DRIN NEXUS ASSESSMENT

WATER–ENERGY MODELING

6th July 2021

Polytechnic University of Tirana:
Klodian Zaimi

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Youssef Almulla
Emir Fejzic

In this presentation …

- Part1:
  - Overview of energy systems modeling and various modeling tools
  - Introduction to OSeMOSYS, its key characteristics, inputs and outputs.
- Part2:
  - Overview of the Drin Integrated Water-Energy model
  - The main scenarios and their key assumptions.
  - Introduction to the Hands-on exercise

Part1:
Energy systems modeling and OSeMOSYS

Energy system and planning

The energy trilemma in policy

Sustainability

- What needs to be done to supply modern energy sources to remote areas?
- What needs to be done to increase the share of renewable technologies?

Security

- Should electricity import be allowed?
- Should existing nuclear facilities be closed down?

Affordability

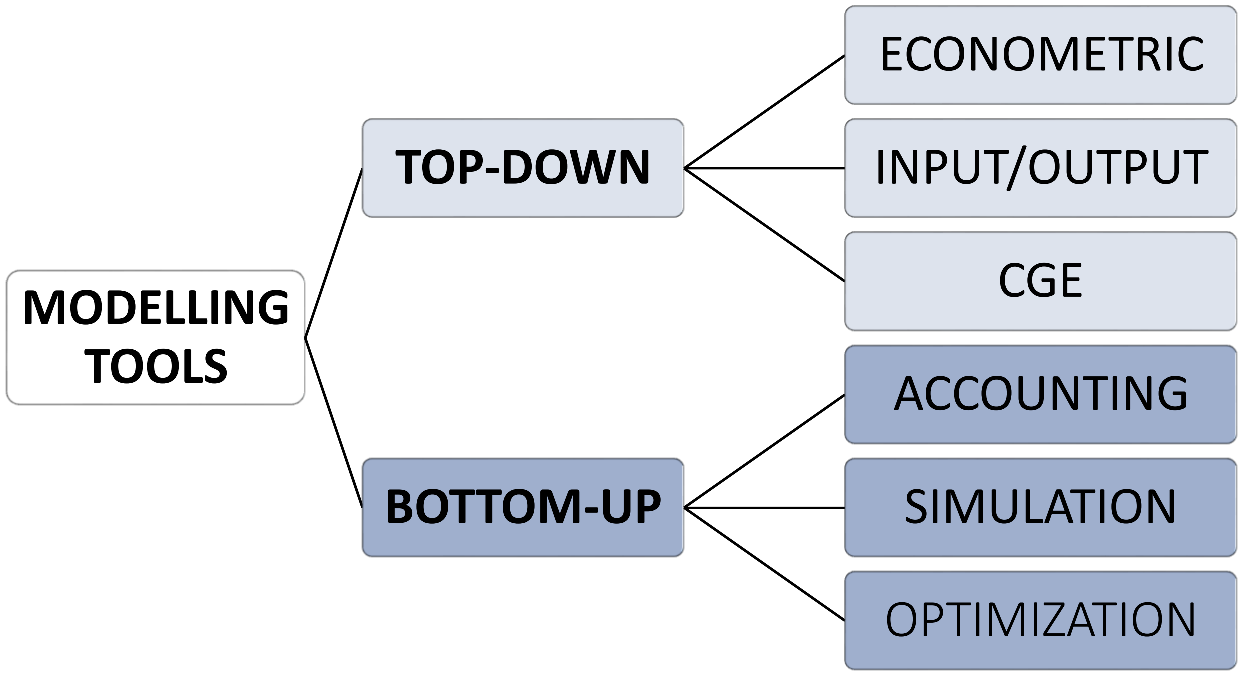
- Can an energy conservation program help in reducing cost of energy supply?

Picture source: Iamme Ubeyou, photo, license under CC 0

Modeling tools are needed to help decision makers and investors understand the potential impacts of decisions aimed to address such questions.

Energy modelling tools

Bottom-up and top-down tools



Energy modelling tools

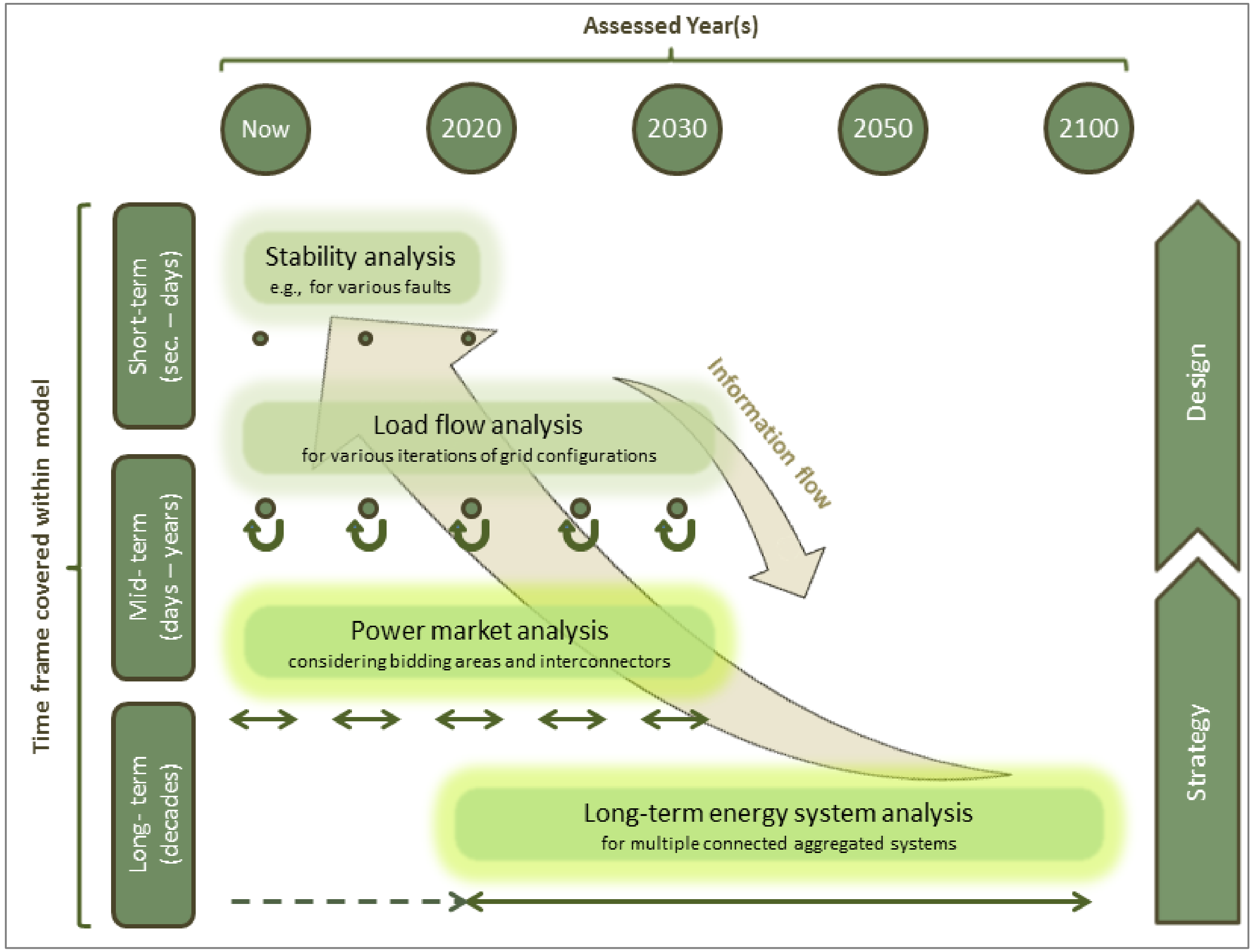
Why use optimization tools?

- **To identify** least-cost energy systems
- **To identify** cost-effective responses to restrictions on emissions
- **To evaluate** new technologies and priorities for R&D
- **To evaluate** the effects of regulations, taxes, and subsidies
- **To project** future greenhouse gas emissions
- **To estimate** the value of regional cooperation

- Investigate scenarios (possible futures);
- Explore alternatives to business as usual practices;
- Inform decisions (policy and strategic planning)

Energy modelling tools

Scope



Picture source: M. Welsch, 2013, I, Author permission

OSeMOSYS

What is it?

www.osemosys.org

Model generator converting the energy system structure represented by equations into a matrix to be solved by specific solvers

- ***Linear optimization***
- Paradigm comparable to MESSAGE and TIMES
- **Freely available and open source**
- Dynamic
- (Usually) Perfect foresight
- (Usually) Deterministic

Reference: M. Howells et al., OSeMOSYS: The Open Source Energy Modeling System: An introduction to its ethos, structure and development, Energy Policy, 39(10), 2011, p.5850-5870

OSeMOSYS

What does it do?

- It determines the energy system configuration with the minimum total discounted cost for a time domain of decades**, <u>constrained by</u>:**

- Demand for commodity (e.g., electricity, heating, cooling, km-passengers, etc.) that needs to be met
- Available technologies and their techno-economic characteristics
- Emission taxations and generation targets (e.g., renewables)
- Other constraints (e.g., ramping capability, availability of resources, investment decisions, etc.)

Basics of OSeMOSYS

Structure

Sets (Components)

- REGION
- YEAR
- **COMMODITY**
- **TECHNOLOGY**
- …

Input data (Parameters)

- Historical capacity
- Annual Demand
- Load
- Efficiency
- Capital, fixed, variable costs
- Emission Activity Ratio
- Availability Factors
- …

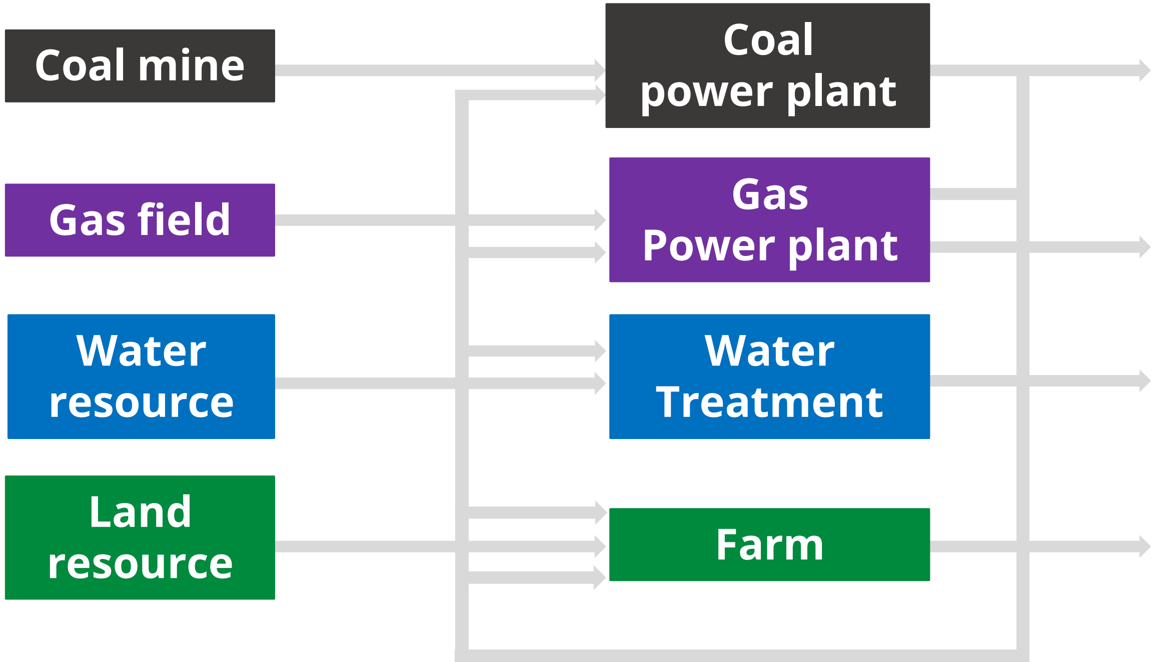
Output variables (Results)

- New Capacity
- Total Annual Production by Technology
- Annual Emissions
- Discounted Costs
- Model Period Cost
- …

