



WORLD  
METEOROLOGICAL  
ORGANIZATION

# The increased vulnerability of the energy sector in a changing climate

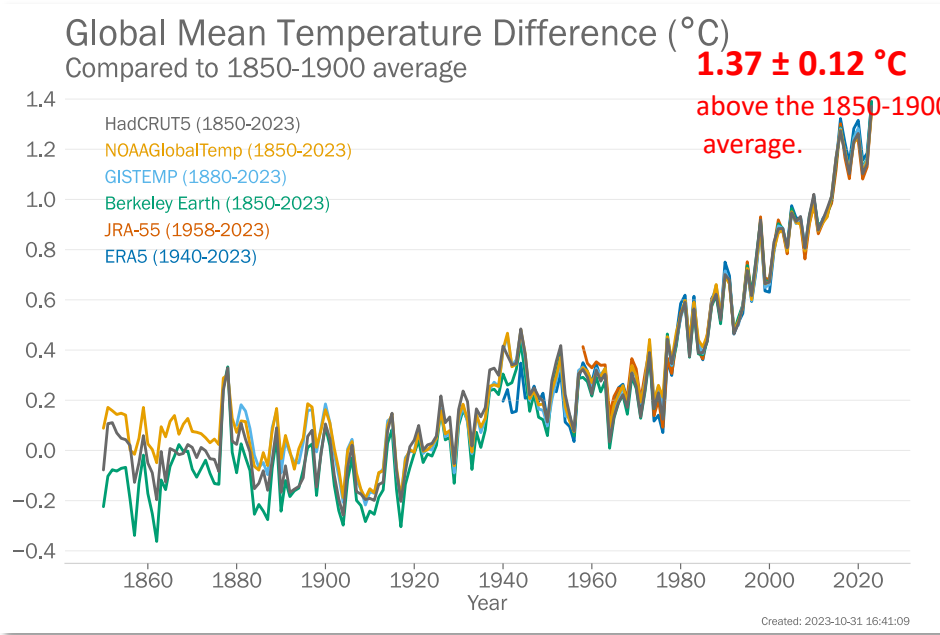
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**World Meteorological Organization (WMO)**

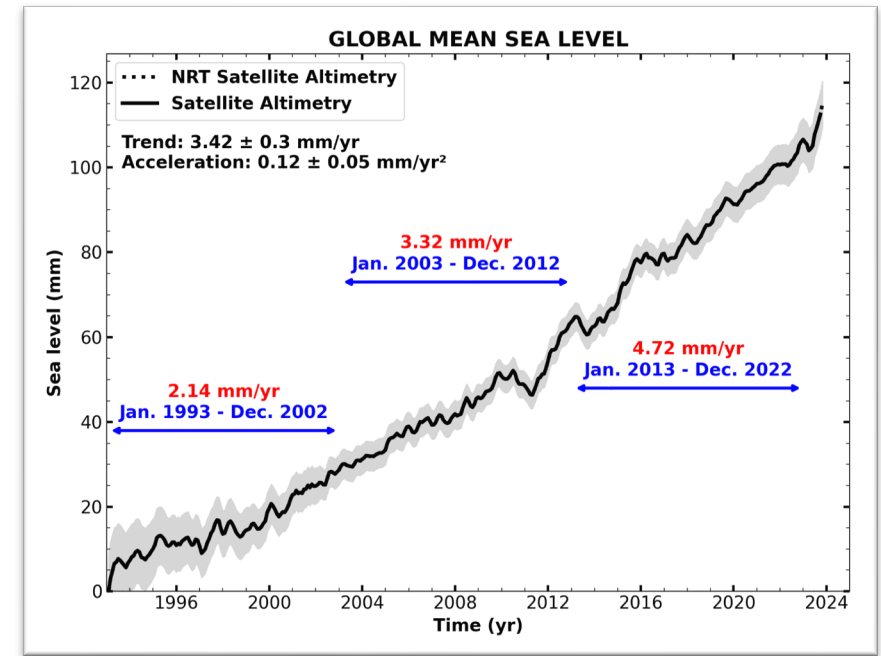
*Convention of the Protection and Use of  
Transboundary Watercourses and International Lakes  
Task Force on the Water-Food-Energy-Ecosystems Nexus, 8th meeting  
Geneva, Switzerland, 7-8 December 2023*



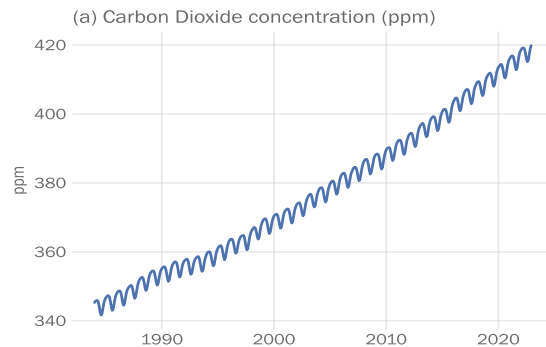
# Climate Indicators 2023



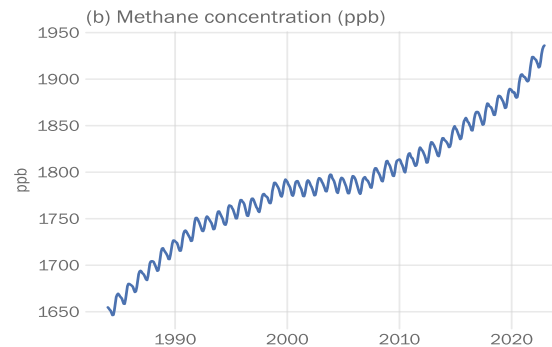
**It is virtually certain that 2023 will be the warmest year on record.**



