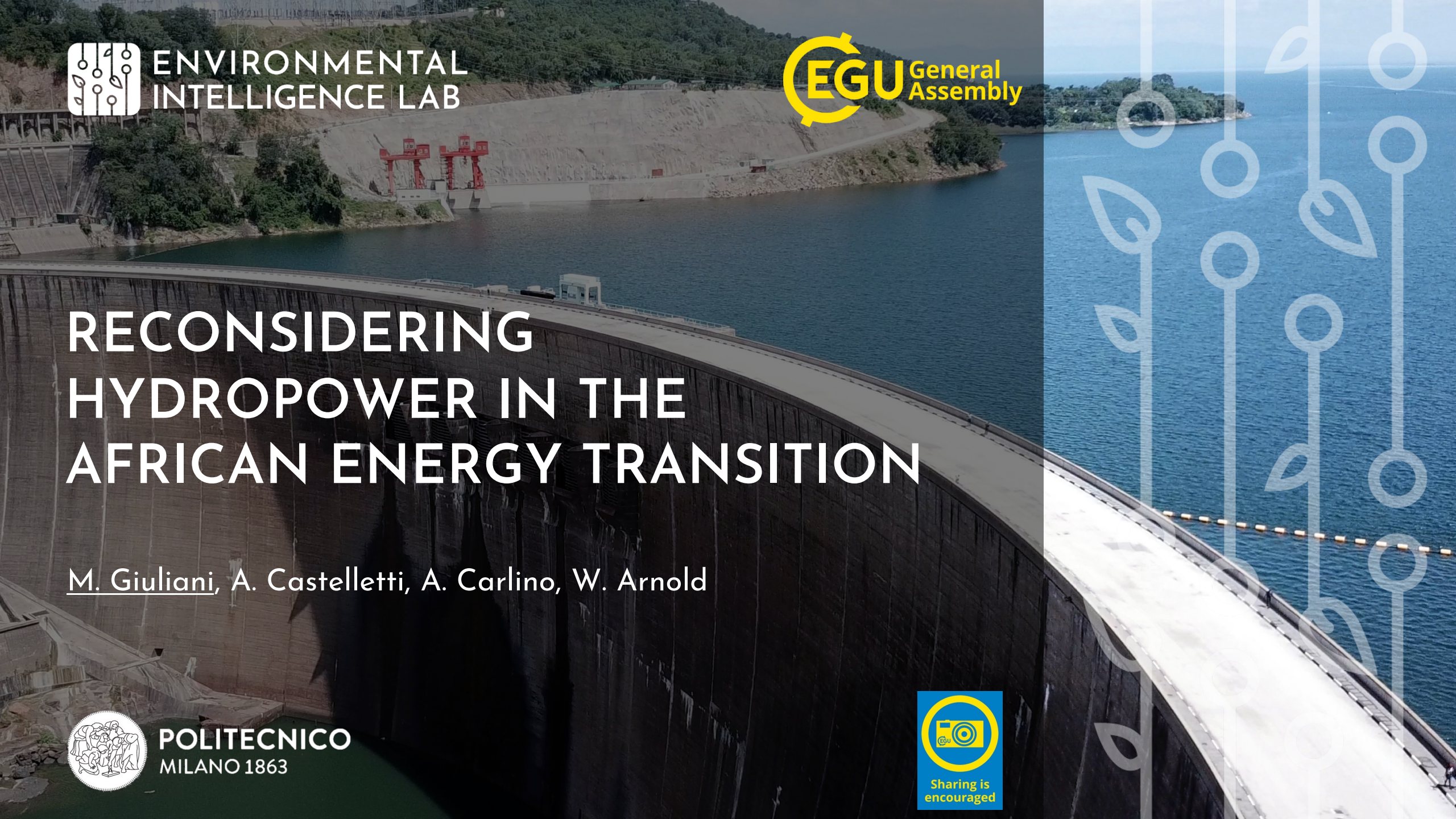

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EGU General Assembly

RECONSIDERING HYDROPOWER IN THE AFRICAN ENERGY TRANSITION

M. Giuliani, A. Castelletti, A. Carlino, W. Arnold

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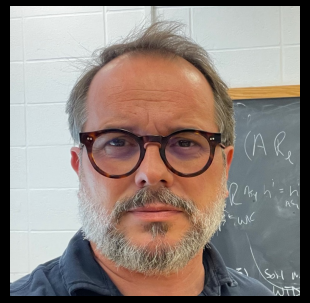
ACKNOWLEDGMENTS



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A. Carlino

W. Arnold

F. Bertoni, S. Bizzi, P. Burlando, C. Chawanda, G. Daily, M. Kondolf, J. Lamontagne, P. Reed, R. Schmitt, S. Sinclair, S. Sterl, W. Thiery, A. van Griensven, M. Wildemeersch, M. Zaniolo, J. Zatarain-Salazar

Research funded by

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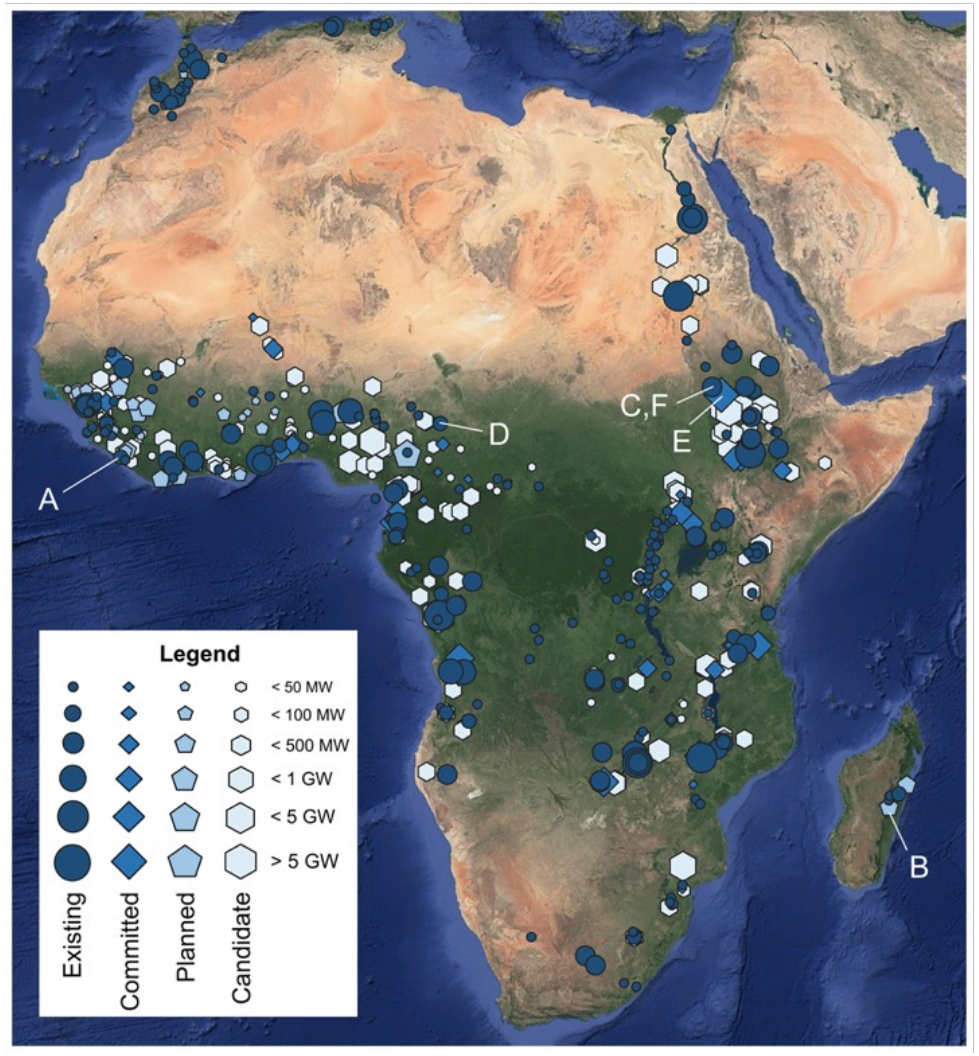
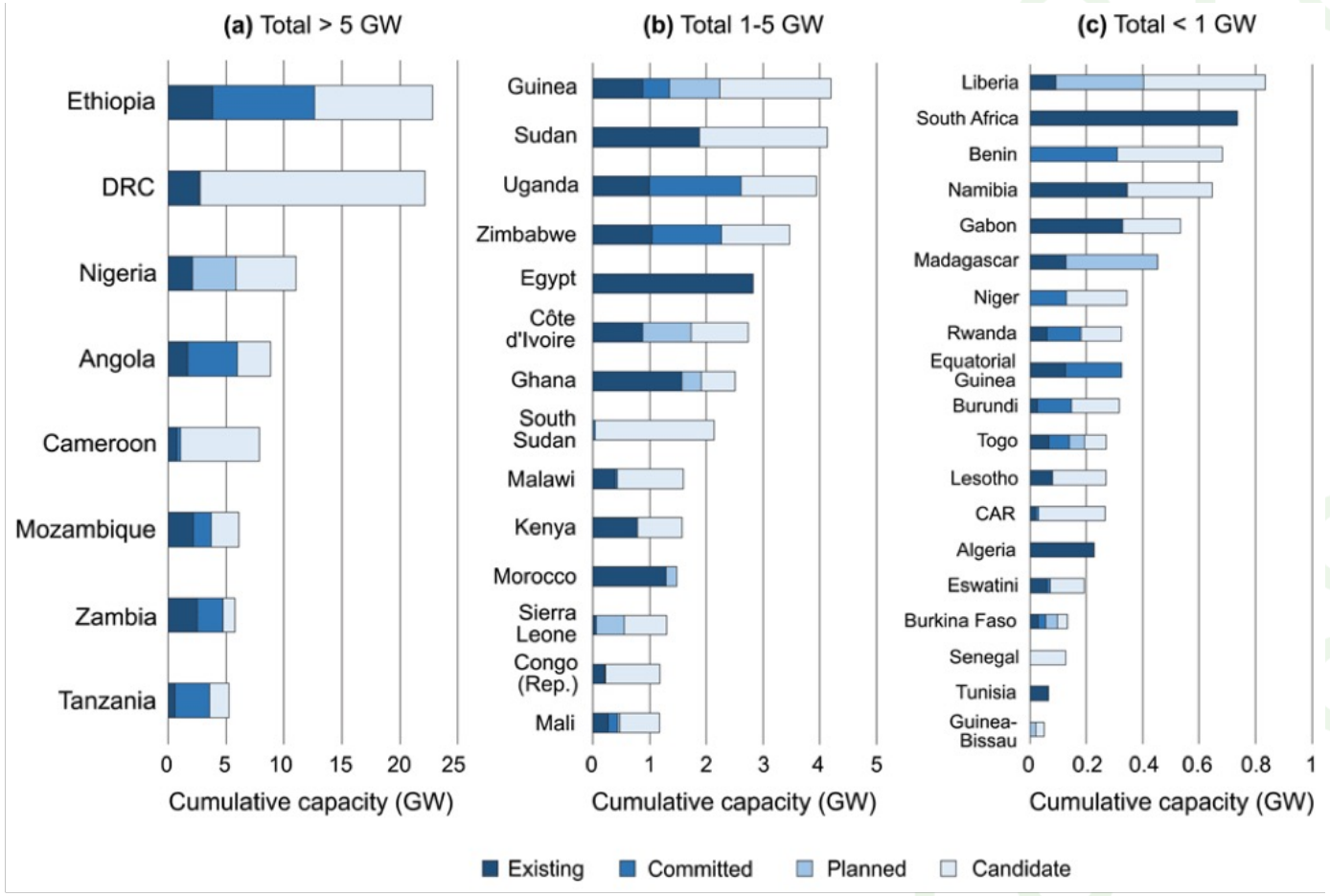
G o N E X U S

DAMS ARE OFTEN USED TO SUPPORT AFRICAN ECONOMIC DEVELOPMENT



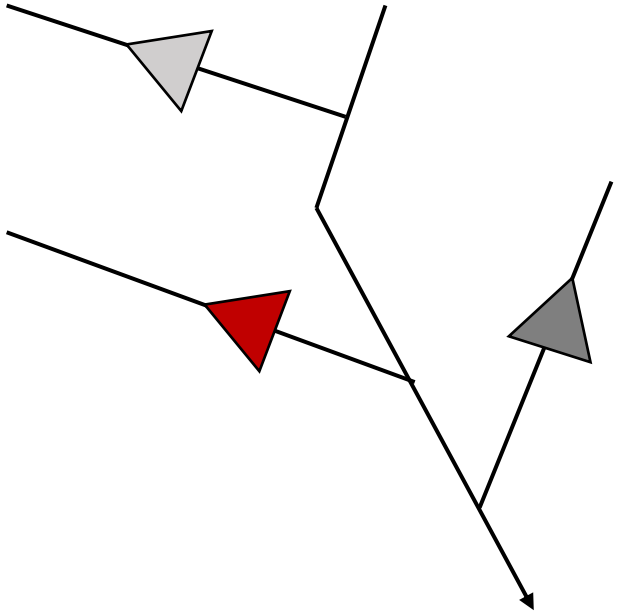


+300 HP projects | +100 GW

Source: Sterl et al. (2022)