Basics of OSeMOSYS

Set: Technology

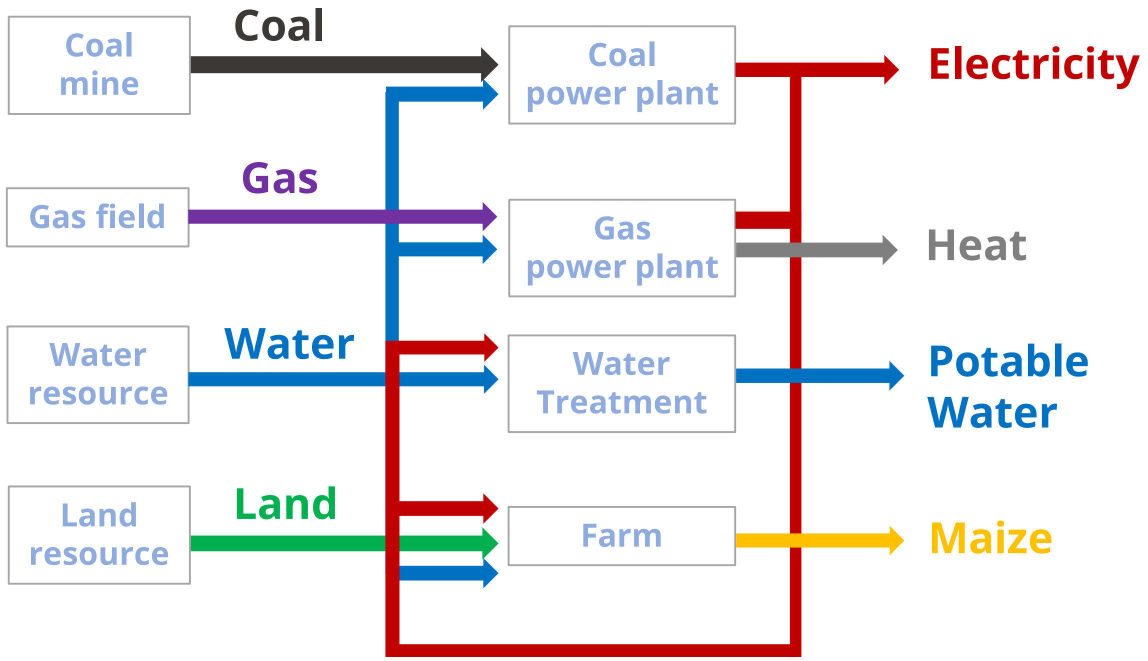
- <u>A technology can be used to:</u>
- Supply or produce a resource
- (e.g., biomass production, natural gas imports)
- Convert one commodity into another
- (e.g., conversion of natural gas to electricity, electricity to light)
- <u>A technology can represent:</u>
- A single process/plant or
- A group of processes/plants with similar characteristics



Basics of OSeMOSYS

Set: Commodity

- Commodities can be used to represent:
- **Flows between technologies**
- (e.g., electricity, natural gas, coal)
- **Final demands**
- (e.g., demand for lighting, cooling, heat, or clean water)



OSeMOSYS

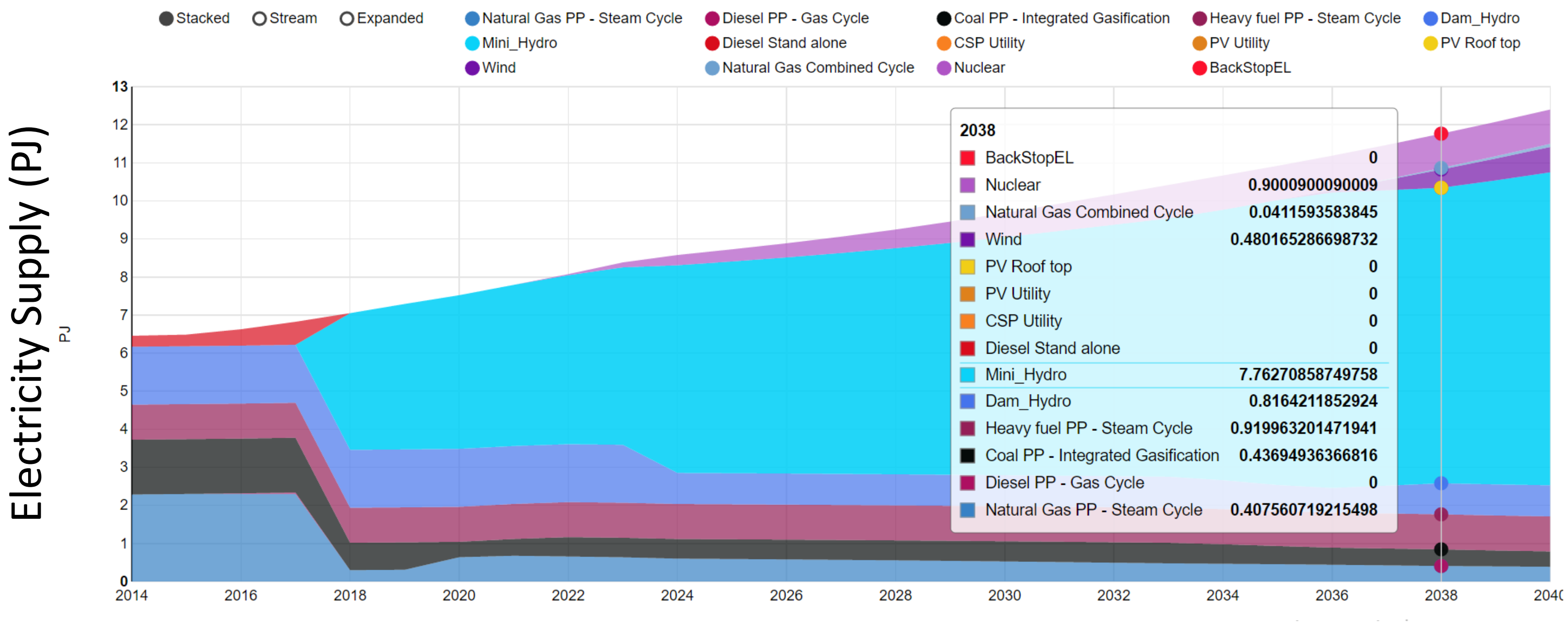
Interpreting its results

- **The results provide <u>insights</u> on questions such as:**

- **Which technologies are phasing out? By when?**
- **What are the optimal investments in new technologies to meet the demand in the future? When is it best to invest?**
- **What are the key generation technologies in the total energy mix?**
- **What costs will the energy system incur?**

OSeMOSYS

Interpreting its results

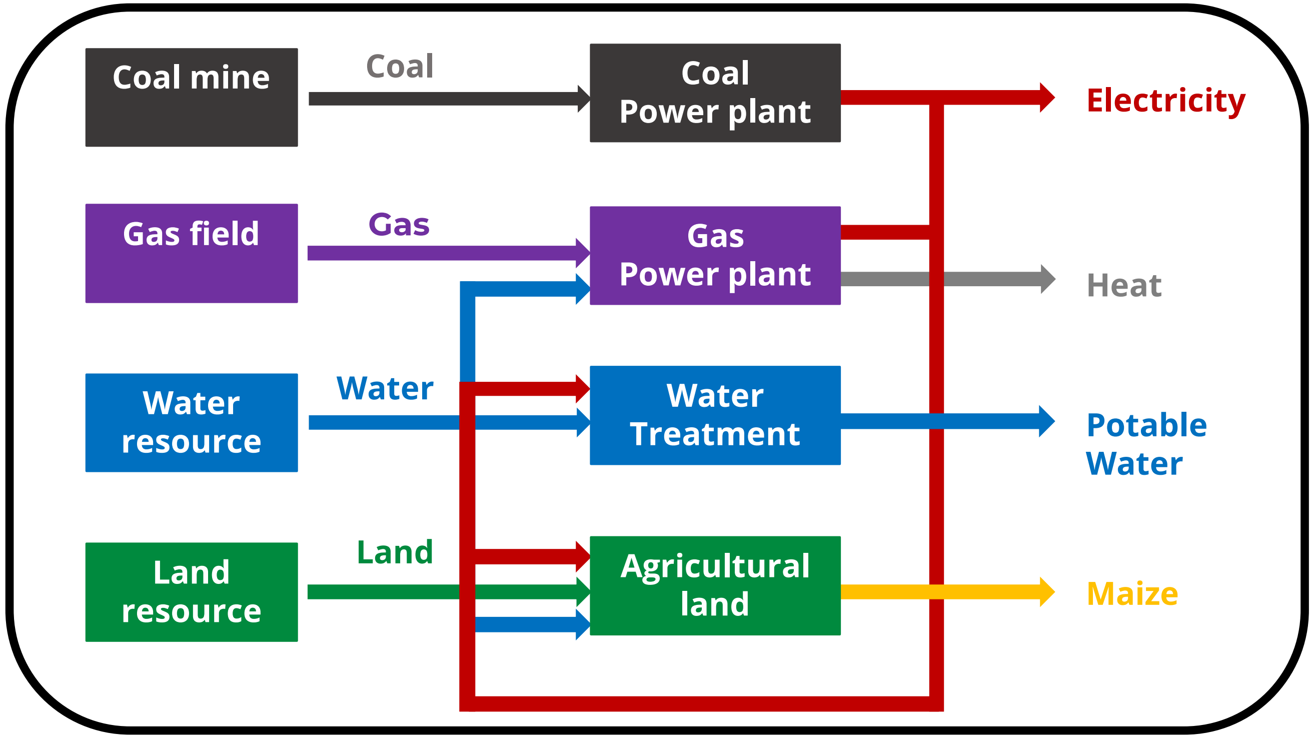


Picture source: Open Energy system Models, image, license under CC-BY-SA 4.0

OSeMOSYS

Use in CLEWs models

- **Minimize:**
- **Total system cost**
- Over a given time period (e.g., 2020 – 2050)
- Subject to a set of constraints (e.g., demand requirements, resource limits)



OSeMOSYS applications

Where and who?

▼ Research and teaching

▼ **Capacity development**

Only some key uses!

Picture source: search.creativecommons.org/, image, license under [CC0 1.0](CC0 1.0)