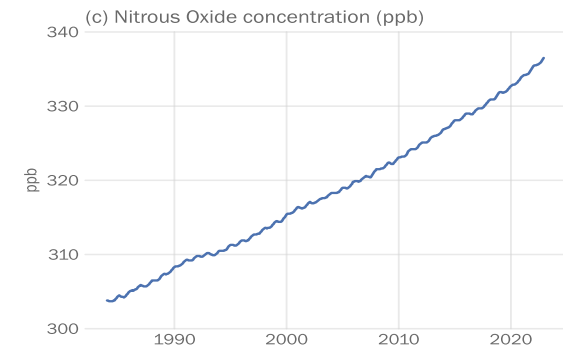
- Ocean heat content and sea level rise both reached record highs. The rate of sea level rise in the current decade is more than double from the first decade of the satellite record.



**Carbon dioxide**  
 $417.9 \pm 0.2$  ppm  
 150% of pre-industrial



**Methane**  
 $1923 \pm 2$  ppb  
 266% of pre-industrial



**Nitrous oxide**  
 $335.8 \pm 0.1$  ppb  
 124% of pre-industrial

**Dry conditions  
and extensive  
wildfires across  
Canada**

**Very wet winter  
and spring**

**Widespread dry  
conditions**

**4<sup>th</sup> successive  
dry year in some  
regions**

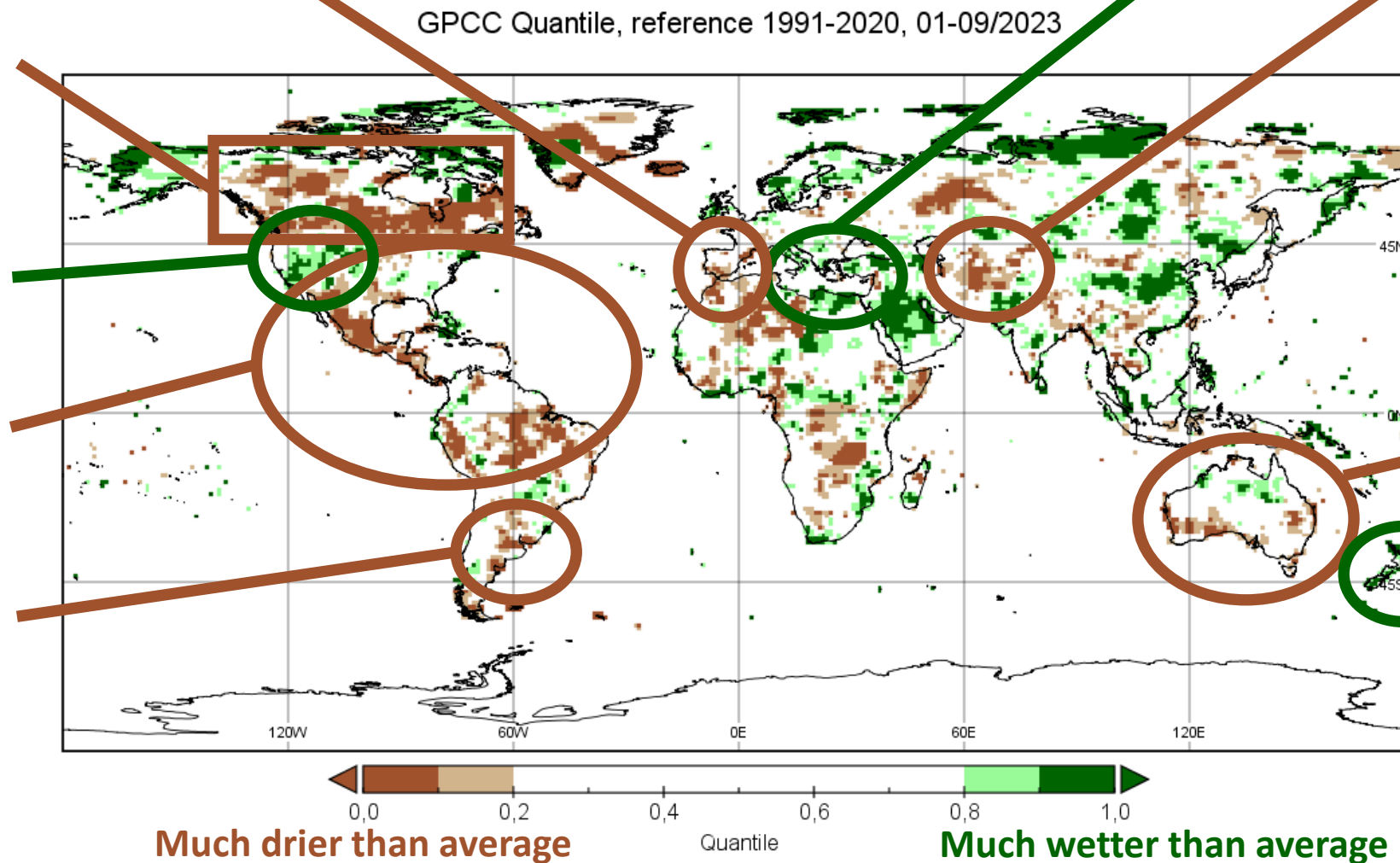
