATION. 2004-2018.

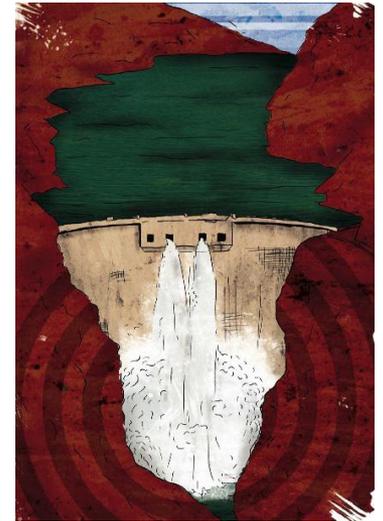
Date	I Inflow m ³ /sec	O Outflow m ³ /sec	REDUCTION I-O/I %	Water level m	FLOOD VOLUME RETENTION Km ³
July 2010	70,000	40,900	42%	161.02	26.4
July 2012	71,200	45,800	36%	163.11	22.8





HYDROPOWER VERDICT

- Cheap and mature technology
- Contributes significantly to climate change mitigation.
- Essential for energy transition
- The only and most effective electricity battery in the networks (“water battery”)
- A key tool for mitigating climate change
- Play an important role in climate change adaptation of water resources availability (Multipurpose projects)
- Roughly more than a terawatt of capacity could be added in the next decades
- Carefull attention and mitigate the substantial social and environmental impacts

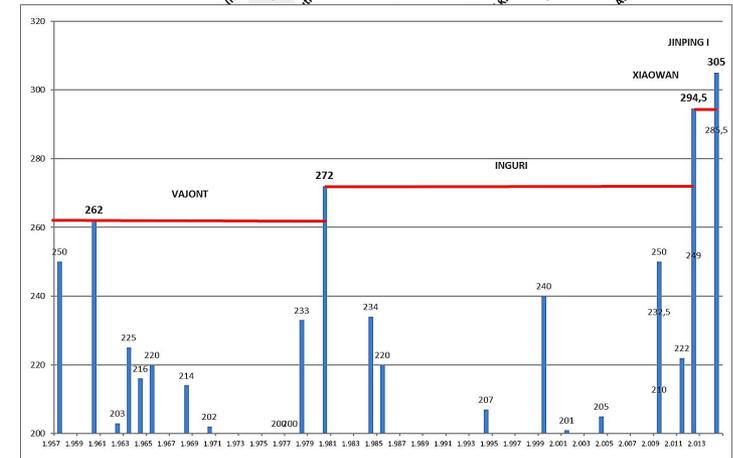
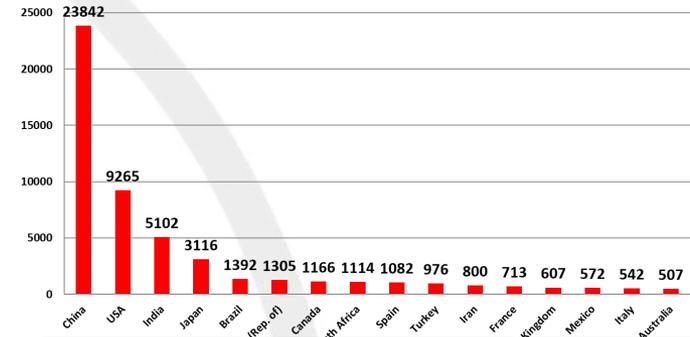




DAMS IN CHINA

- 100.000 dams
- Leader in number of large dams in the world
- Large Dams > 15m 38.000
- Large Dams > 30 m 6.500
- Highest dam in operation in the world
Jinping I (VA): 305 m

16 COUNTRIES WITH MORE THAN 500 LARGE DAMS





HYDROPOWER IN CHINA

- The world's **leading producer of hydropower**

1.233 TWh/year

- The first country in installed capacity

352 GW

- The **largest hydropower plant in the world**

Three Gorges

22.500 MW

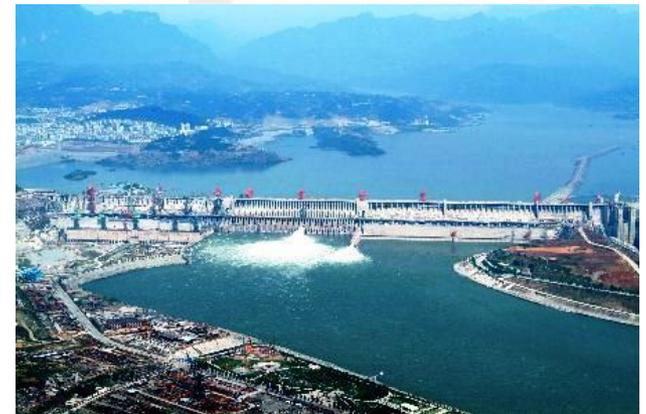
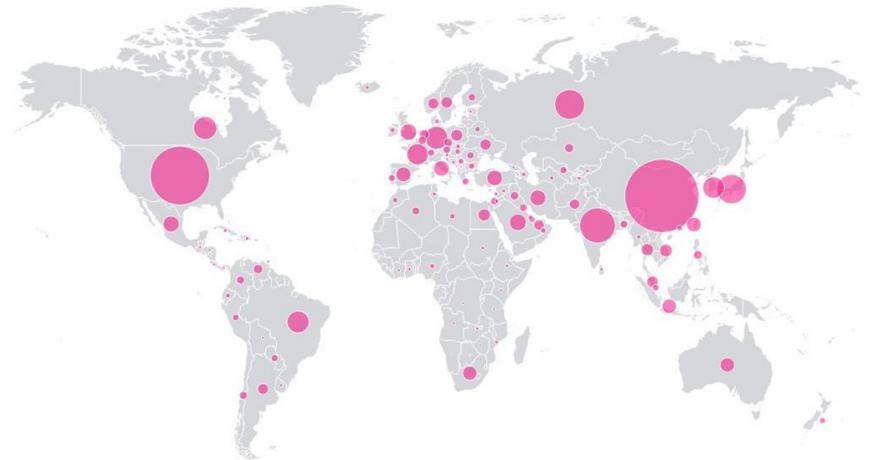


Table 3

Top 10 projects with the largest installed capacity in the world.

Rank	Dam name	Country	Dam type	Dam height (m)	Total storage capacity ($\times 10^8 \text{ m}^3$)	Installed capacity (MW)	Year of completion
1	Three Gorges	China	Gravity dam	181.0	450.50	22 500	2010
2	Itaipu	Brazil/Paraguay	Gravity dam	196.0	290.00	14 000	1991
3	Xiluodu	China	Arch dam	285.5	126.70	13 860	2014
4	Guri	Venezuela	Gravity dam	162.0	1350.00	10 235	1986
5	Tucuruí	Brazil	Earth-rock dam	98.0	455.40	8 370	2002
6	Sayano-Shushenskaya	Russia	Arch dam	245.0	313.00	6 400	1989
7	Yiangjaba	China	Gravity dam	163.0	51.62	6 400	2015



COMMISSION INTERNATIONALE
DES GRANDS BARRAGES

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HYDROPOWER CHALLENGES FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