OSeMOSYS applications

What

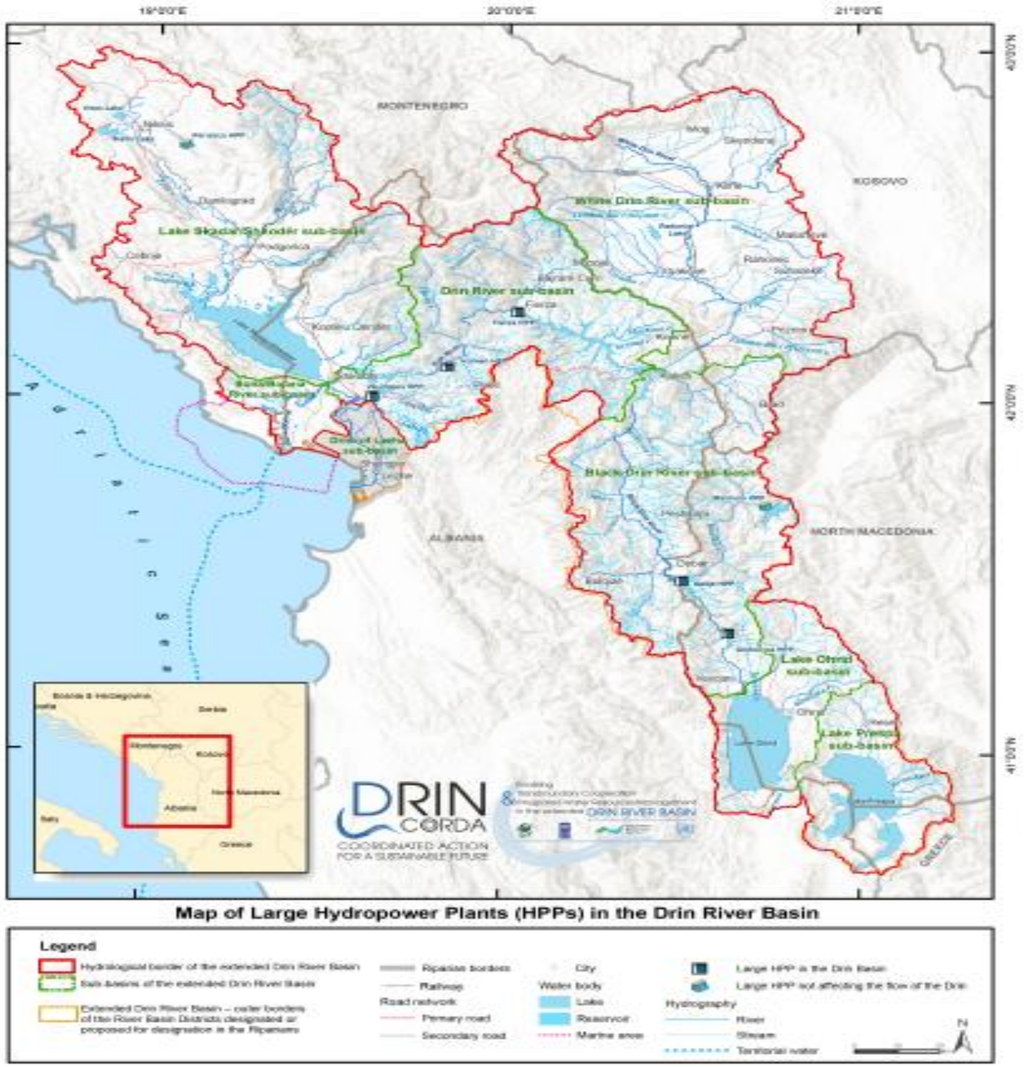
- **TEMBA – The Energy Model Base for Africa. [Link]**
- **IRENA African Power Pools: Planning and Prospects of Renewable Energy.**
- **IEA WEO 2014 – Africa Energy Outlook.**
- **World Bank – Enhancing the Climate Resilience of African Infrastructure. [Link]**
- Among the UN Modelling Tools for Sustainable Development. Link
- **Used by UNECE for assessment of water-energy cooperation benefits in transboundary river basins. [Link]**
- **Used by UNDP, UNDESA in CLEWs technical capacity development programmes for update of Nationally Determined Contributions**

Part2:
Drin Integrated Water-Energy model

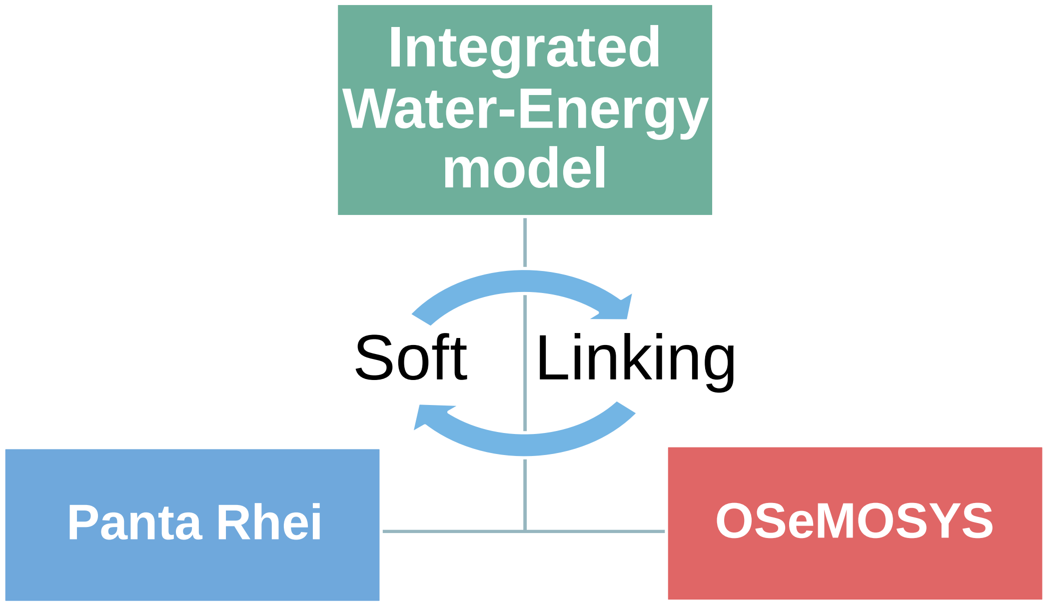
WHAT WE ARE TRYING TO DO?

Aim:

To quantify the costs and benefits of shifting to a **“flood-smart”, cooperative hydropower operation** regime along and between the two hydropower cascades in the Drin basin.



How? (Methodology)



* **Panta Rhei: a** Hydrological Model for the Drin Basin.

* **OSeMOSYS**: **O**pen **S**ource **e**nergy **MO**deling **SYS**tem.

Panta Rhei: Hydrological model

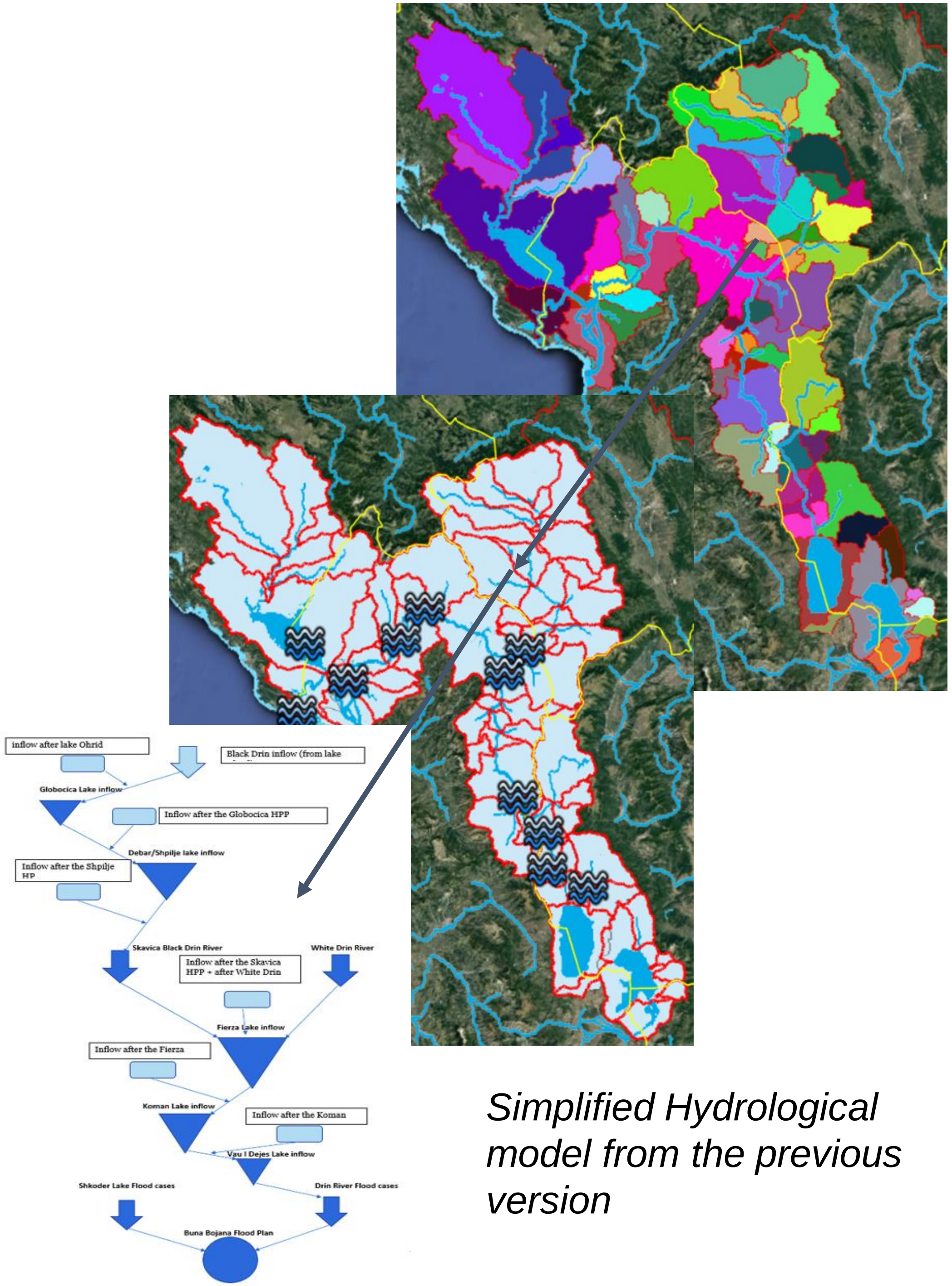
- Application of the hydrological model in around 20 000 km2.
- The model outputs are: rainfall(mm) distribution, ETP(mm), **Volume(m3)**, **Average discharge(m3/s)**

The number of hydrometeorological stations with available data in the tables below:

Sub-basin	Discharge	Water level	Storage elevation curve	Cross-sections	Rating curve
Albania	15	12	1	n.a.	n.a.
Montenegro	5	9	n.a.	n.a.	n.a.
Macedonia	6	6	2	5	n.a.
Kosovo	15	17	n.a.	11	n.a.

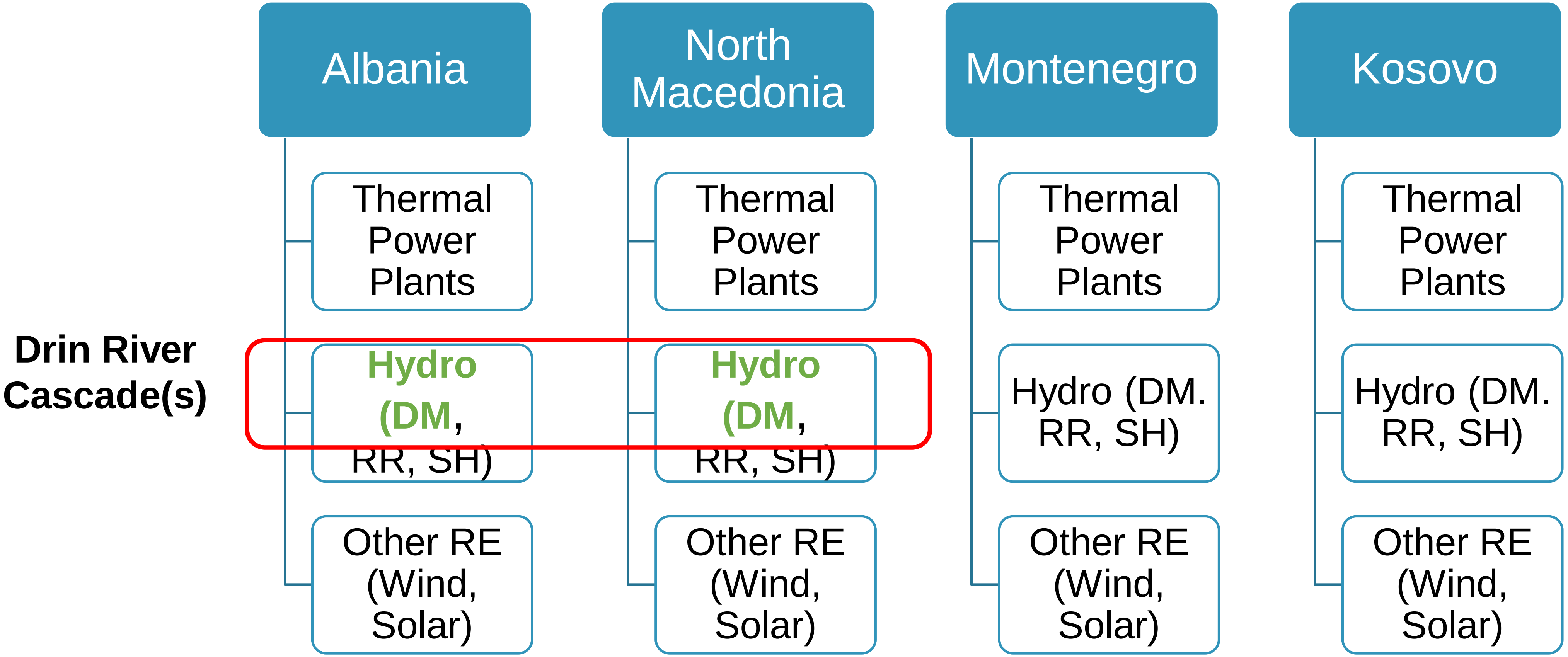
Sub-basin	Precipi-tation	Air temp-erature	Snow	Sunshine duration	Global radiation	Relative humidity	Wind
Albania	31	28	1	4	1	n.a.	n.a.
Montenegro	11	2	1	2	2	2	2
Macedonia	10	4	10	3	n.a.	3	4
Kosovo	2	3	1	n.a.	n.a.	3	3

n.a. time series data are not available.