**Continued  
drought**

**Storm Daniel.  
Flooding in Italy,  
Croatia, Slovenia**

**multi-year  
drought**

**September  
driest month  
on record**

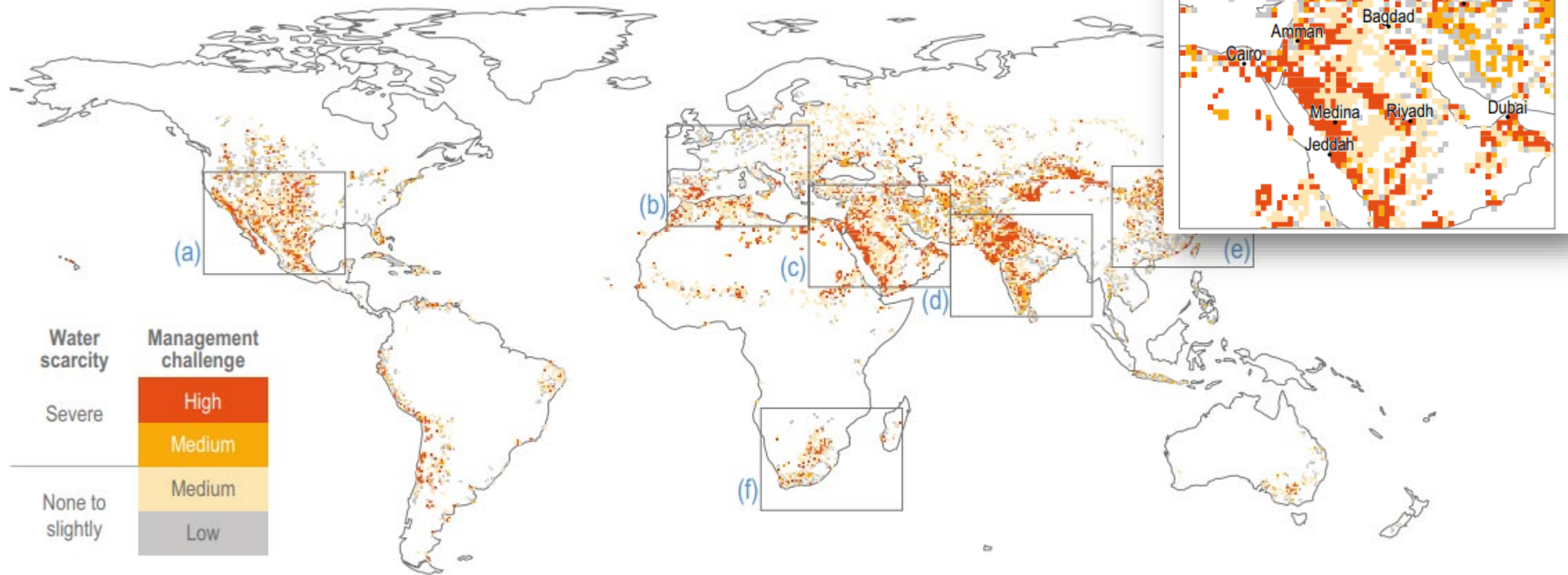
**New Zealand  
extreme rain  
and flooding Jan  
and Feb**





# Drought Projection by 2050 - IPCC

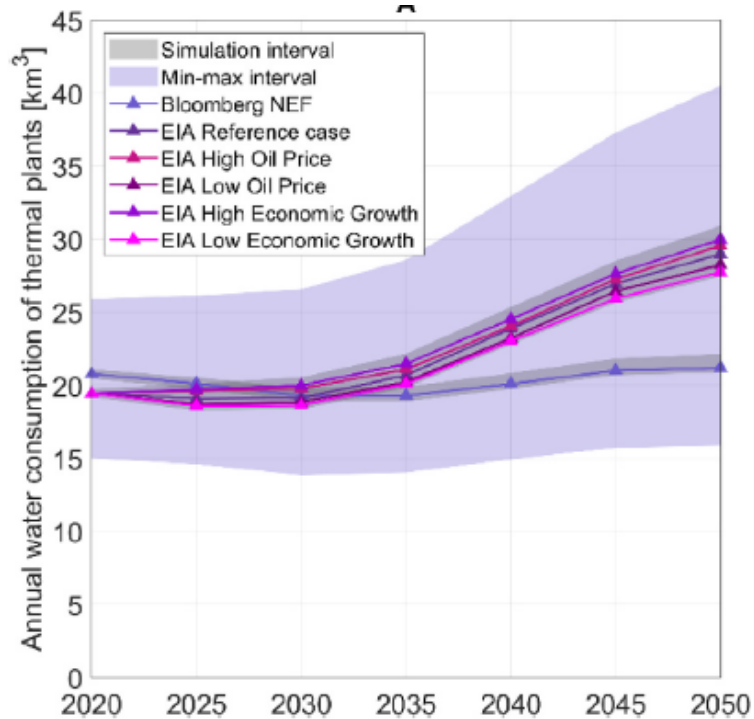
Drought is exacerbating water management challenges which vary across regions with respect to anticipated water scarcity conditions by 2050



Zoomed-in map segments of six most affected regions of differing management challenges with respect to anticipated water scarcity conditions by 2050.