HYDROPOWER PLANNING AT RIVER BASIN SCALE: A WELL-KNOWN PROBLEM

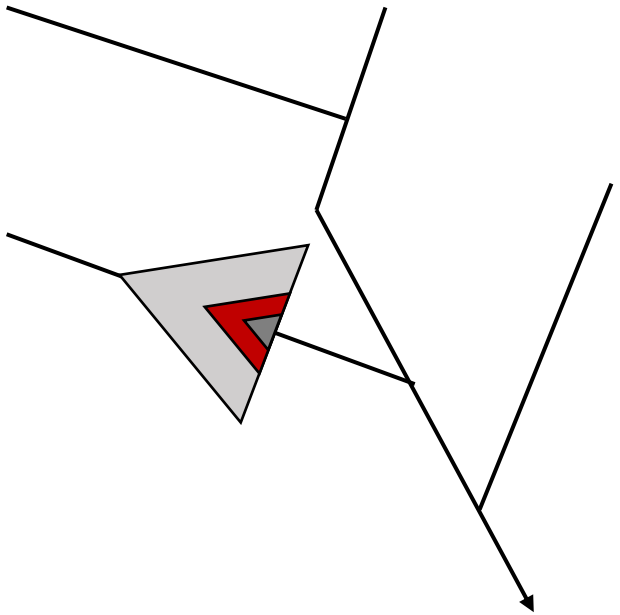
1. SITING



EXAMPLE
Schmitt et al. 2021, PNAS

HYDROPOWER PLANNING AT RIVER BASIN SCALE: A WELL-KNOWN PROBLEM

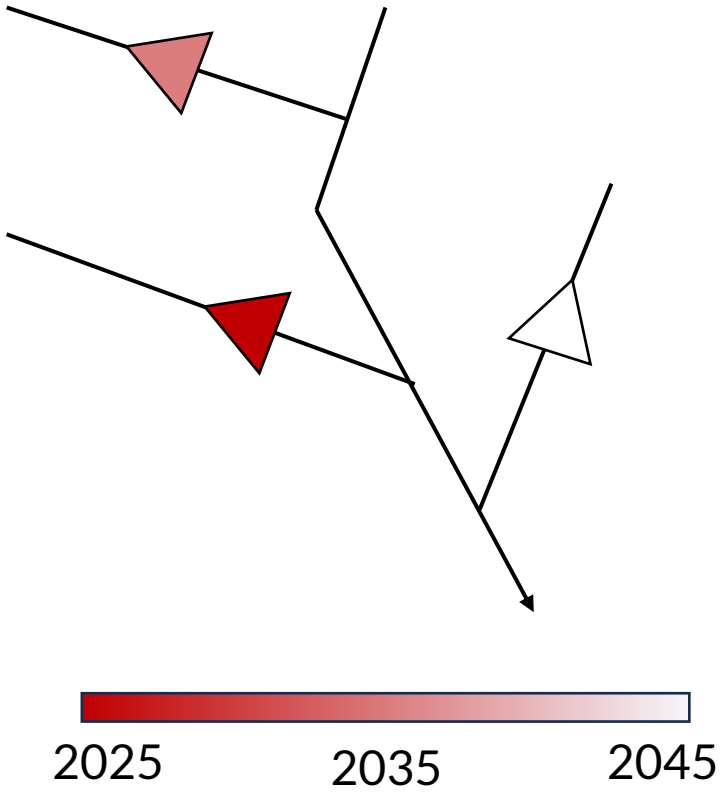
1. SITING
2. SIZING



EXAMPLE
Bertoni et al. 2019, EF

HYDROPOWER PLANNING AT RIVER BASIN SCALE: A WELL-KNOWN PROBLEM

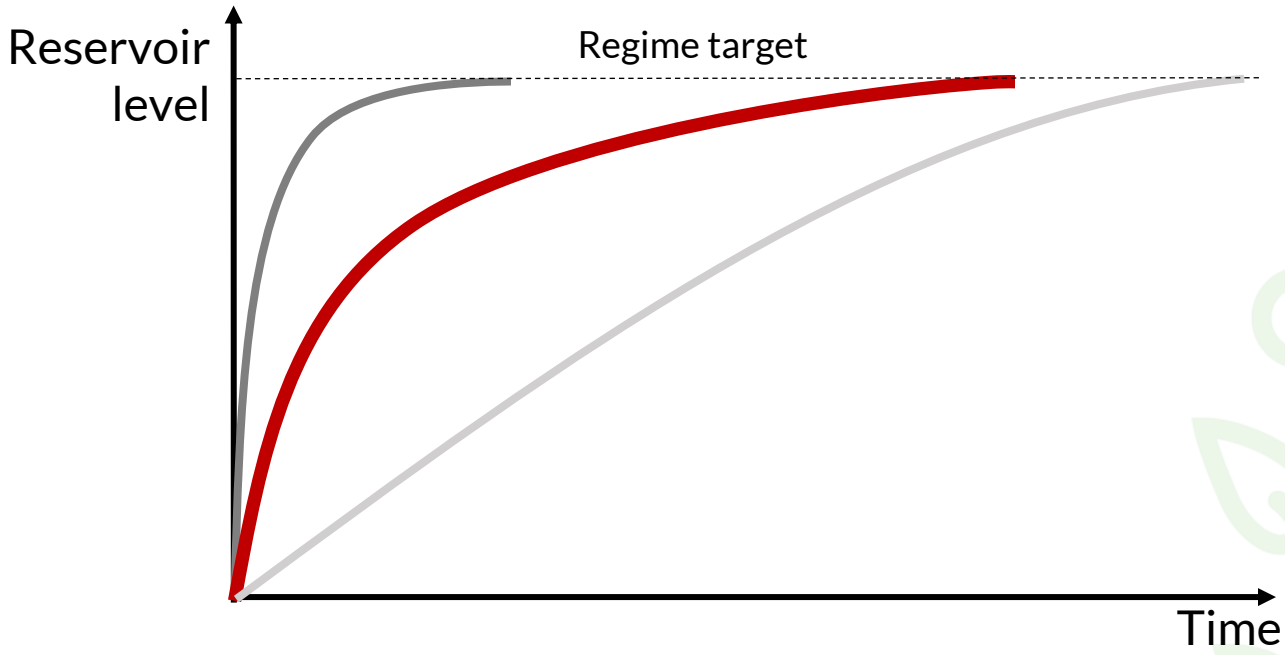
1. SITING
2. SIZING
3. SEQUENCING



EXAMPLE
Arnold et al. 2023, EF

HYDROPOWER PLANNING AT RIVER BASIN SCALE: A WELL-KNOWN PROBLEM

1. SITING
2. SIZING
3. SEQUENCING
4. FILLING