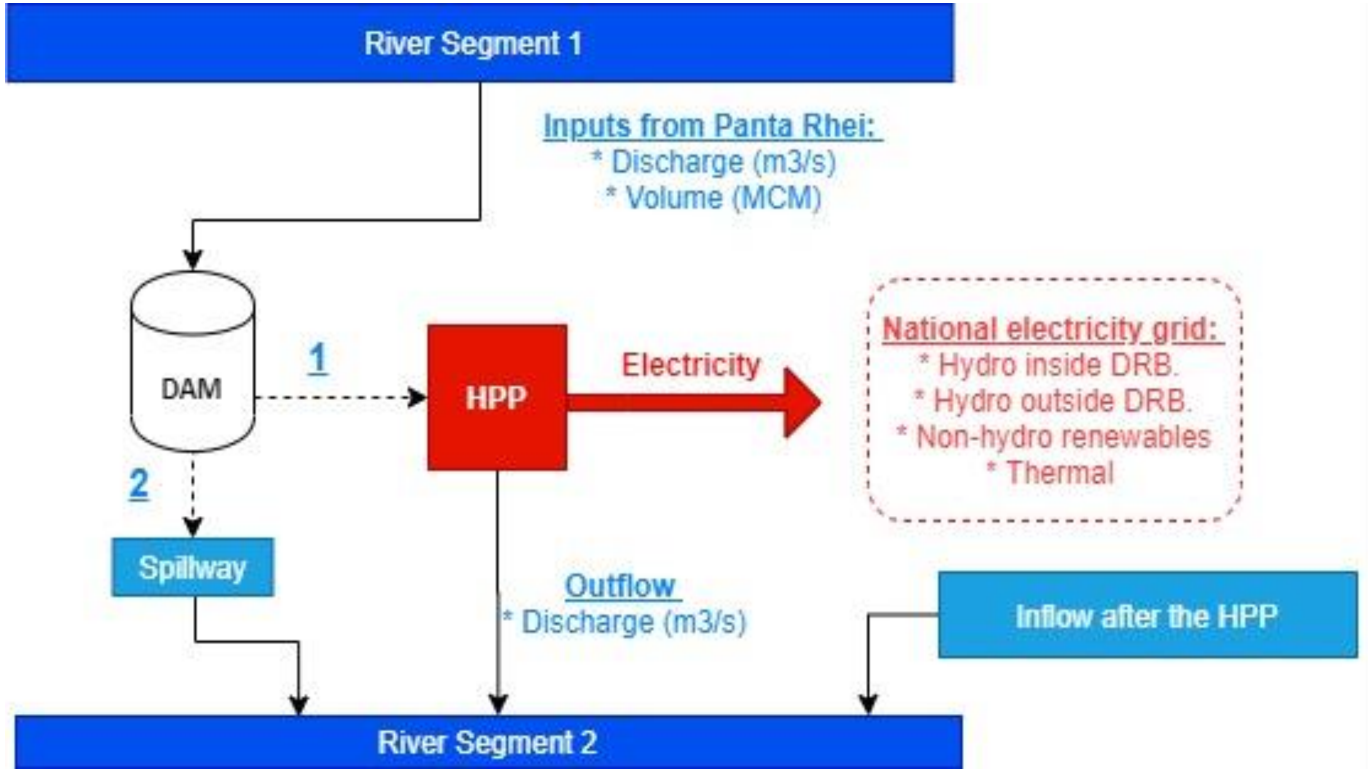
Simplified Hydrological model from the previous version

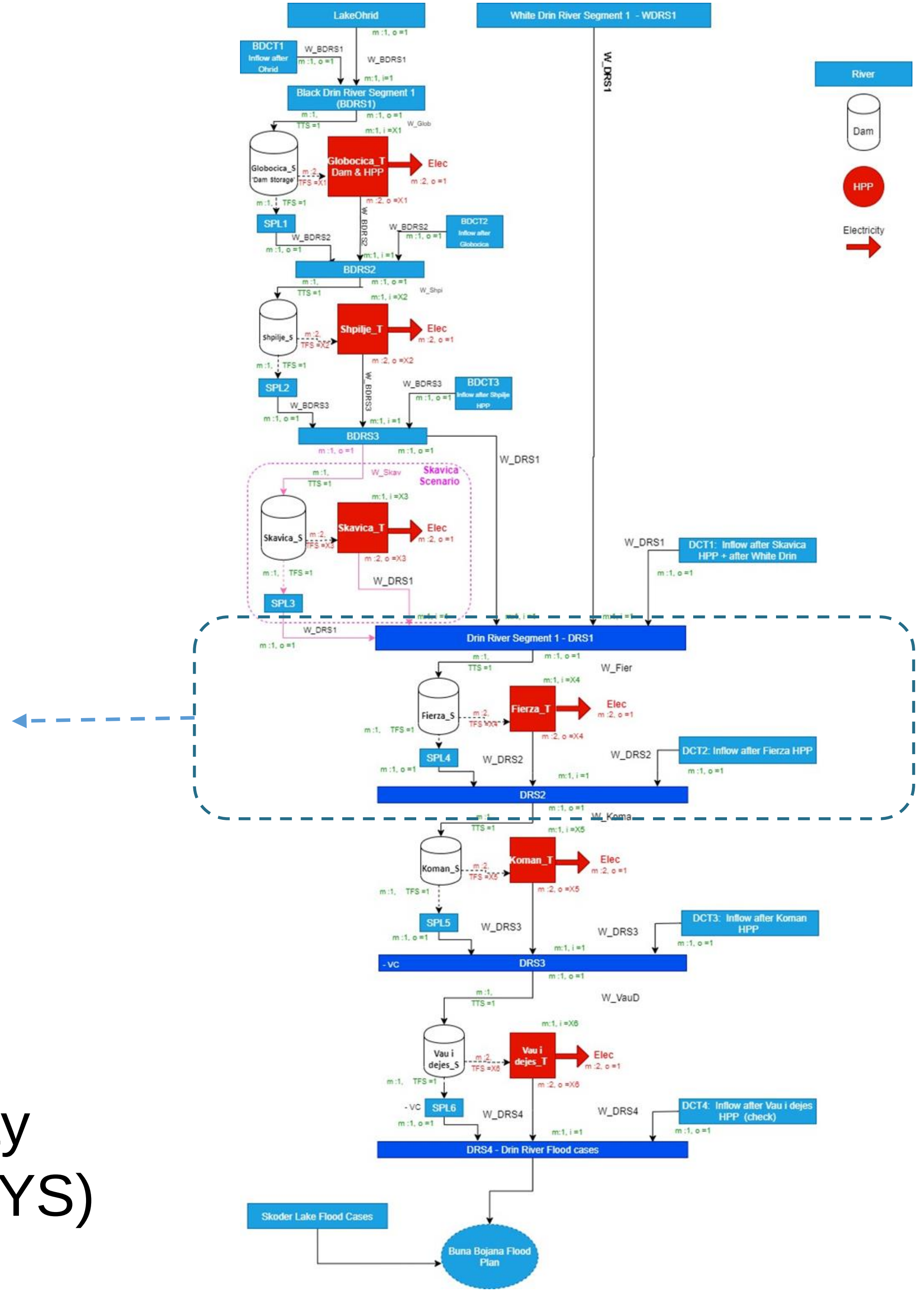
OSeMOSYS: Energy model



* In addition to the above, all power plants are classified into (inside Drin and Outside Drin).

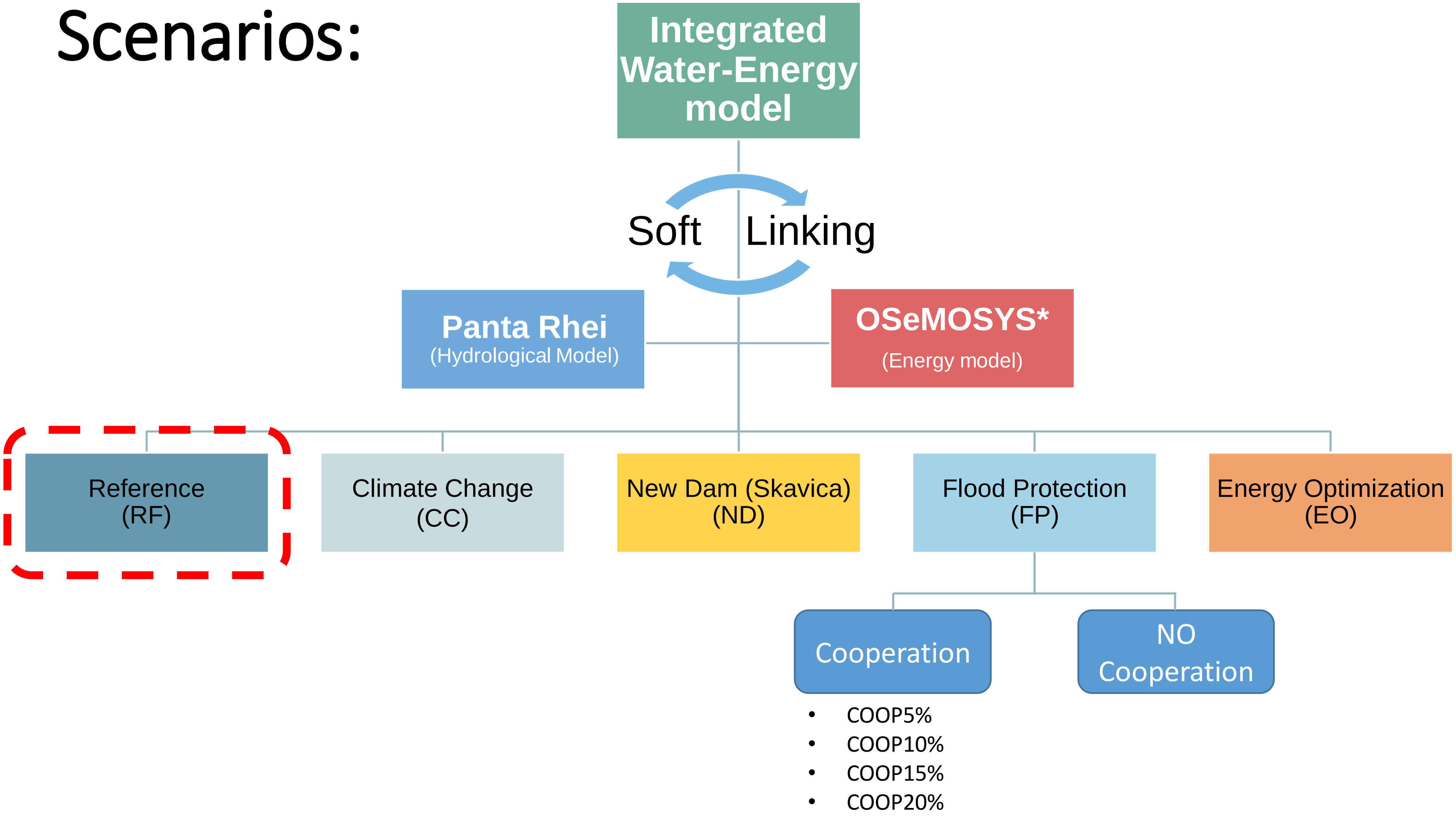
SCHEMATIC REPRESENTATION OF THE DRIN RIVER CASCADES





Change in water availability (Panta Rhei) → Change in Electricity generation (OSeMOSYS)