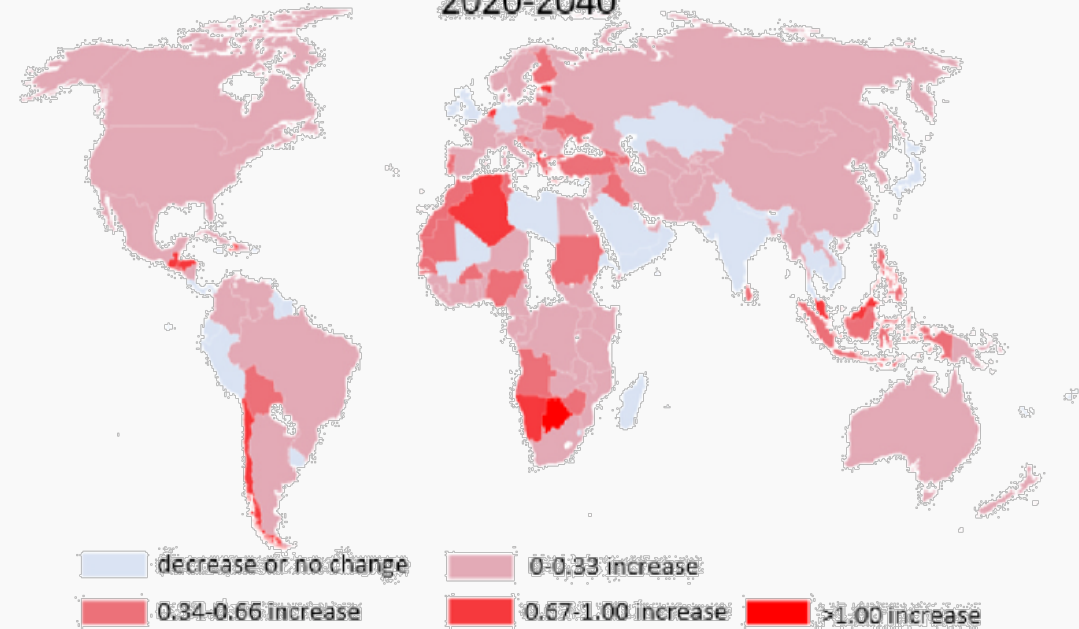
# water footprint in thermal power plants

## Projections of annual water consumption of thermal power plants globally



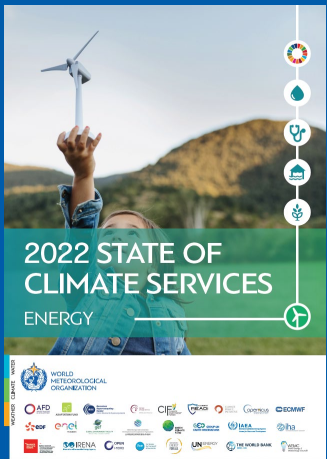
Journal Article:  
**Troubled waters: Estimating the role of the power sector in future water scarcity crises,**  
 Journal Energy, 2023  
<https://doi.org/10.1016/j.energy.2023.128820>

## H: Projected increase (absolute) in water stress score in 2020-2040



- the water stress level is projected to worsen in most countries around the globe by 2040.
- For some countries (for instance, Saudi Arabia, Oman, Yemen, Libya, Kazakhstan, etc.), the water stress score remains unchanged due to the fact that these countries are already facing the highest level of water stress.
- **Water consumption of thermal power sector compared to the 2020 level is projected to increase by 130% by 2040 in Turkey, by 61% in Pakistan and by 84% in India.**

# Climate Change Impacts on the Energy sector



- In 2020, **87% of global electricity generated from thermal, nuclear and hydroelectric systems** directly depended on water availability;
- Meanwhile, **33% of the thermal power plants** that rely on freshwater availability for cooling are already located in **high water stress areas**;
- **15% of existing nuclear power plants are located in high water stress areas.** The share expected to increase to 25% in the next 20 years;

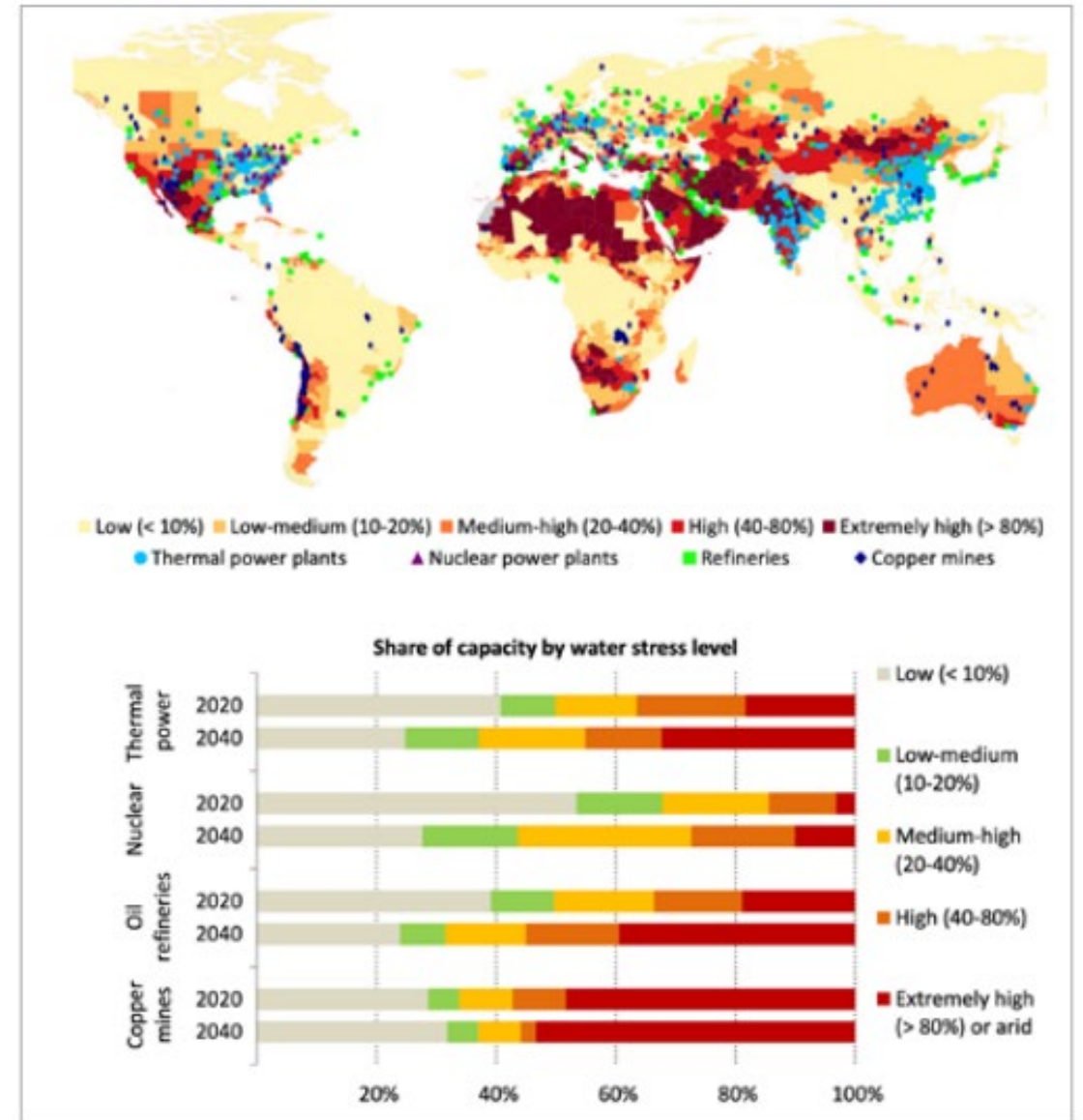
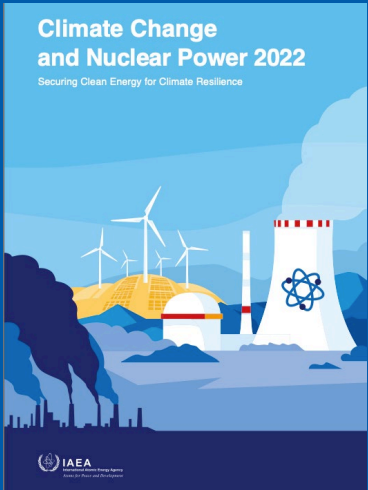