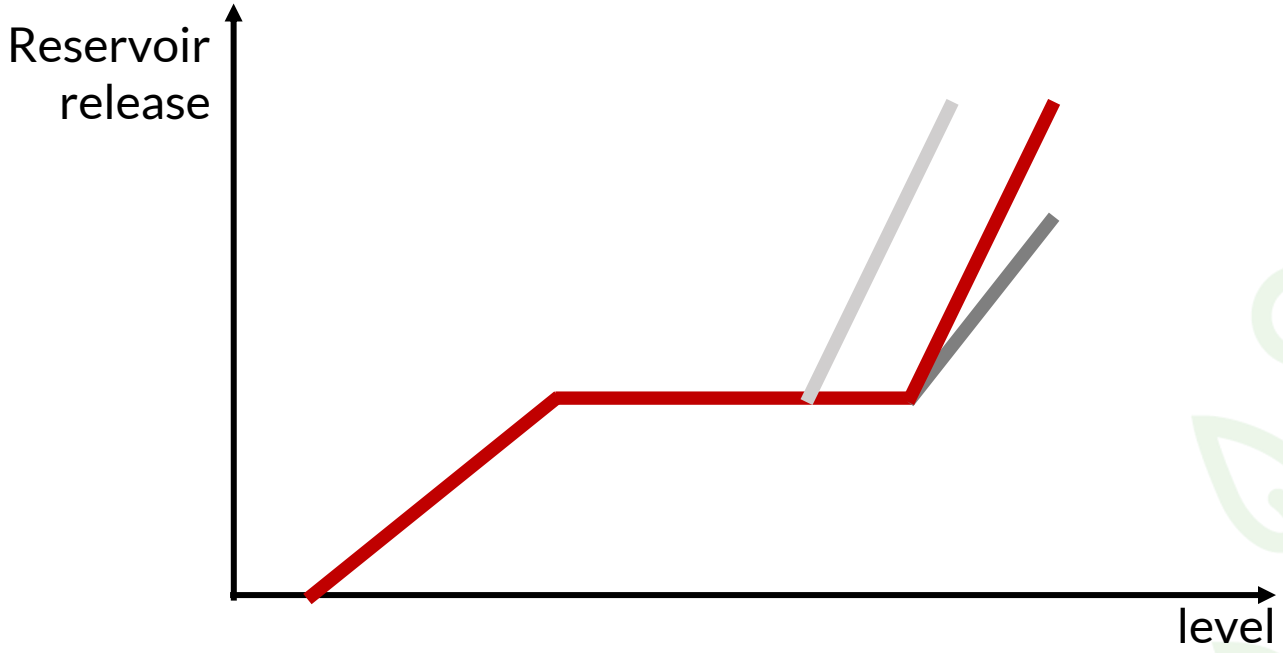


EXAMPLE
Zaniolo et al. 2021,
Nature Communications

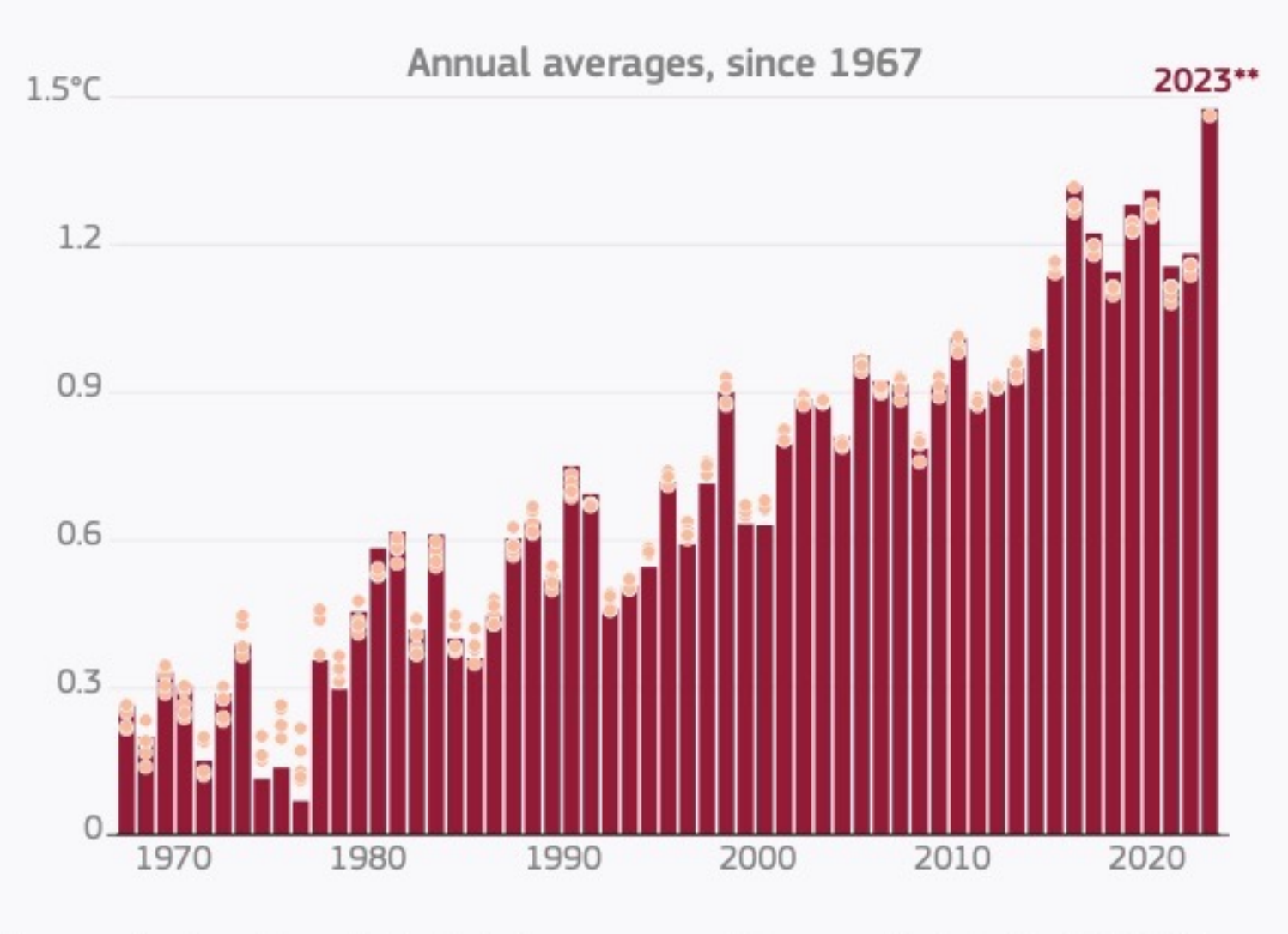
HYDROPOWER PLANNING AT RIVER BASIN SCALE: A WELL-KNOWN PROBLEM

1. SITING
2. SIZING
3. SEQUENCING
4. FILLING
5. OPERATIONS

EXAMPLE
Giuliani et al. 2021, WRR

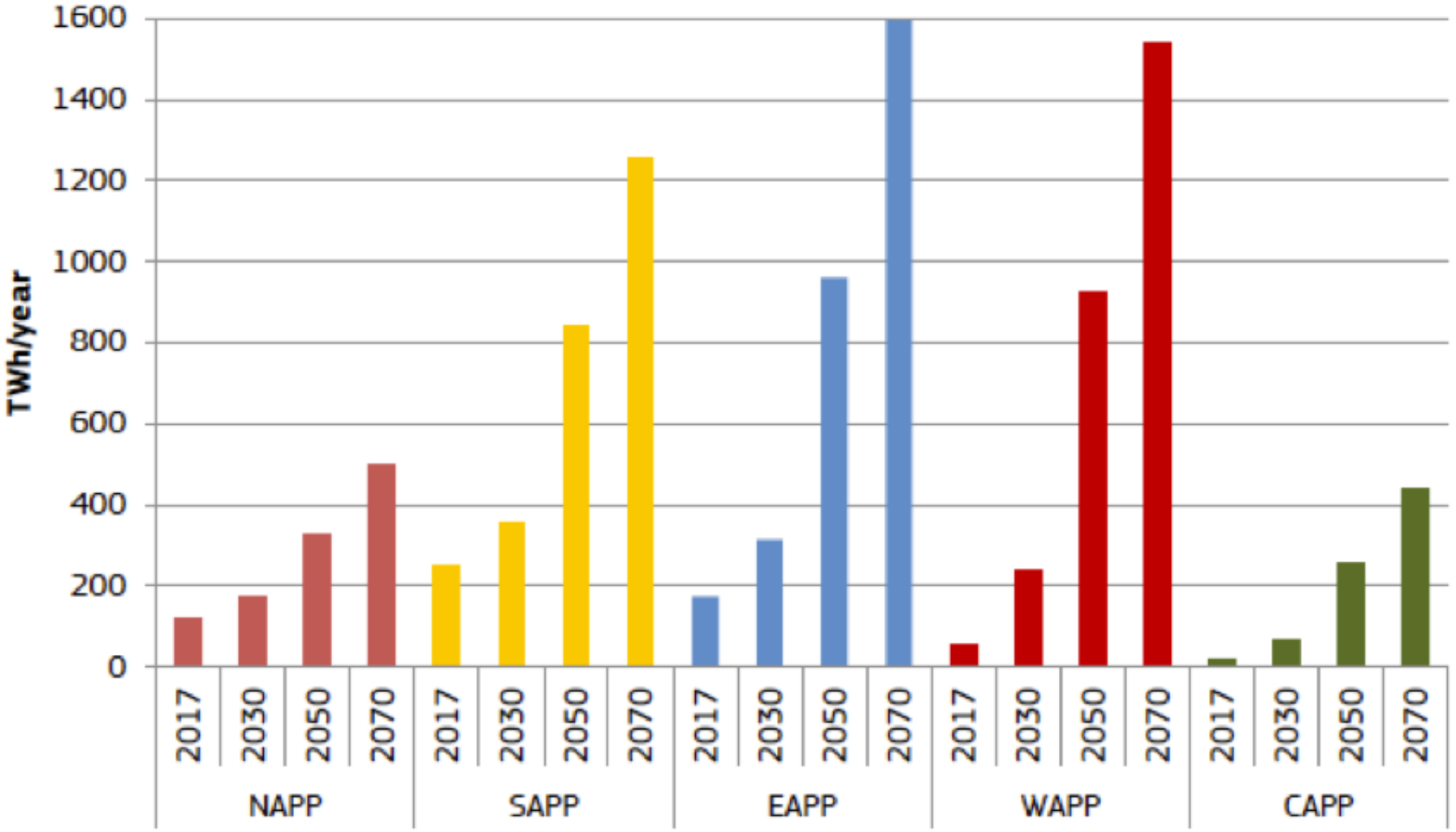


THE GLOBAL TRANSFORMATION CHALLENGE: CLIMATE IS CHANGING



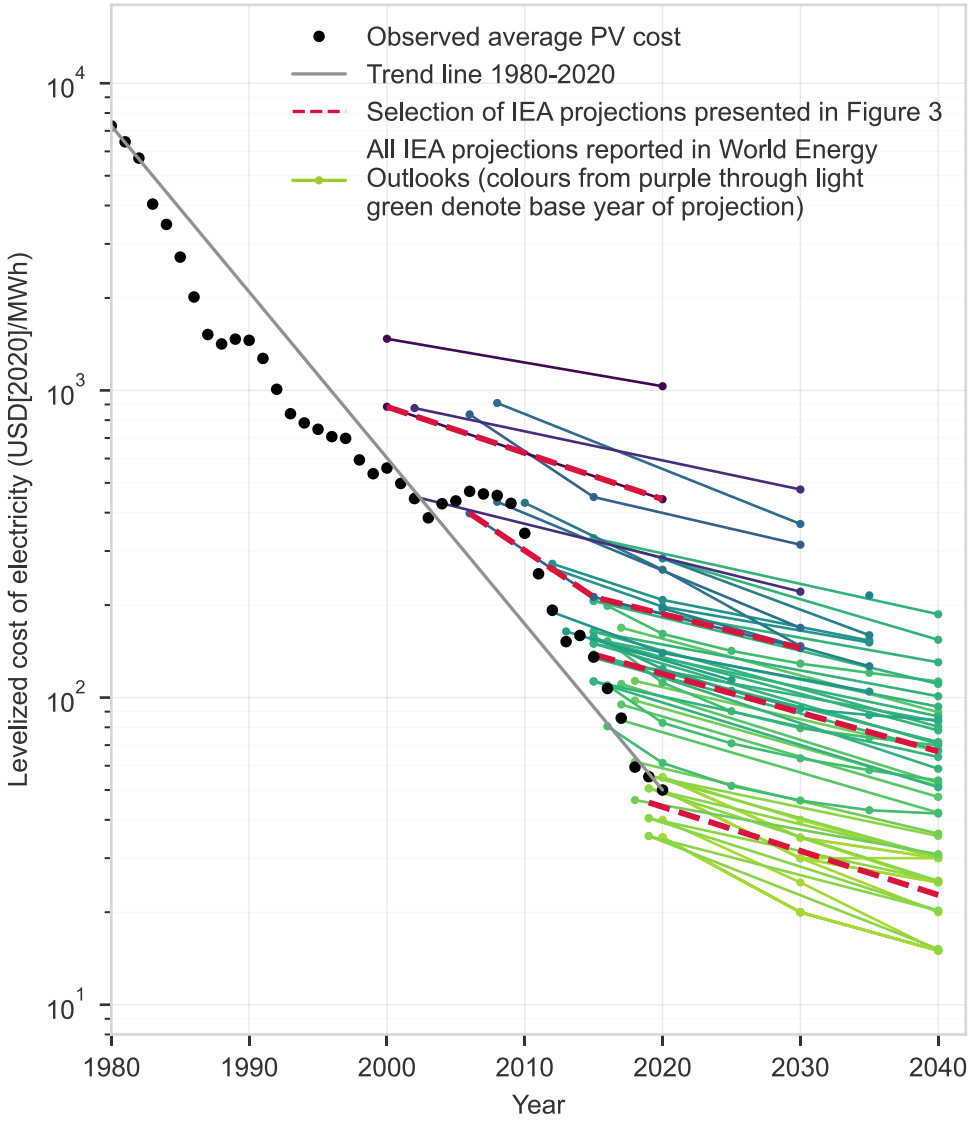
Source: Copernicus C3S/ECMWF

THE GLOBAL TRANSFORMATION CHALLENGE: ENERGY DEMAND IS GROWING



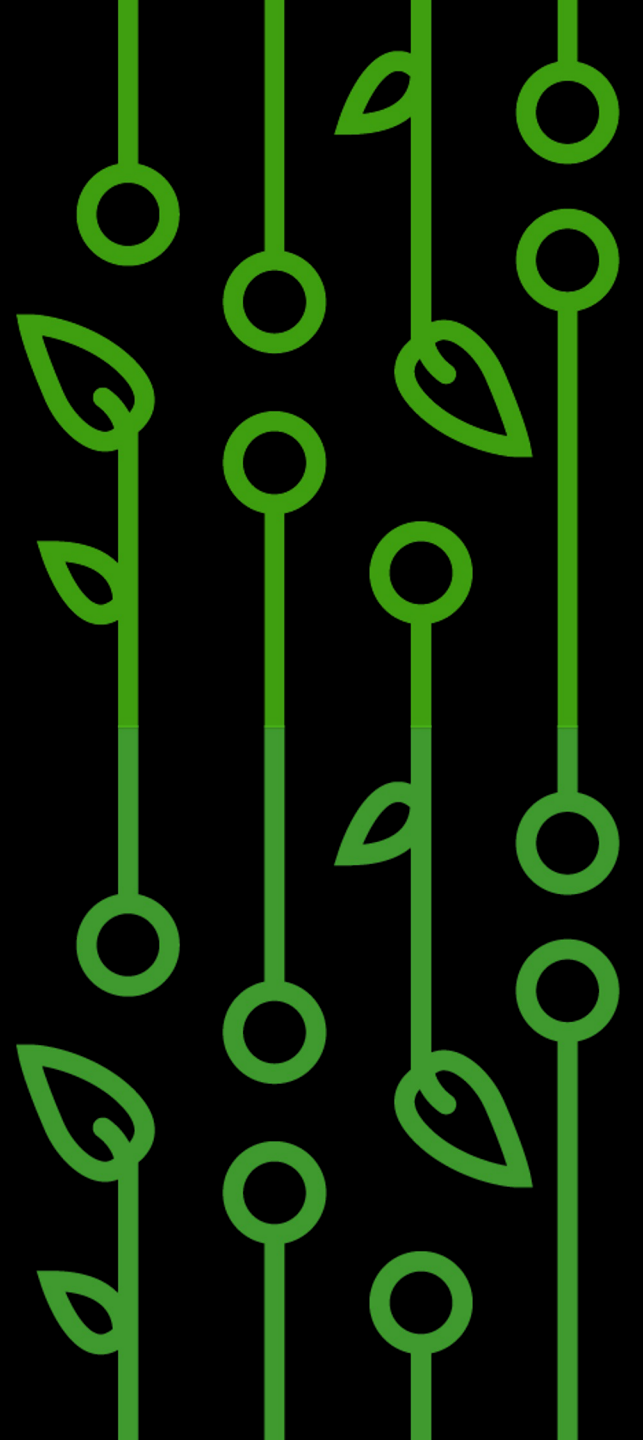
Source: Pappis et al. (2019)