Scenarios:


Integrated Water-Energy model
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Panta Rhei
(Hydrological Model)
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Reference
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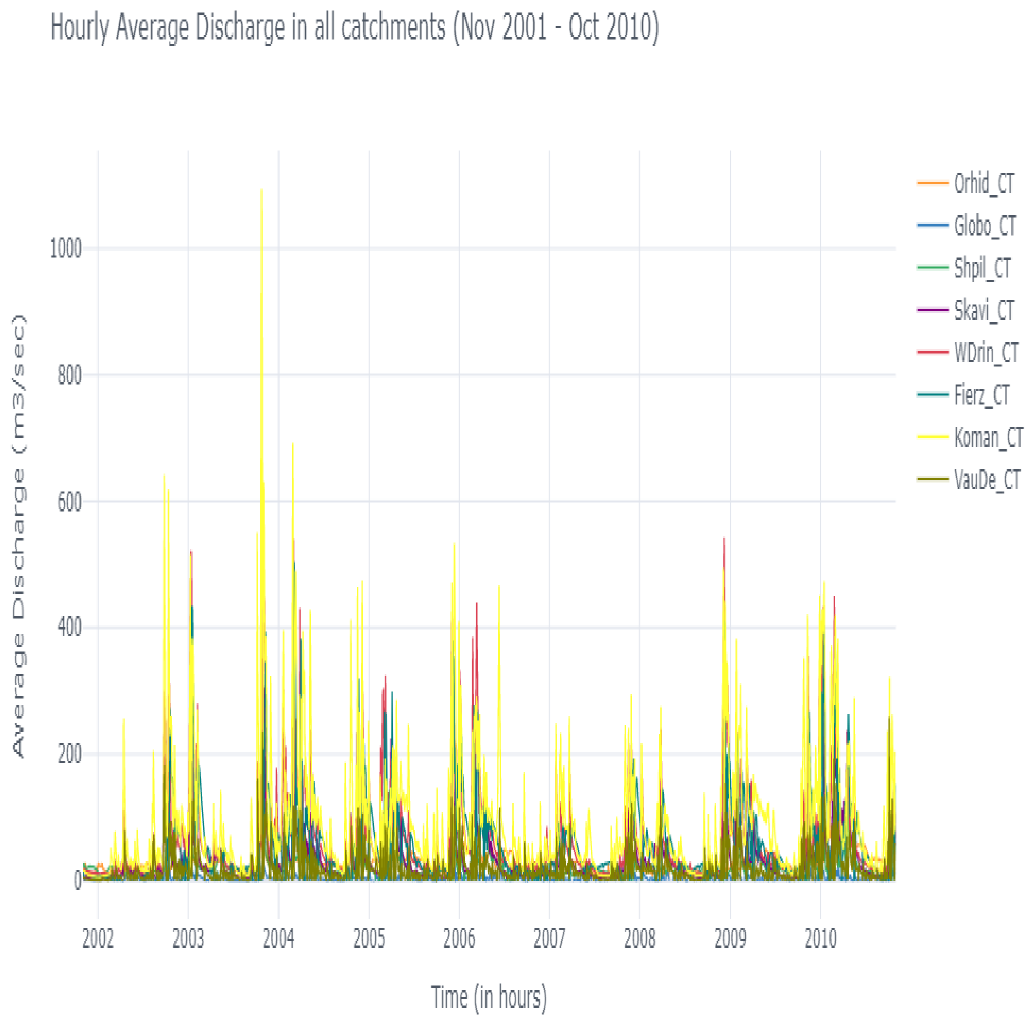
Climate Change
(CC)
New Dam (Skavica)
(ND)
Flood Protection
(FP)
Energy Optimization
(EO)
Cooperation
NO Cooperation
COOP5%
COOP10%
COOP15%
COOP20%

Reference Scenario (RF): Key assumptions

- Represents the current situation in the **four countries**:
  Albania, North Macedonia, Montenegro and Kosovo.
- Flow: the **average discharge** in the river segments based on historical data from 2001-2010.
- Temporal resolution: **weekly representation** (52 weeks), for the period (2020-2050).
- Renewable Capacity factors: are based on hourly data* and separated for inside and outside Drin basin.
- Future investments (**hydro, solar, wind**): are considered as follows:
  - **Confirmed** projects: are **forced** into the model
  - Projects with **no commissioning dates**: are allowed as **optional** capacity investments.
  - Additionally: the **max cap** on solar and wind are **gradually relaxed** after 2030.



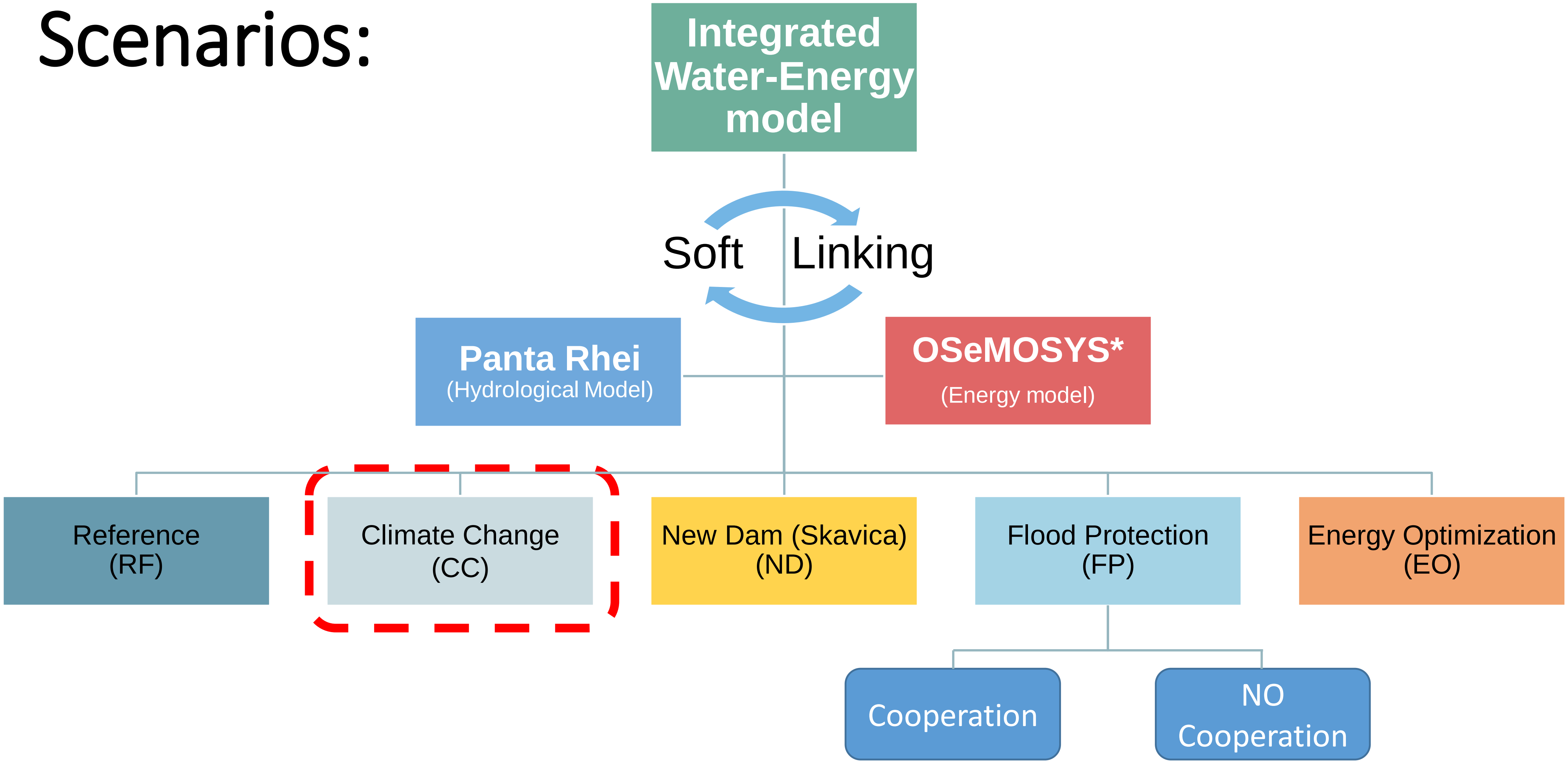
* Source: https://www.renewables.ninja/

Reference Scenario (RF): Key assumptions

- Electricity trade: is modelled in a simplified manner due to lack of data (volumes and prices). One export and one import technology for each country.
- An upper limit on imports for each country was set based on historical records (2011-2018).
- Similar approach was used for all other scenarios.

Source: https://www.eqmagpro.com/

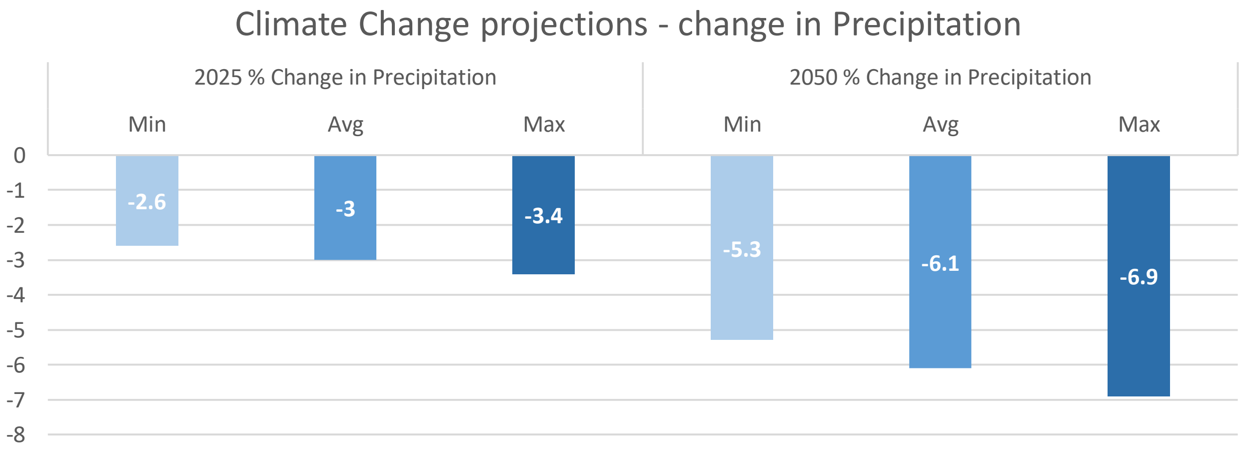
Scenarios:

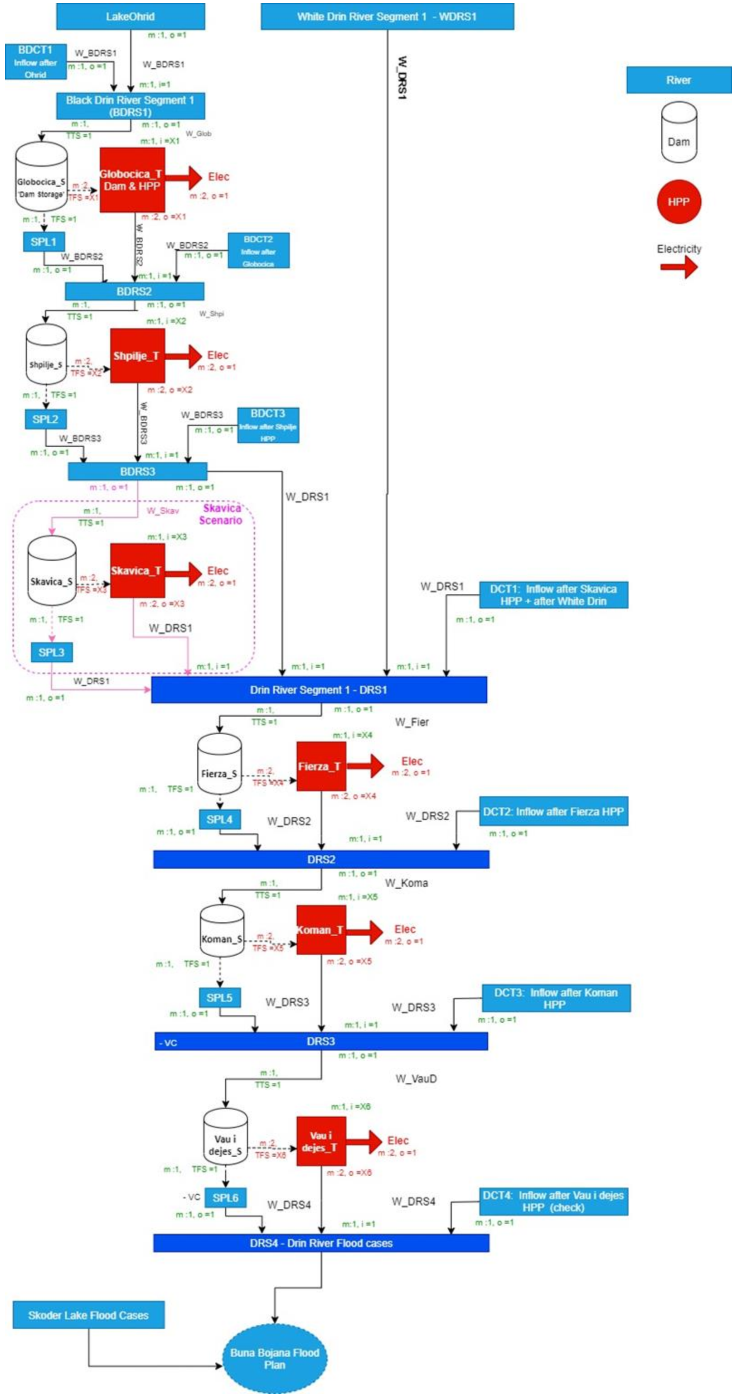


- COOP5%
- COOP10%
- COOP15%
- COOP20%

Climate Change scenario (CC):

- ❖Flow: based on two sets of projections:
  - ❖2025: with avg (**-3%**) change in precipitation.
  - ❖2050: with avg (**-6%**) change in precipitation.
  - ❖ linear decline in water flow assumed between (2021-2025) and (2026-2050).
- ❖ Changes implemented to all ‘catchments’ and upstream river segments.
- ❖ Not included: annual variability in water flow due to climate change.





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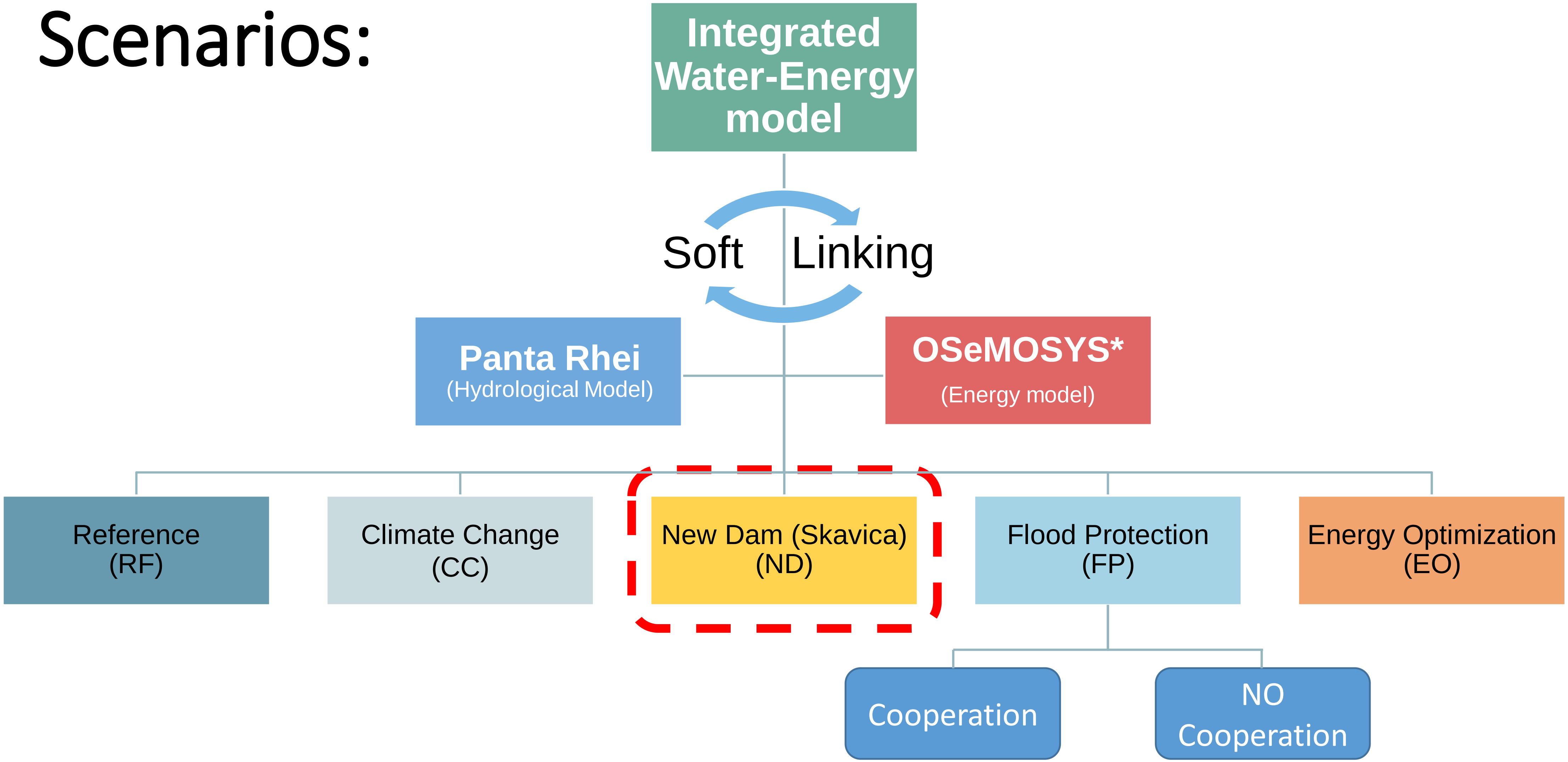
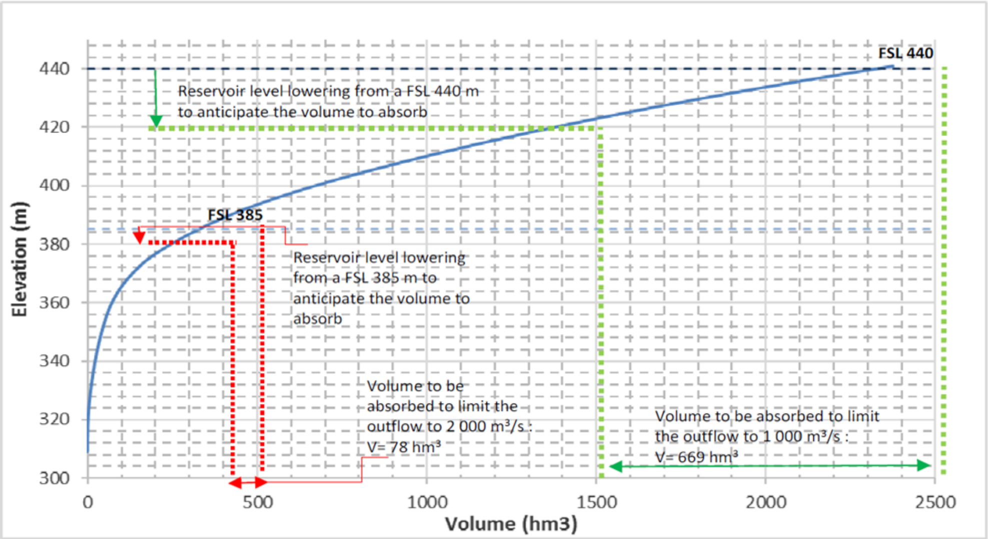
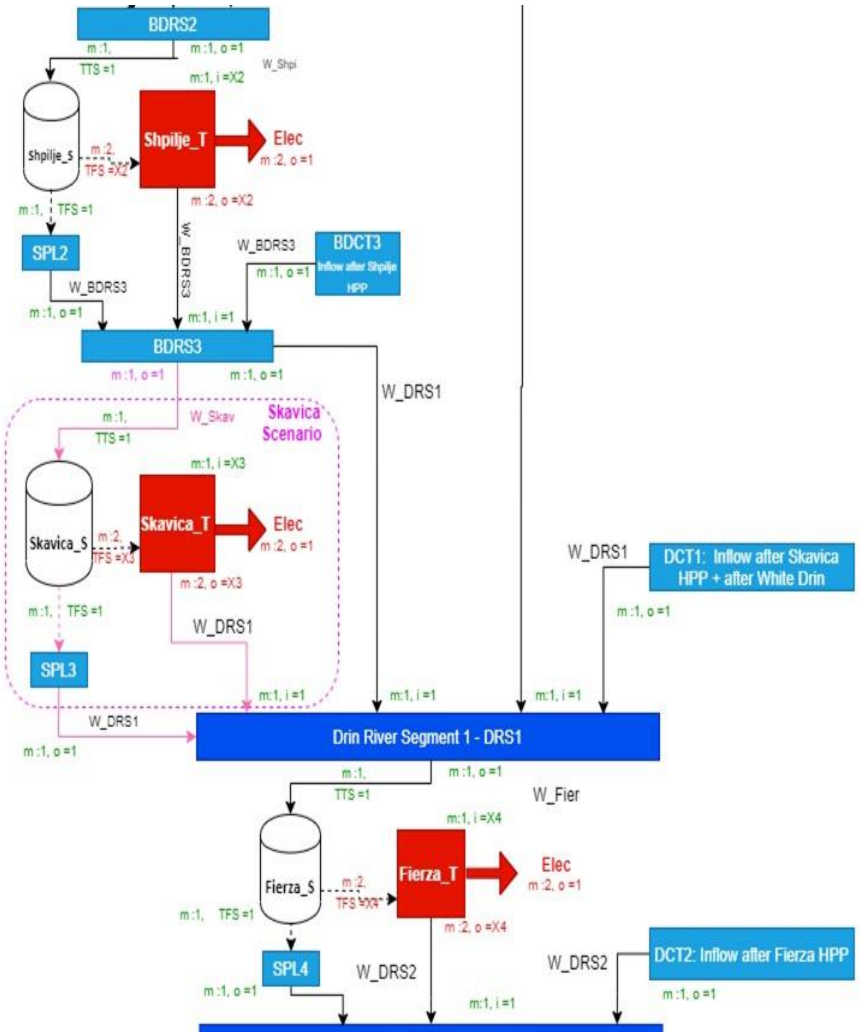