Figure 2: Location of selected energy-related infrastructure and water stress levels, 2020  
 Source: World Energy Outlook 2021; IEA analysis based on WRI Aqueduct 3.0 (2019) and S&P Global (2

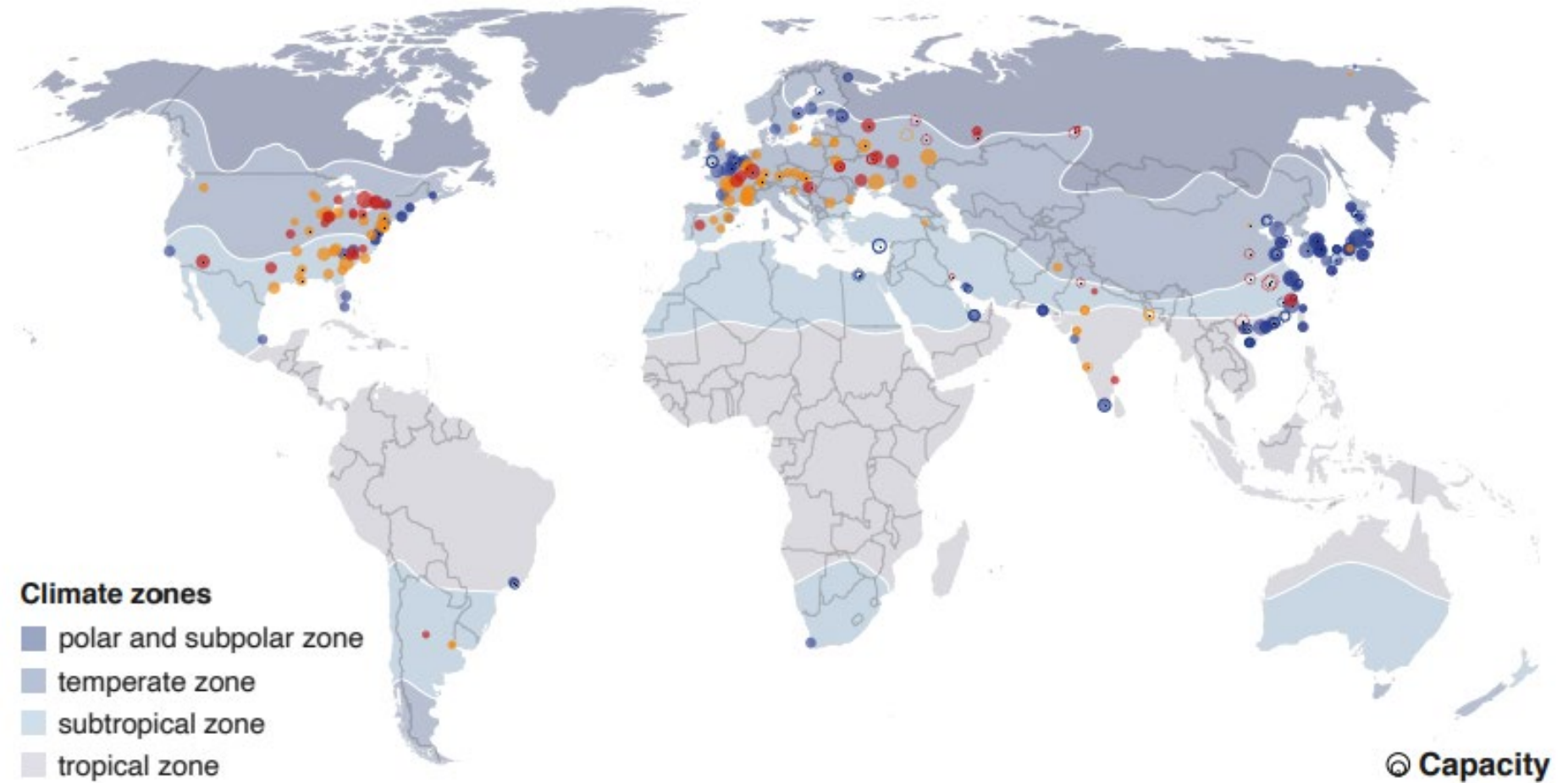
Source: WMO 2022 State of climate services for energy