THE GLOBAL TRANSFORMATION CHALLENGE: TECHNOLOGY IS EVOLVING

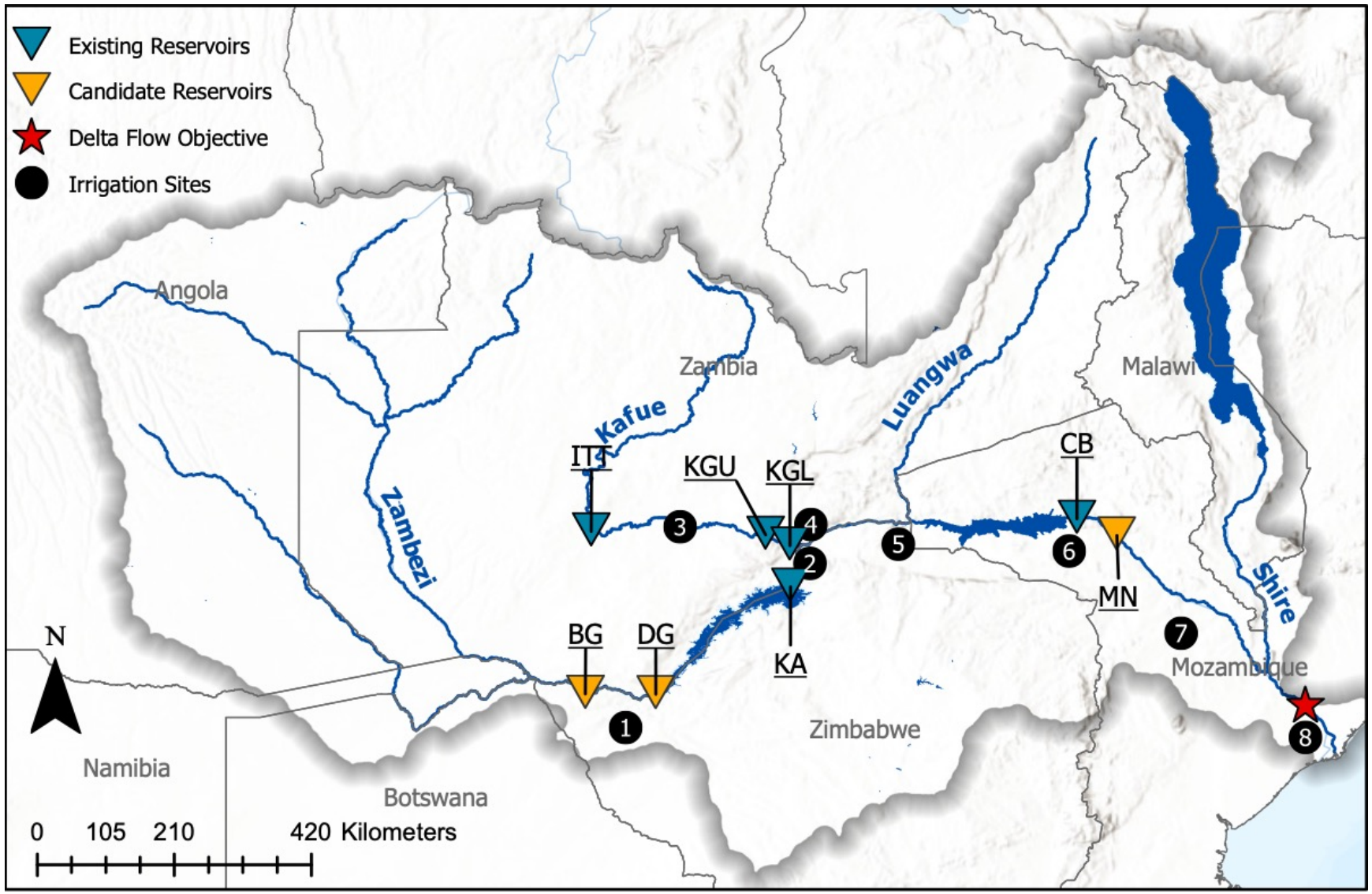


Source: Way et al. (2022)

HOW CAN WE BETTER EVALUATE THE ROLE OF HYDRO FOR ENERGY TRANSITION INVESTMENTS?



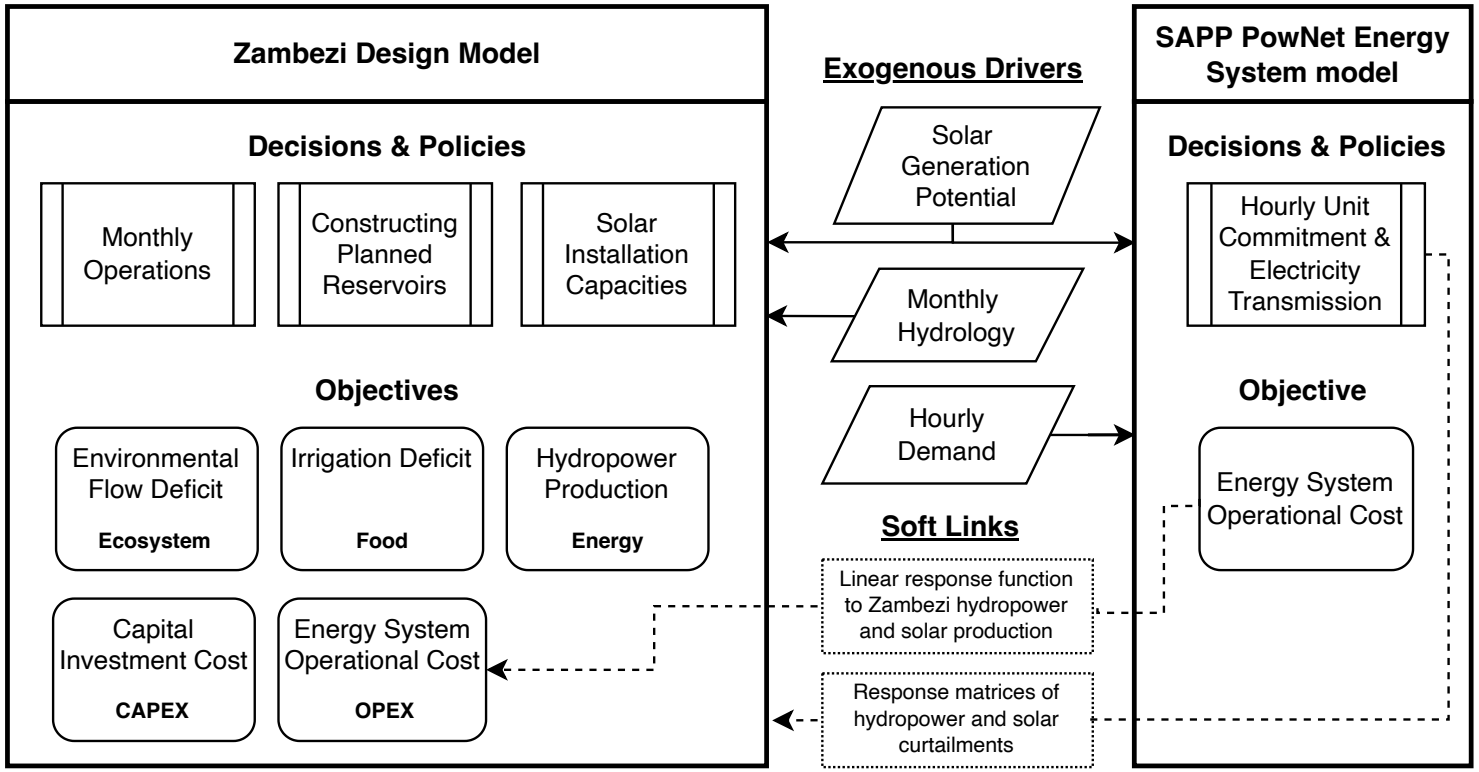
HYDROPOWER EXPANSION IN THE ZAMBEZI WATERCOURSE

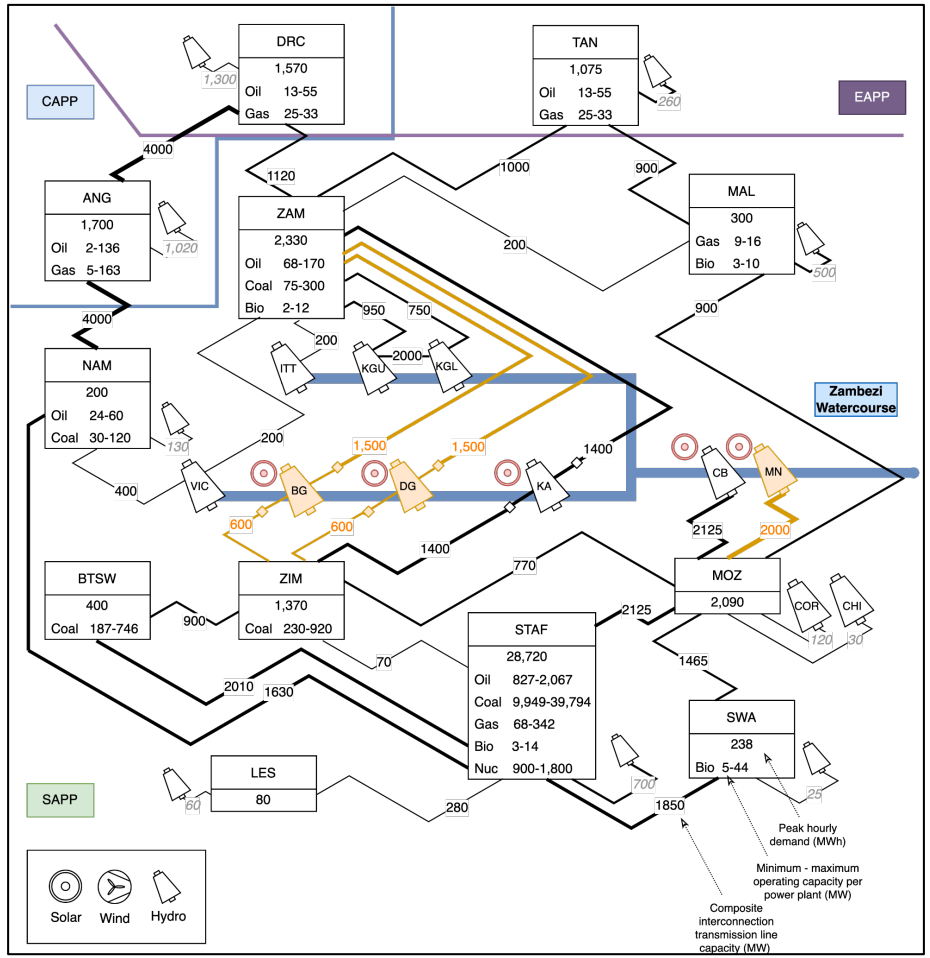


Three planned reservoirs:

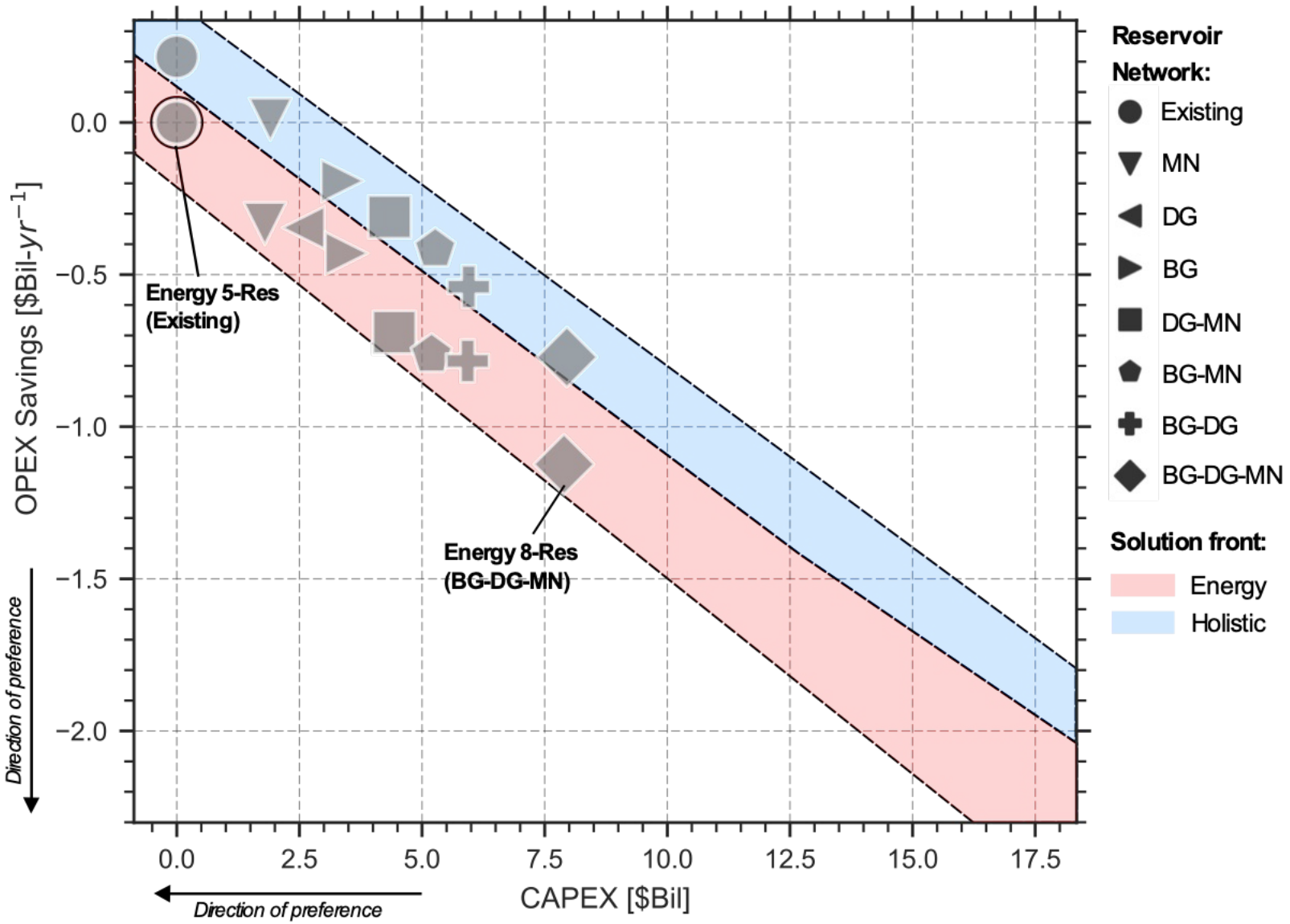
- +4.1 GW (+37%)
- ≈$8 Billion

FROM RIVER BASIN TO POWER POOL SCALE



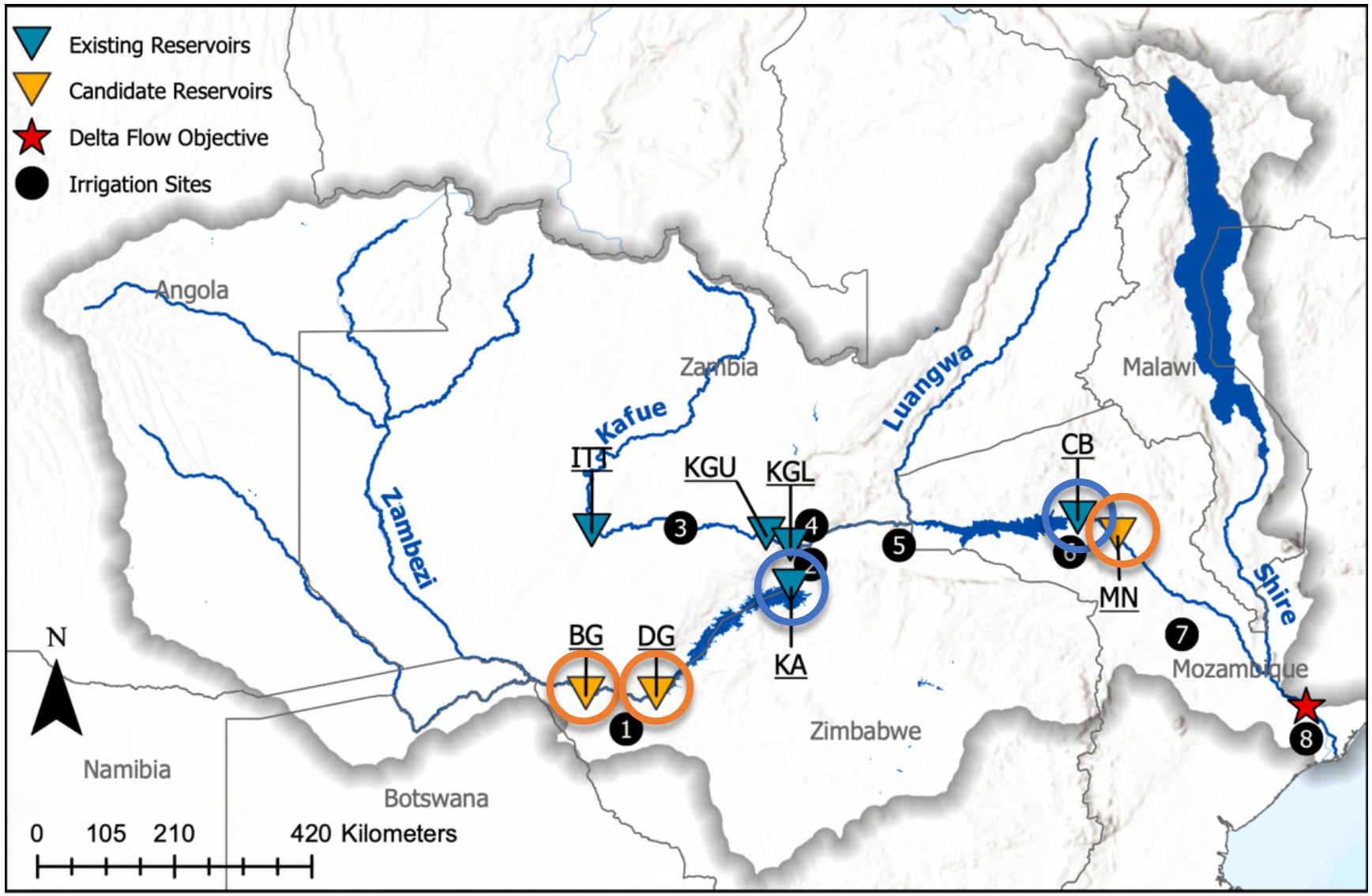


IMPACTS OF HYDRO EXPANSION AT SAPP LEVEL



Arnold et al. 2024, Nature Energy

HYDROPOWER VS FLOATING PHOTOVOLTAIC



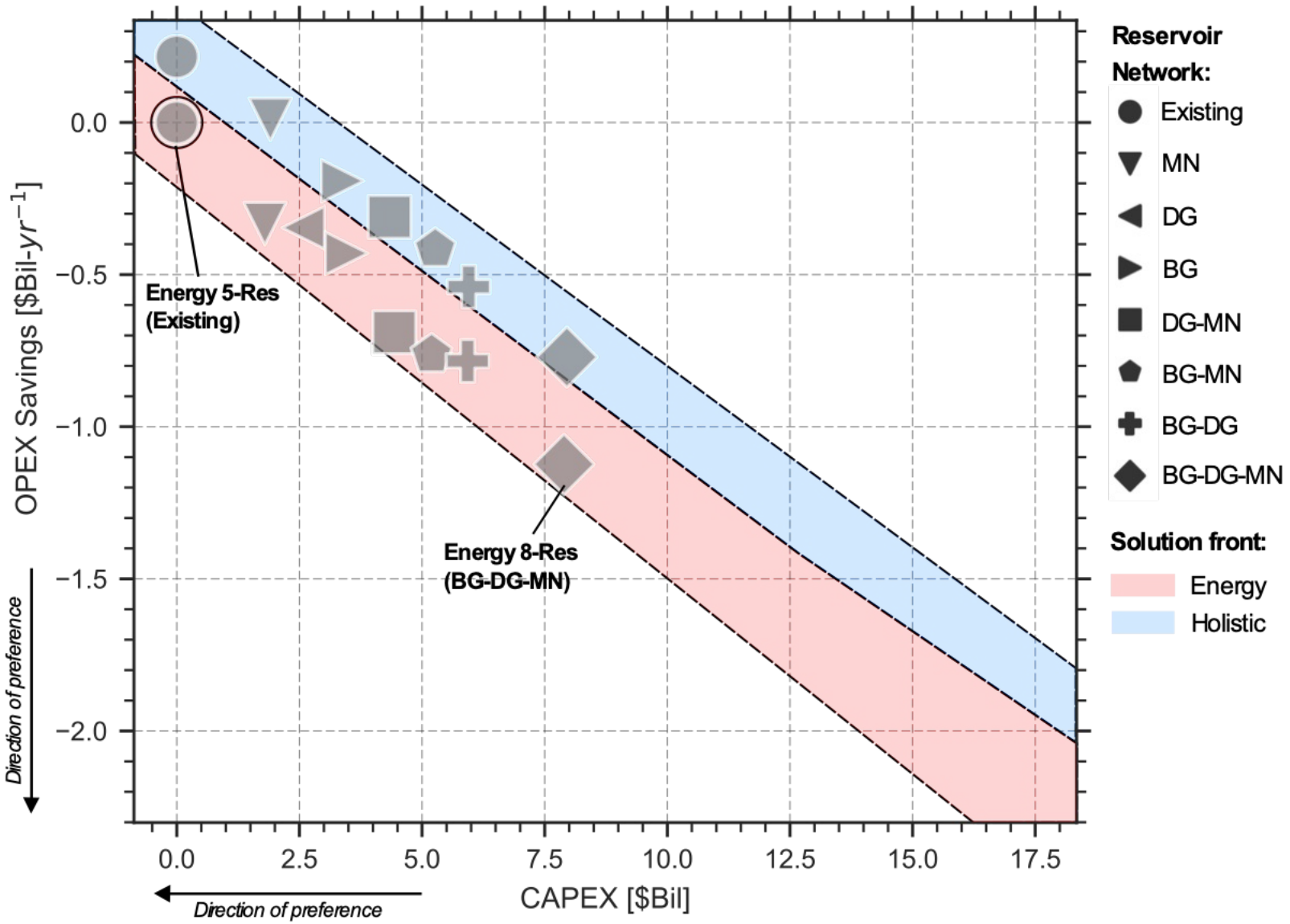
Three planned reservoirs:

- +4.1 GW (+37%)
- ≈$8 Billion

FPV candidates:

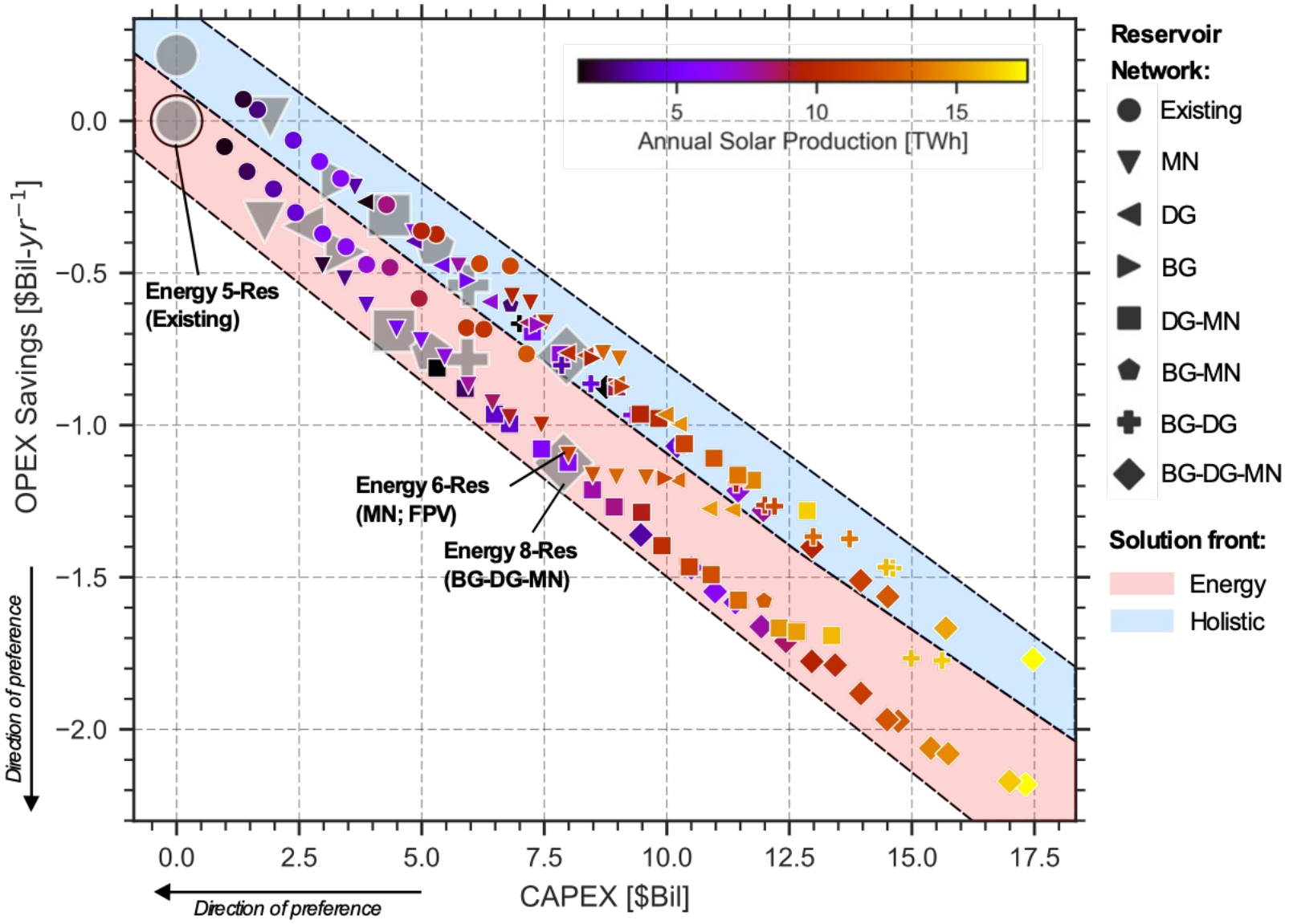
- 12.6 GW
- ≈$12.6 Billion

HYDRO EXPANSION WITH NO FPV



Arnold et al. 2024, Nature Energy

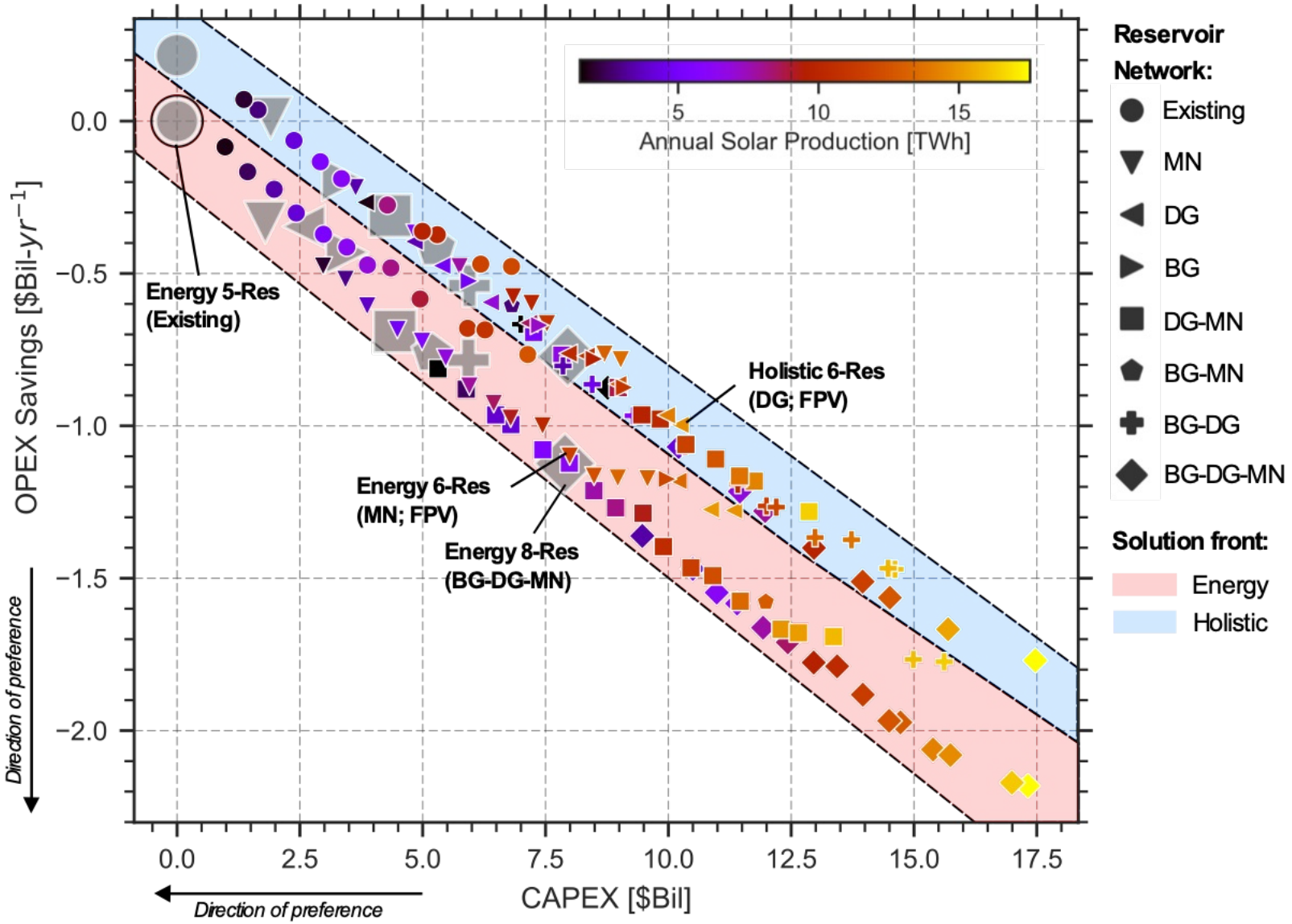
JOINT HYDRO+FPV EXPANSION



Energy 6-Res is equivalent to Energy 8-Res with 2 DAMS LESS

Arnold et al. 2024, Nature Energy

FPV CAN CONTRIBUTE TO MULTIPURPOSE OPERATION

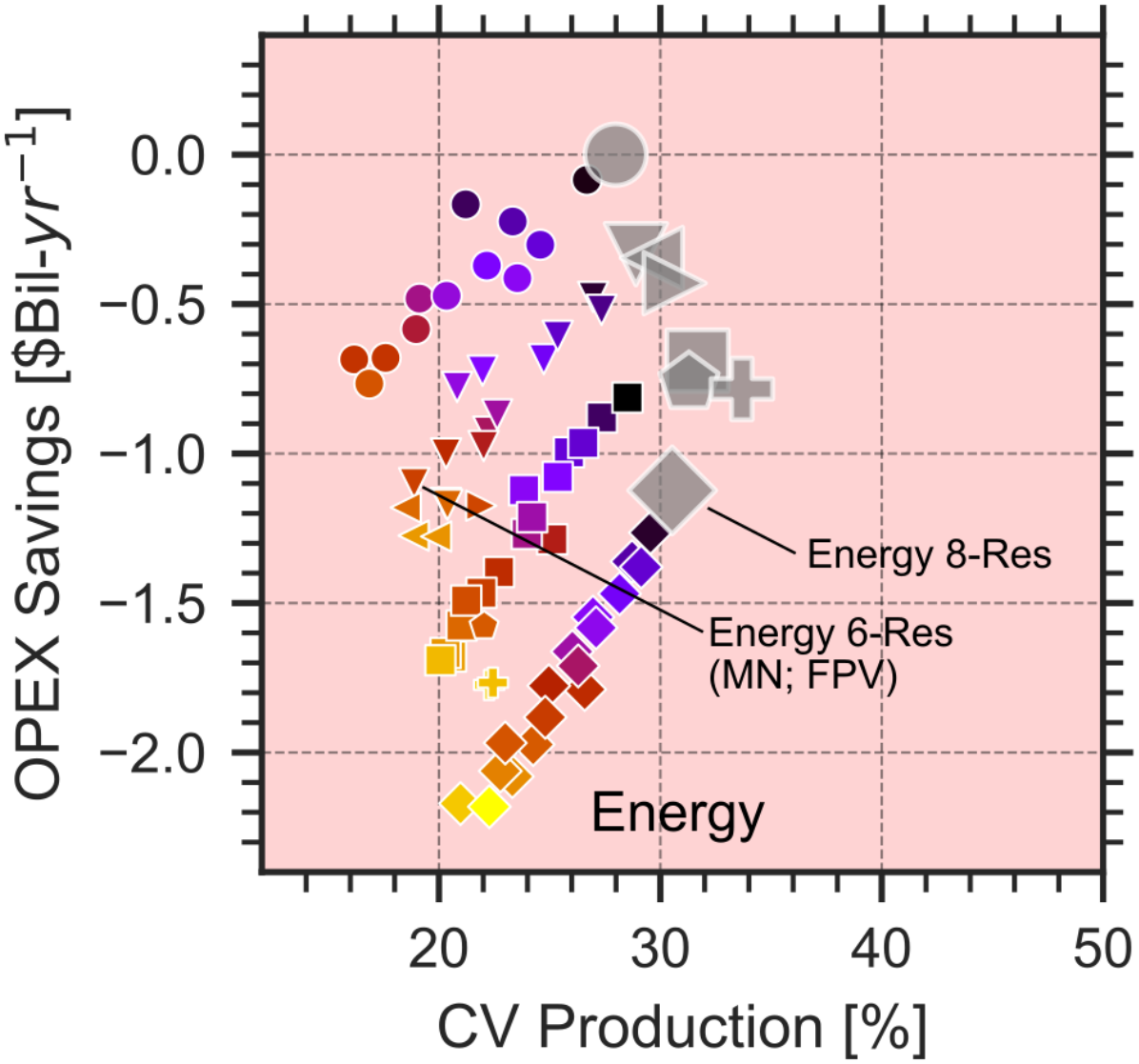


Energy 6-Res is equivalent to Energy 8-Res with 2 DAMS LESS

Holistic 6-Res adds more FPV to meet 8-res energy with >80 percentile environmental and irrigation performance