- COOP5%
- COOP10%
- COOP15%
- COOP20%

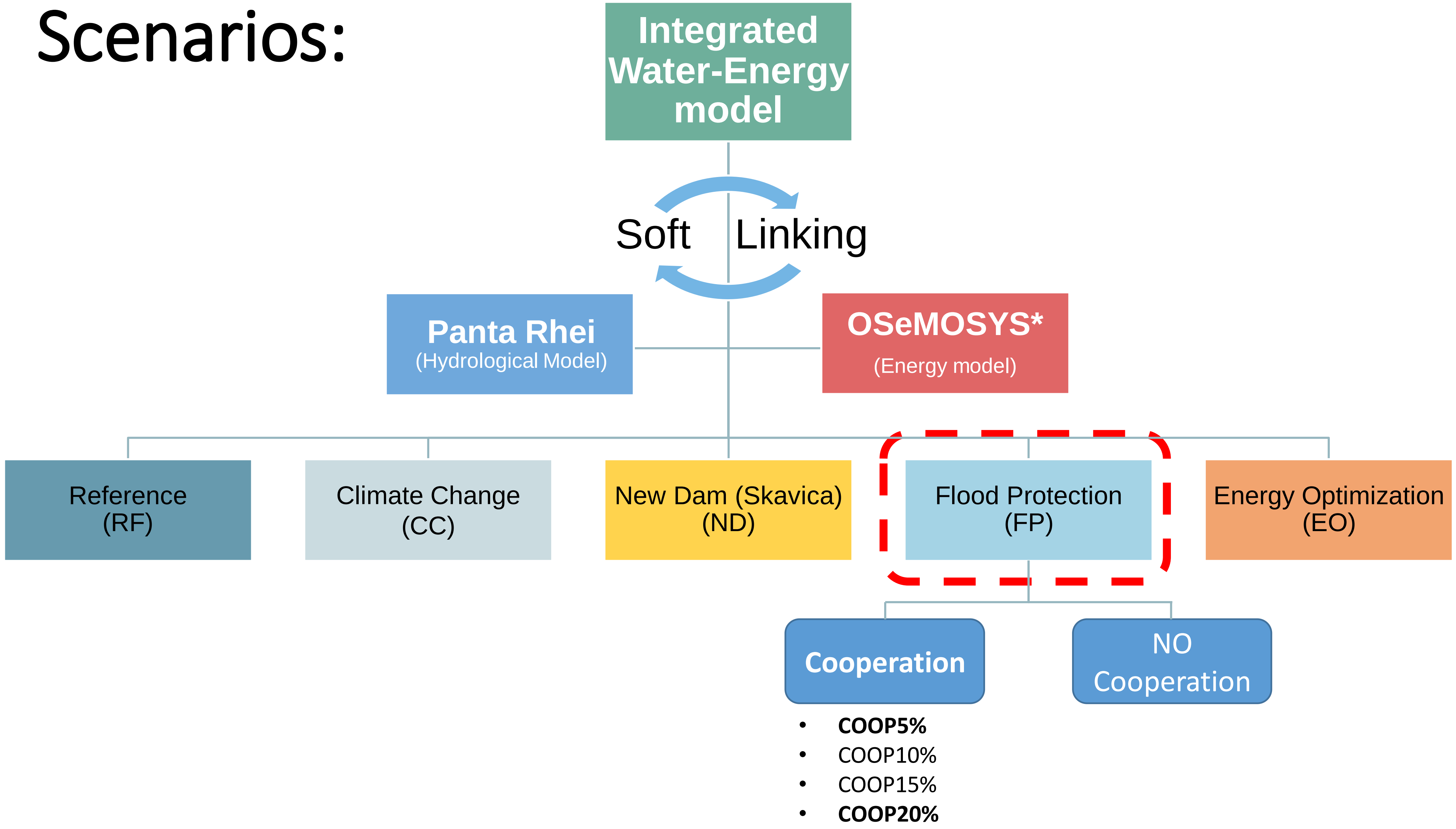
New Dam - Skavica:

Skavica	Data
Capacity (in MW)	**196**
Investment cost	EUR 500 mln
Reservoir size (in Mm3)	**2300**
Installation year	**2025**
Buffer zone area (masl)	441
Spillway capacity	2800
Number of turbines	2
Flow in each pentock in (m3/sec)	87
Project Net Head	140 (around)





Scenarios: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Cooperation
NO Cooperation
• **COOP5%**
• COOP10%
• COOP15%
• **COOP20%**

Flood Protection (FP) scenario:

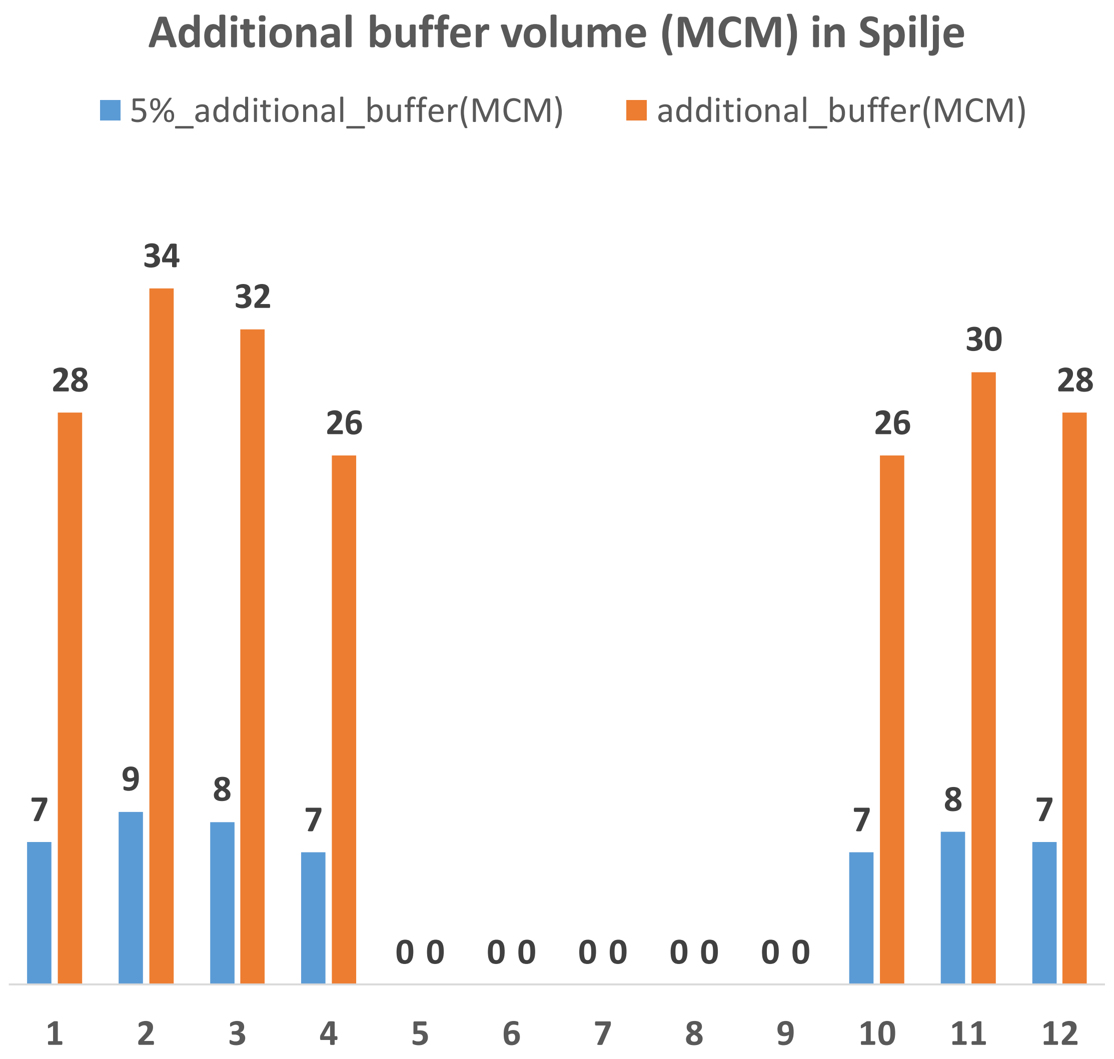
- In this scenario we explore the impact of increasing the buffer volume in certain reservoirs on
  - Electricity generation from HPPs
  - Flood area downstream and flood damage.

- Two reservoirs were chosen (one in each country) to study this scenario:
  - Spilje (N.M): 506 MCM
  - Fierza (AL): 2350 MCM

- Sensitivity analysis: increasing the buffer volume by
  - **5%**
  - 10%
  - 15%
  - **20%**

- Changes were applied in the wet season (Oct-May)

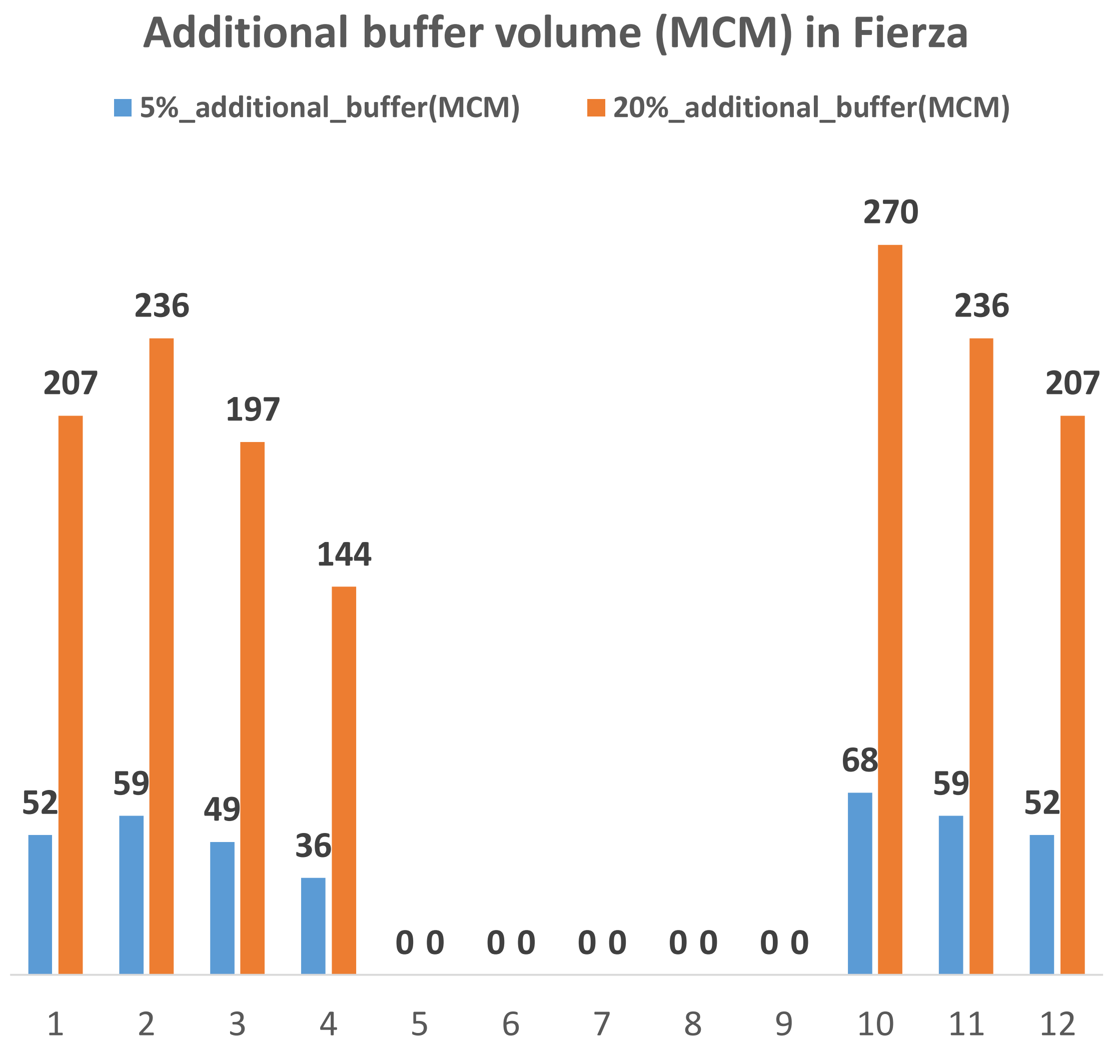
Flood Protection (FP) scenario:



Changes in the water level (masl) under different rules

month	hist_level (m)	level (m) +5% buffer	level (m) +20% buffer	Diff in m (+5%)	Diff in m (+20%)
1	569	566.3	564.7	2.7	**4.3**
2	566	564	562.2	2	3.8
3	567	564.7	563	2.3	4
4	570	567.1	565.7	2.9	4.3
5	576	576	576	0	0
6	578	578	578	0	0
7	576	576	576	0	0
8	575	575	575	0	0
9	572	572	572	0	0
10	570	567.1	565.7	**2.9**	4.3
11	568	565.5	563.9	2.5	4.1
12	569	566.3	564.7	2.7	4.3