# Climate Change Impacts on the Energy sector



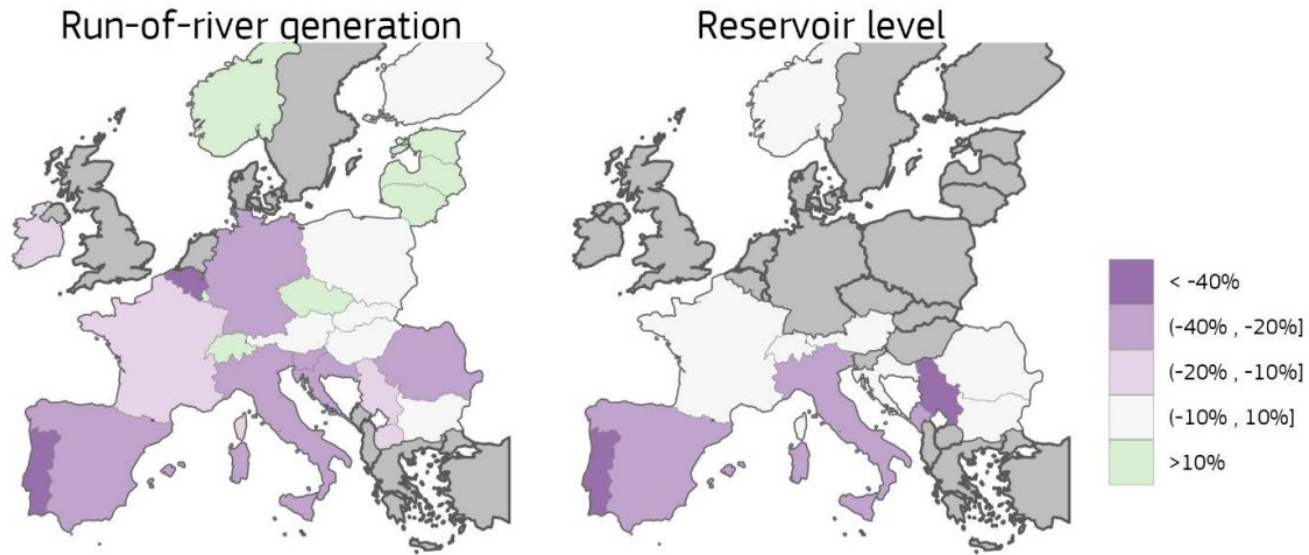
Nuclear power plants depend on **water**, and are often located in **low lying coastal areas**



**179** operational nuclear power plant sites  
73 ● at the sea coast 71 ● inland near a lake 35 ● inland near a river

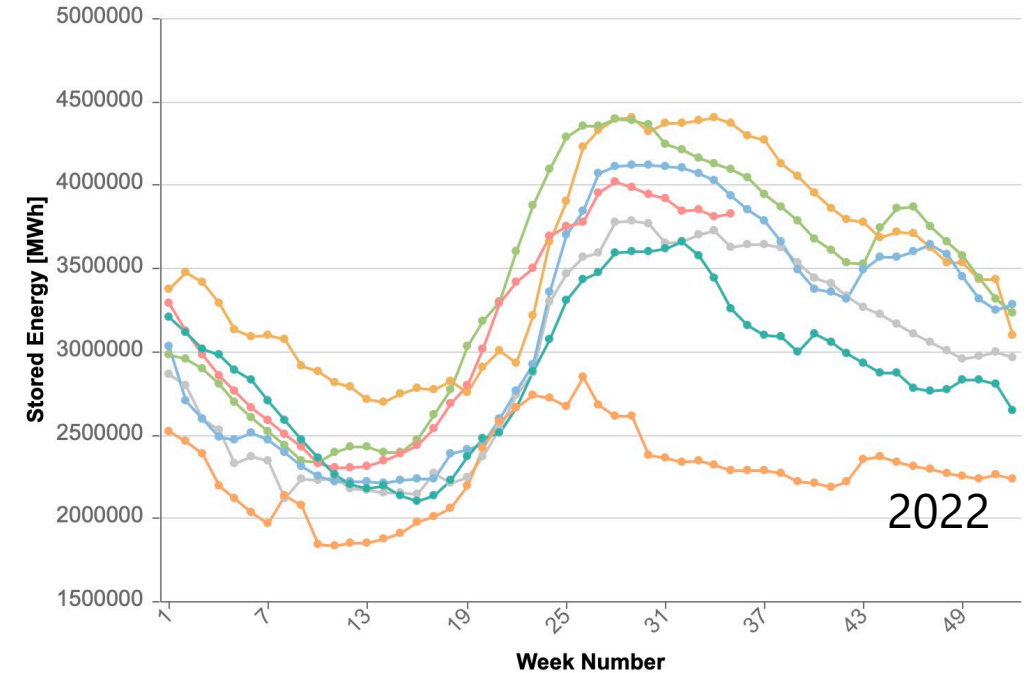
# European Summer Drought Impact Hydropower Generation

Difference (%) between the cumulative hydropower run-of-river generation and storage levels for June 2022 compared to the 2015-2021 mean (same month)



- The Low level of European hydropower reservoirs may exacerbate the current situation of the European power markets, which are already experiencing record-breaking wholesale prices.