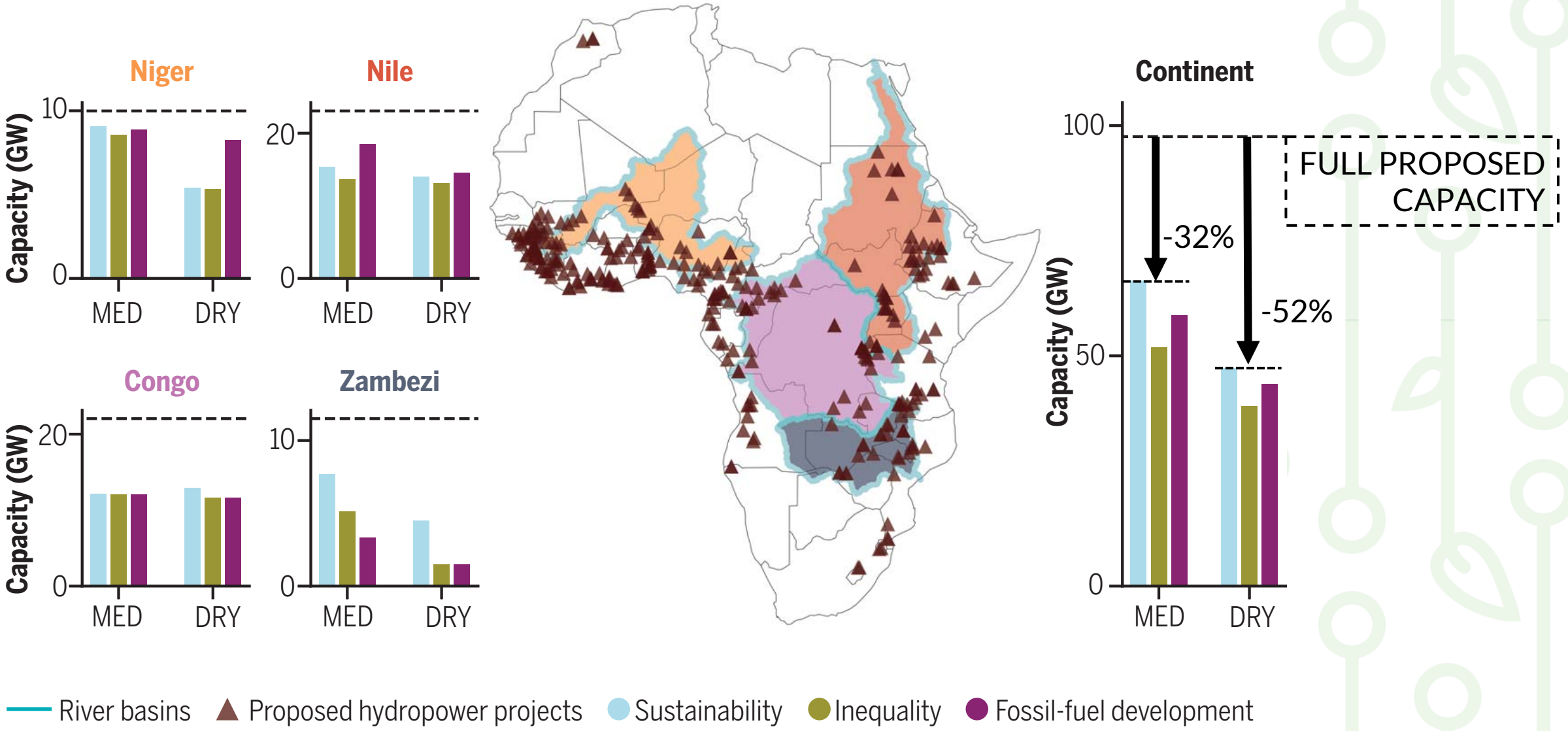
Arnold et al. 2024, Nature Energy

FPV INCREASES PRODUCTION RELIABILITY



Arnold et al. 2024, Nature Energy

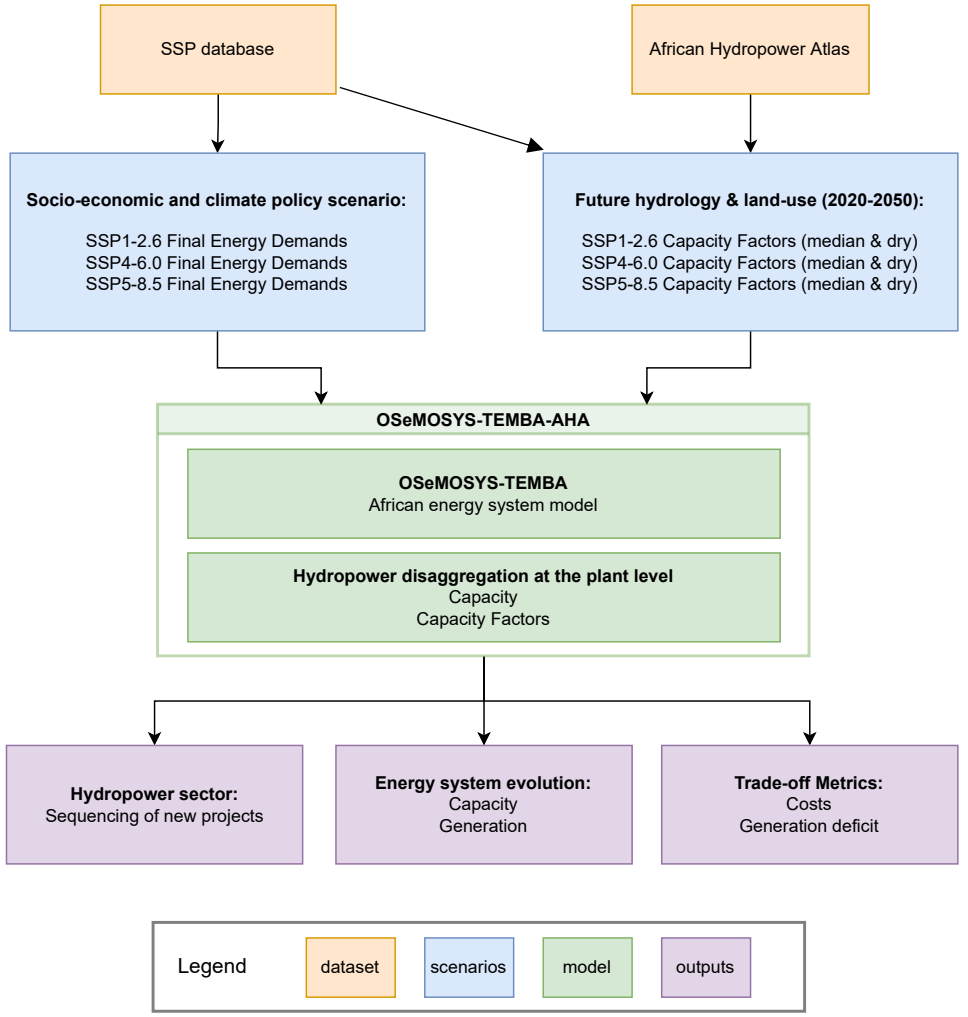
FROM POWER POOL TO CONTINENTAL AFRICA: 32% OF HYDRO PROJECTS ARE NOT COST OPTIMAL



Carlino et al. 2023, Science

OSEMOSYS-TEMBA AHA FRAMEWORK

Scenario definition	
SSP1-2.6	Sustainability
SSP4-6.0	Inequality
SSP5-8.5	Fossil-fueled development



Dataset collecting information on 633 **hydropower projects** in Africa, both existing and planned

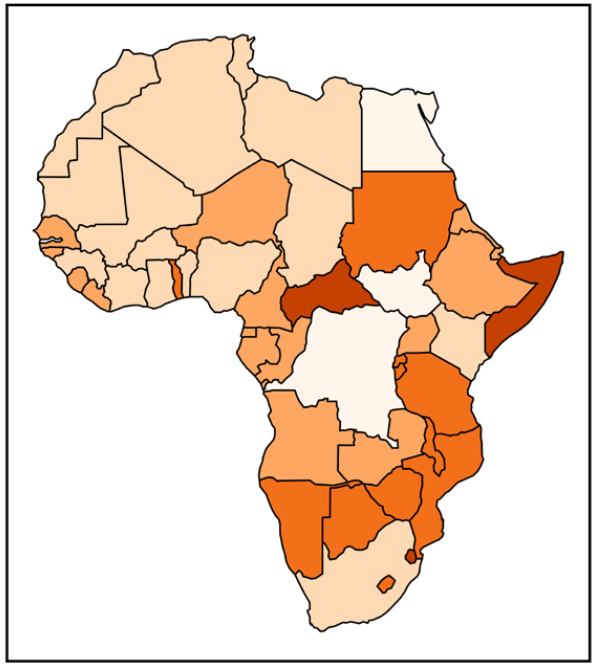
Energy demand inputs associated to three combinations **SSPs** and **RCPs,** capacity factors of hydropower plants for **median** and **very dry hydrology**

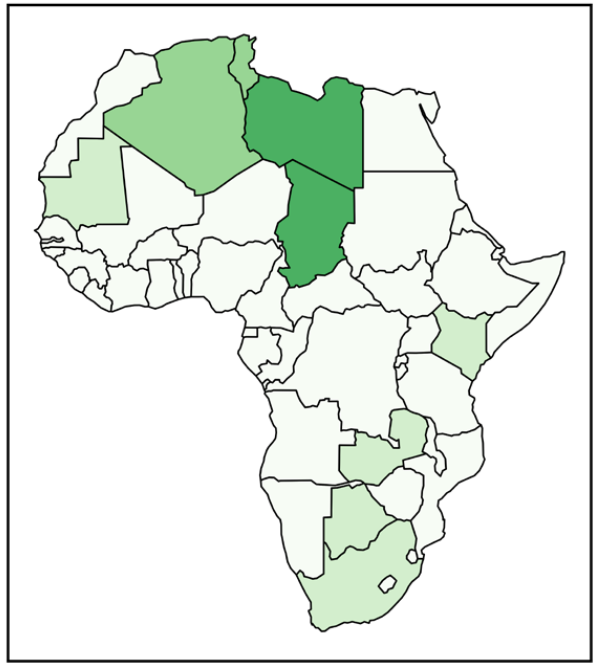
Large scale **energy system model** for least-cost energy planning in Africa

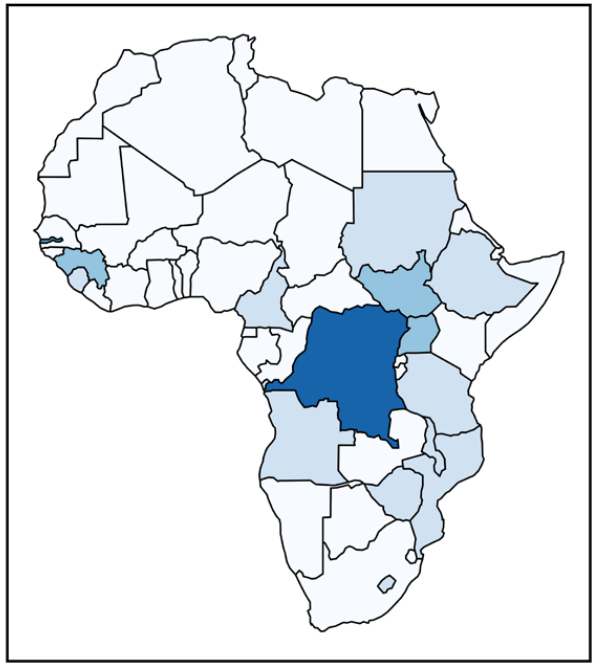
Cost-optimal national energy generation strategies and hydropower portfolios

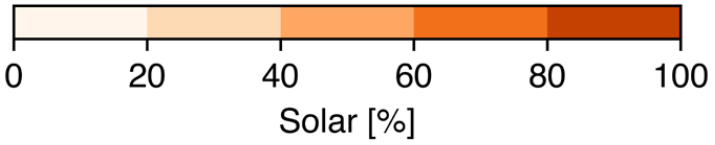
Carlino et al. 2023, Science

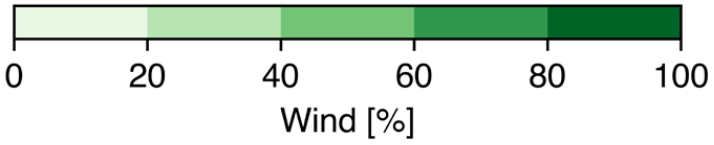
NATIONAL GENERATION MIX IN 2050 UNDER SSP1-2.6