Hydropower storage levels in northern Italy for the period 2015-2022. Each coloured line represents a specific year.



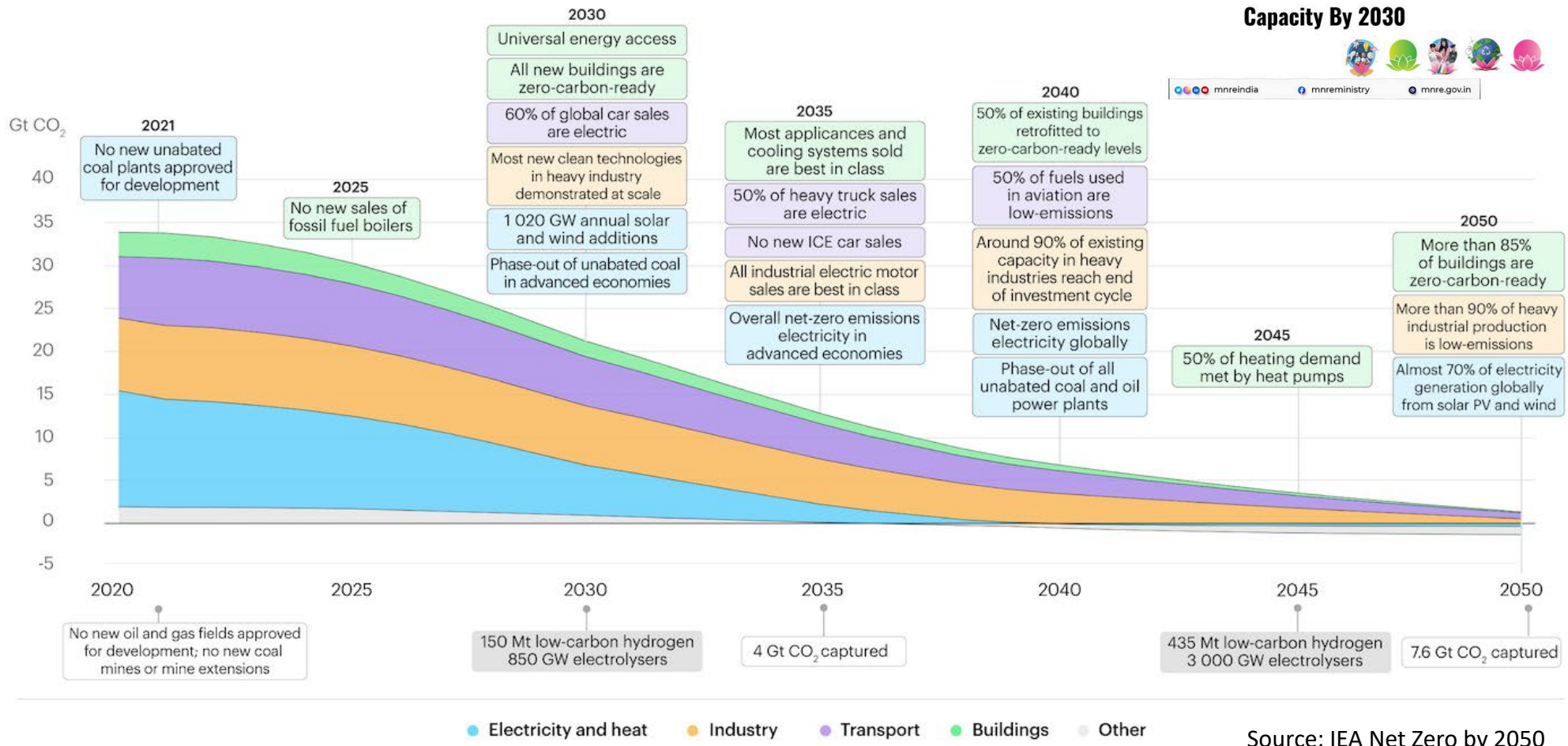
- As an example, the Italian hydropower generation has been particularly affected by the drought.
- 1375 GWh at week 26 (July) is 34.8% less than the 8-year minimum (2110GWh in 2021)





# Renewable Energy Transition Key to Climate Change Solutions

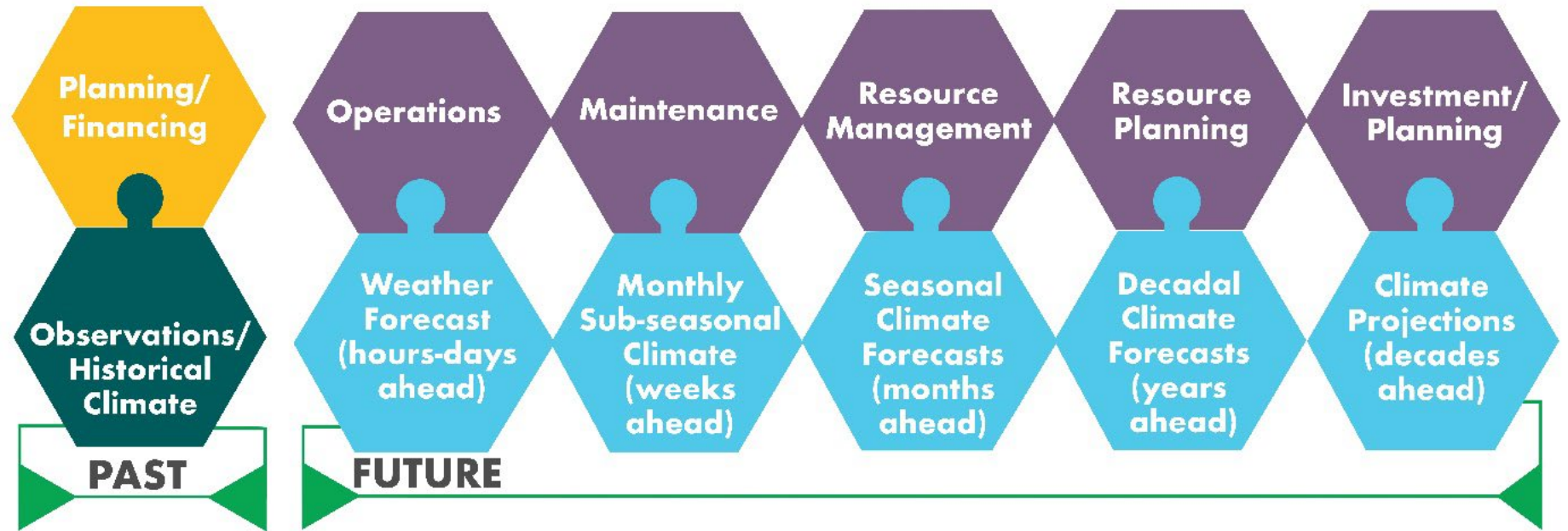
# EFFORTS To TRIPLE RENEWABLE ENERGY Capacity By 2030



Source: IEA Net Zero by 2050

**Weather and climate science and services for enhancing the resilience of the energy sector**

Provision and use of climate information in decision-making includes data collection, monitoring, analysis, predictions and projections of climate variables



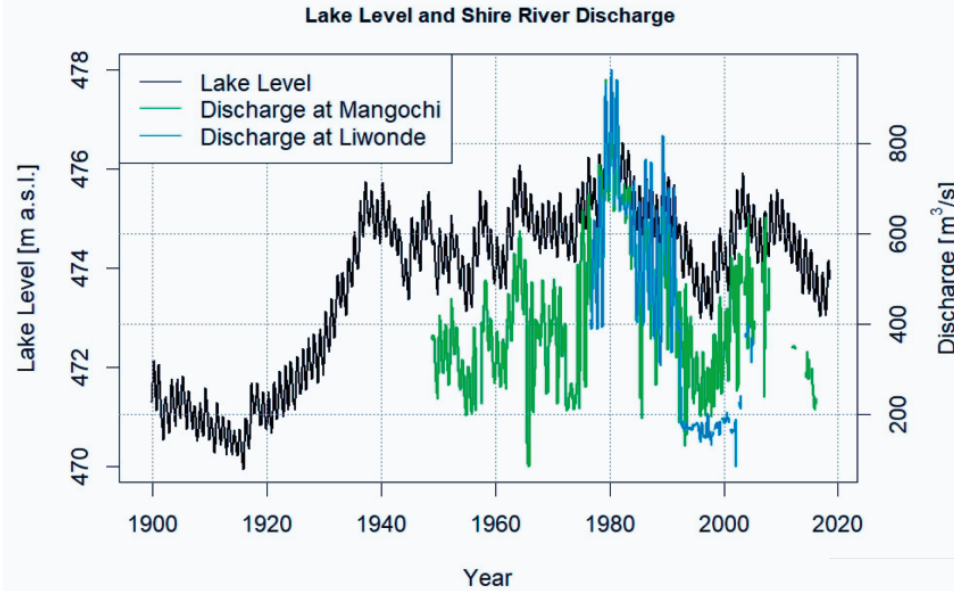
While 80% of WMO Members provide some climate information for the energy sector, less than 50% provide monthly to seasonal climate predictions for this sector

# Water resources and Energy Security



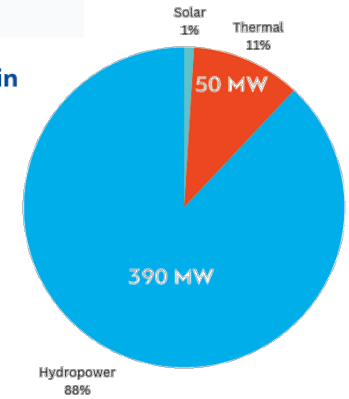
Shire River Basin

- The levels of Lake Malawi and Shire River discharge are forecast to decrease by 0.5 m - 2.1 m (23% - 75%) in the coming decades.
- 1% to 24% Resulting potential losses in hydropower production.
- Hydropower contributes 88% of Malawi installed energy capacity, of which most stations are located on the Shire river.
- The existing power stations do not have reservoirs that would allow them to store water.
- Projected rising temperatures, increased drought conditions and length of dry spells, increased intensity and frequency of heavy rainfall events impose risks on hydropower generation and infrastructure.



For every 1 °C of temperature increase there is a decrease of 0.3 m in lake level and 17% in lake outflow (Mtilatila, 2020).

Malawi heavily relies on hydropower, which is projected to be increasingly exposed to large climate fluctuations.



Installed Energy capacity(442 MW)  
(IRENA, 2020)





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THANK YOU!



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# WEF Nexus. Session at Hydrology Assembly/WMO Cg-19 (May 2023) Outcomes and recommendations

1. Increasing demand pressures on water resources
  - Projected increase in water withdrawals by 2050
    - 20% for energy
    - 15% for agriculture
2. Well-planned infrastructure for sustainable water use
  - Such as use of dams for water regulation and allocation for different uses: energy, agriculture, water supply and ecosystem services
3. Clear Communication and collaboration:
  - Timely communication of hydrological services is crucial.
    - Flood and drought alerts, seasonal and sub-seasonal predictions
  - Common platform for engagement
  - Collaboration among different sectors enhances knowledge sharing