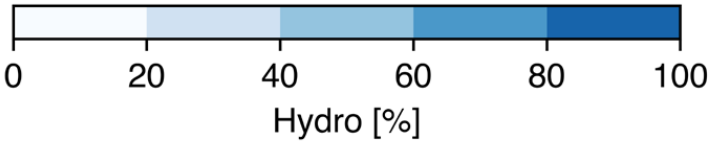






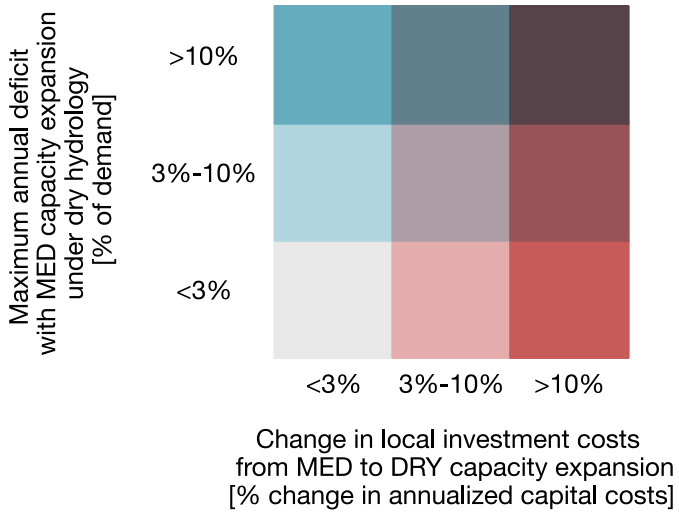


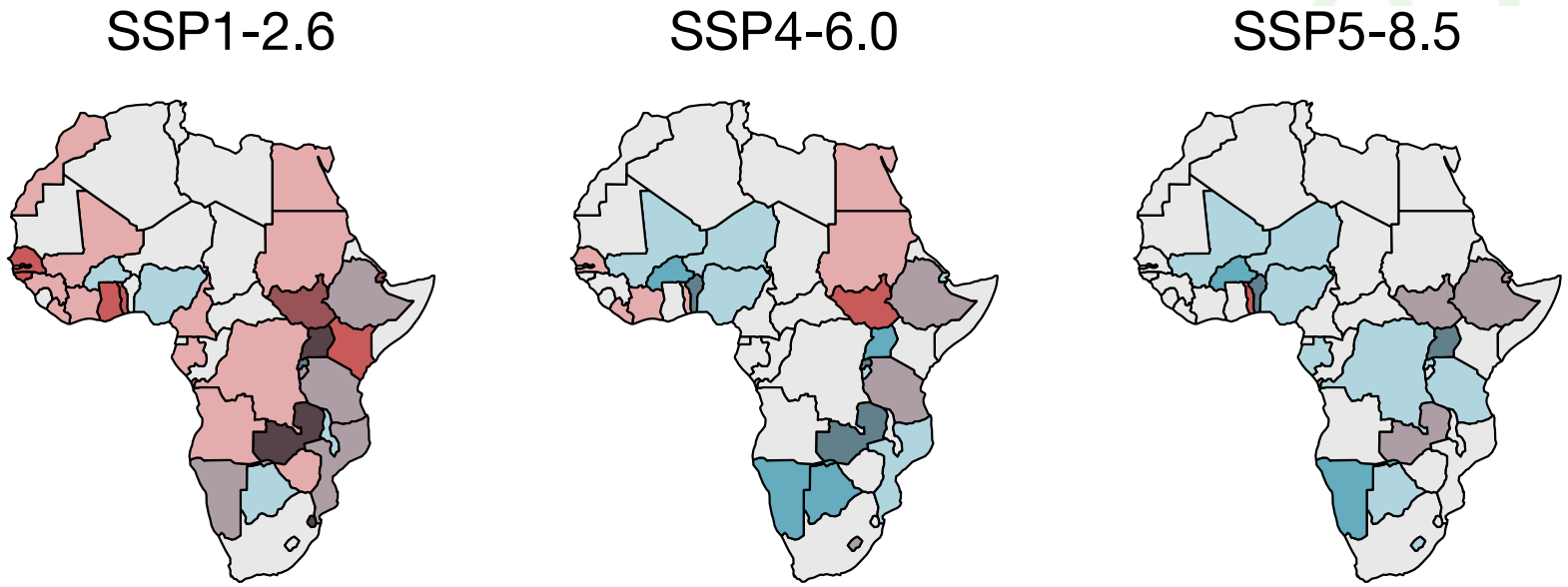




Carlino et al. 2023, Science

HYDROCLIMATIC VARIABILITY GENERATES COST-DEFICIT TRADEOFFS



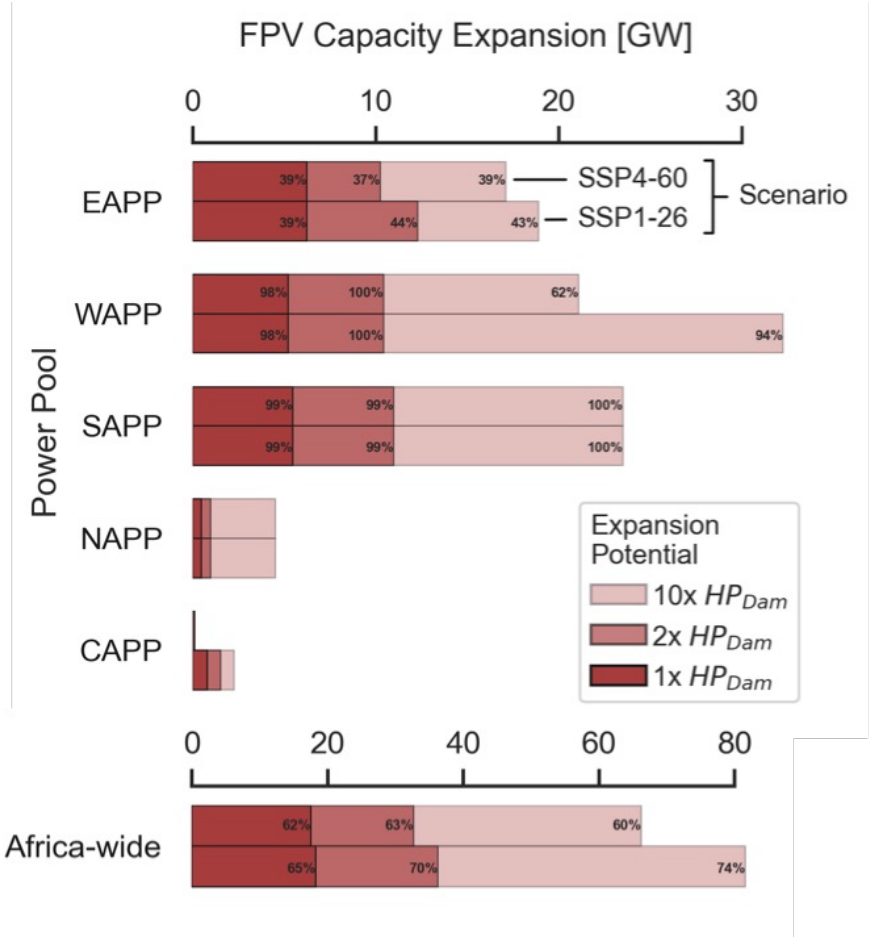


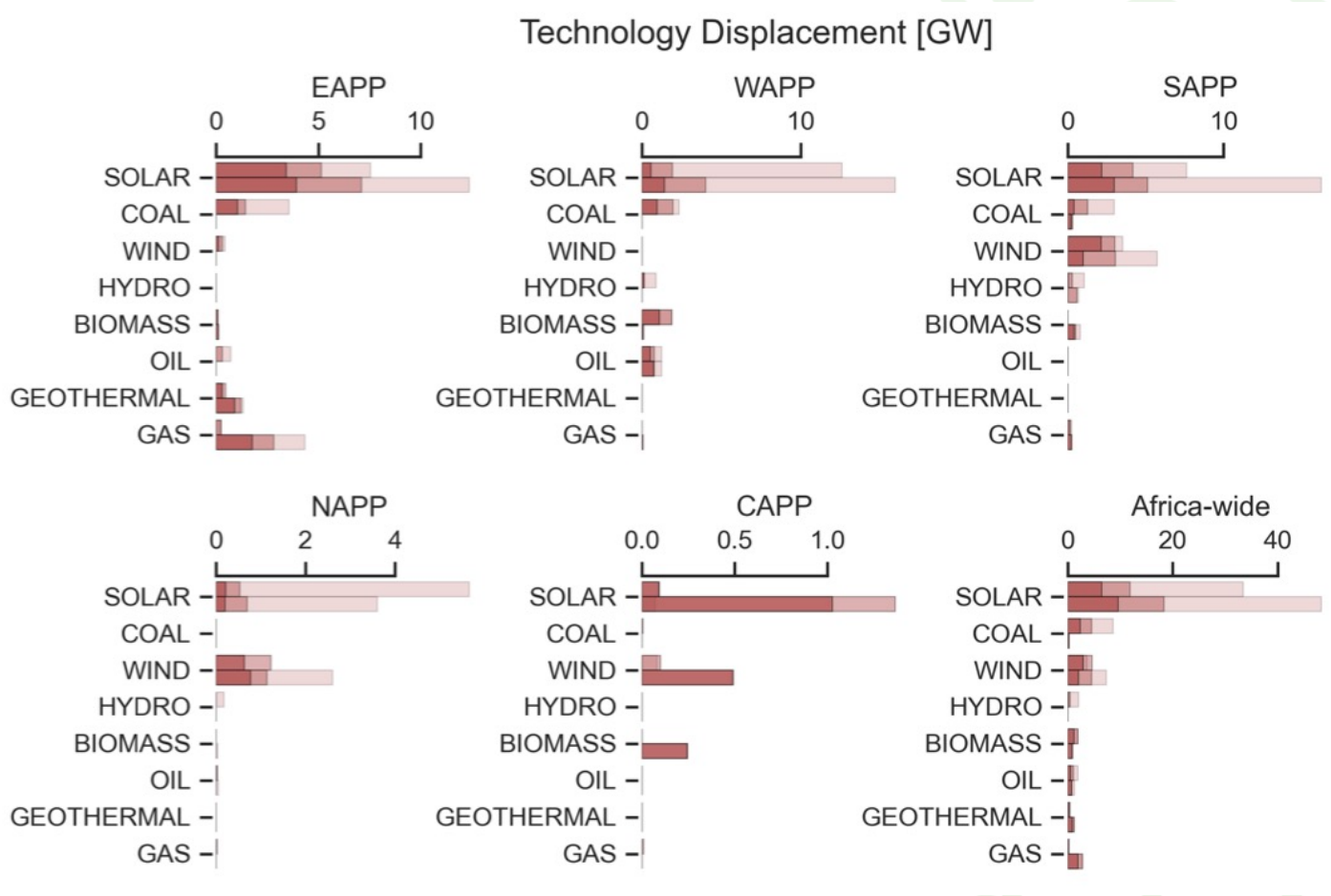
Climate proofing the MED capacity expansion against the DRY hydrology requires a 1.8-4% increase in annual continental investments

Carlino et al. 2023, Science

TECHNOLOGICAL DISPLACEMENT WITH FPV EXPANSION IN OSEMOSYS-TEMBA

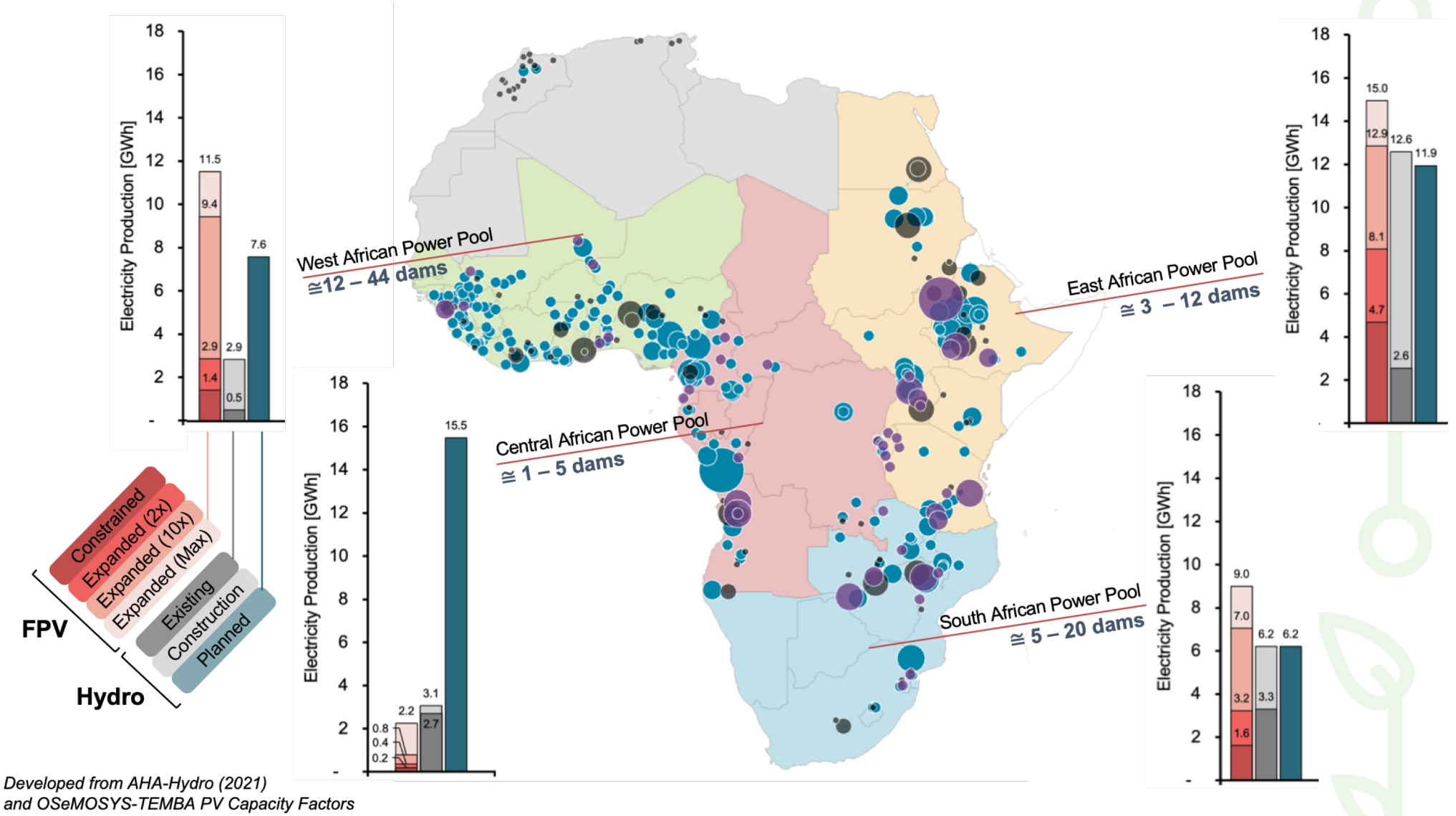
FPV is competitive with other renewables, particularly in the SAPP and WAPP





Arnold et al. 2024, Nature Energy

FPV CAN SUBSTITUTE BETWEEN 20-100% OF PLANNED DAMS



Developed from AHA-Hydro (2021) and OSeMOSYS-TEMBA PV Capacity Factors

Arnold et al. 2024, Nature Energy

TAKEAWAYS

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- The cost competiveness of African hydropower is declining

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- We need to go beyond the river basin scale to study the energy transition

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- The cost competiveness of African hydropower is declining
- We need to go beyond the river basin scale to study the energy transition
- We need to consider global socio-economic teleconnections to explore future scenarios and multisectoral competition

REFERENCES

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POLITECNICO DI MILANO

DEPT. of ELECTRONICS, INFORMATION,
and BIOENGINEERING

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