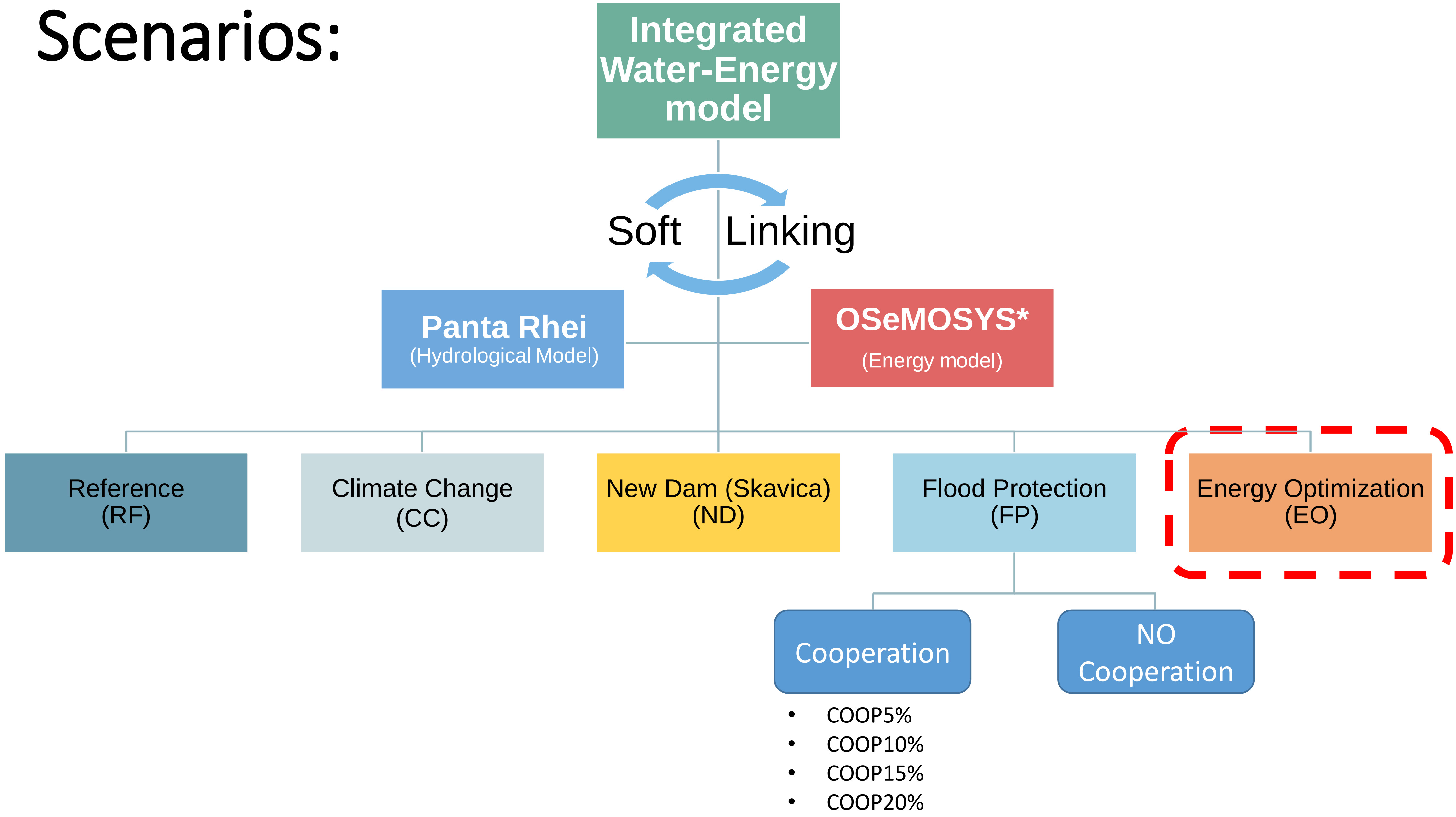
Flood Protection (FP) scenario: Fierza



Change in water level (masl) under different rules

month	hist_level (m)	5%_level (m)	20%_level (m)	Diff in m (5% level)	Diff in m (20% level)
1	279	278.5	275	0.5	4.2
2	276	274.9	270	1.1	5.8
3	280	279.7	276	0.3	3.8
4	285	285.3	283	-0.3	1.7
5	290	290	290	0	0
6	296	296	296	0	0
7	293	293	293	0	0
8	286	286	286	0	0
9	275	275	275	0	0
10	272	270.1	264	1.9	**7.8**
11	276	274.9	270	1.1	5.8
12	279	278.5	275	0.5	4.2

Scenarios: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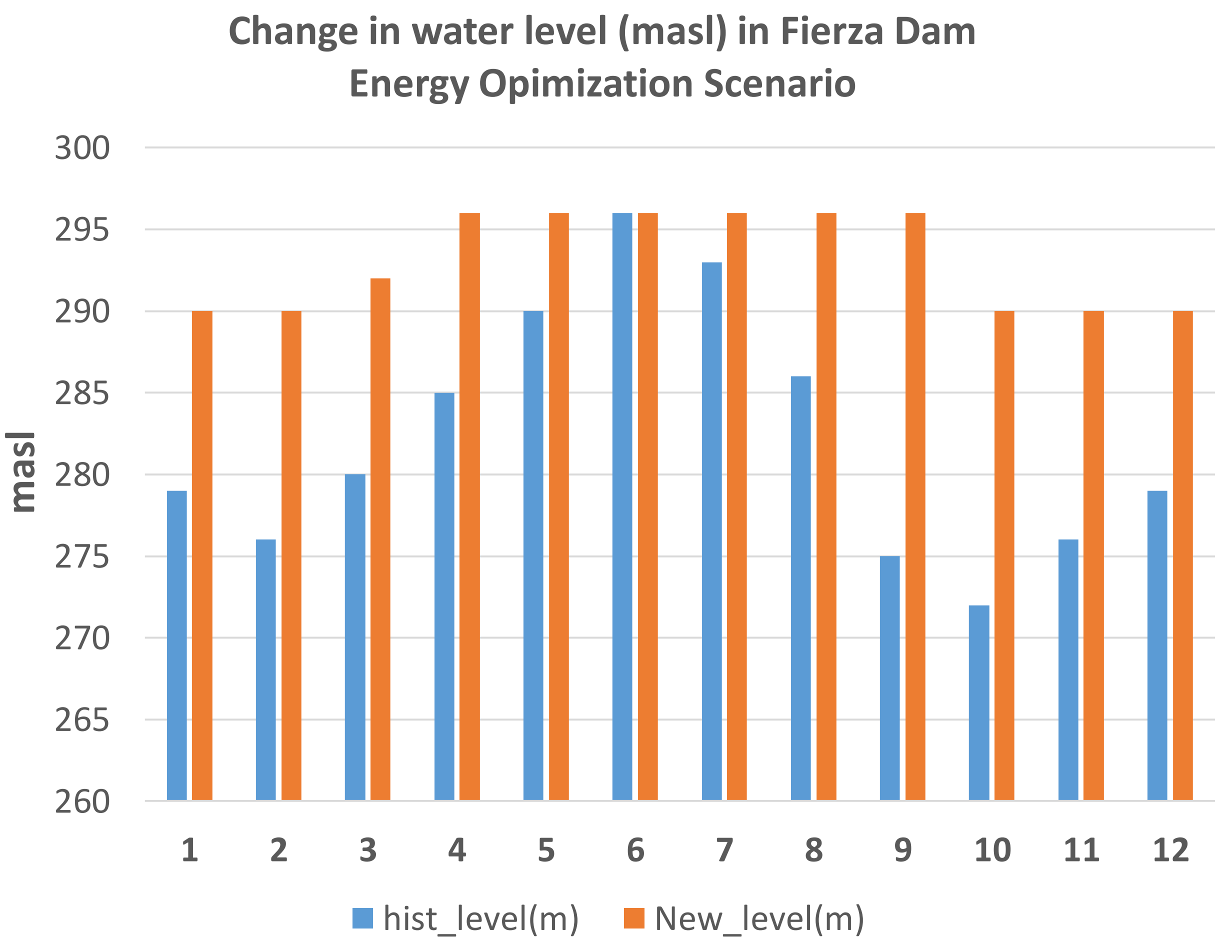
Energy Optimization (EO) scenario: Fierza

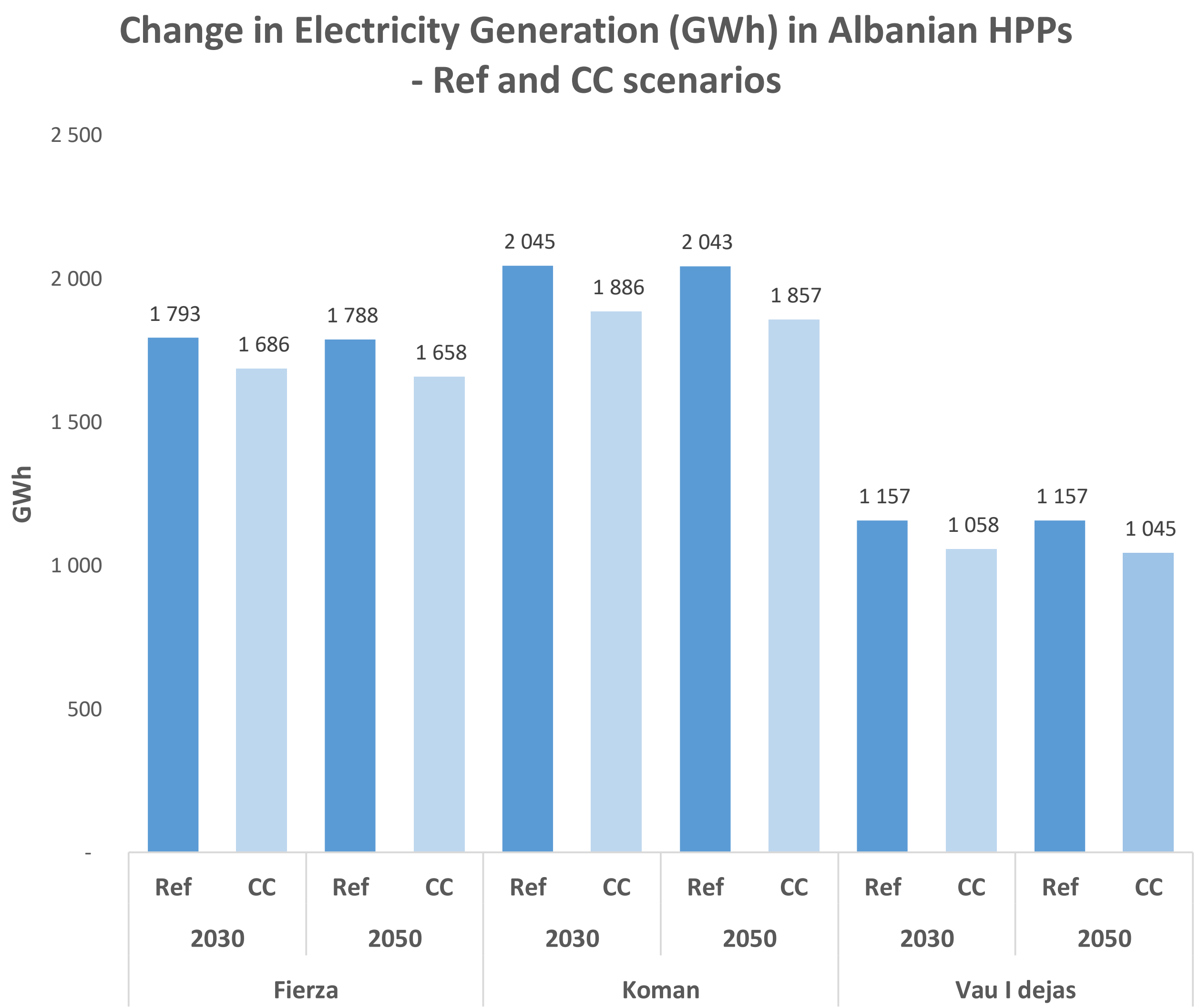
- Increasing the storage level in Fierza dam to the maximum allowed level in the regulations.

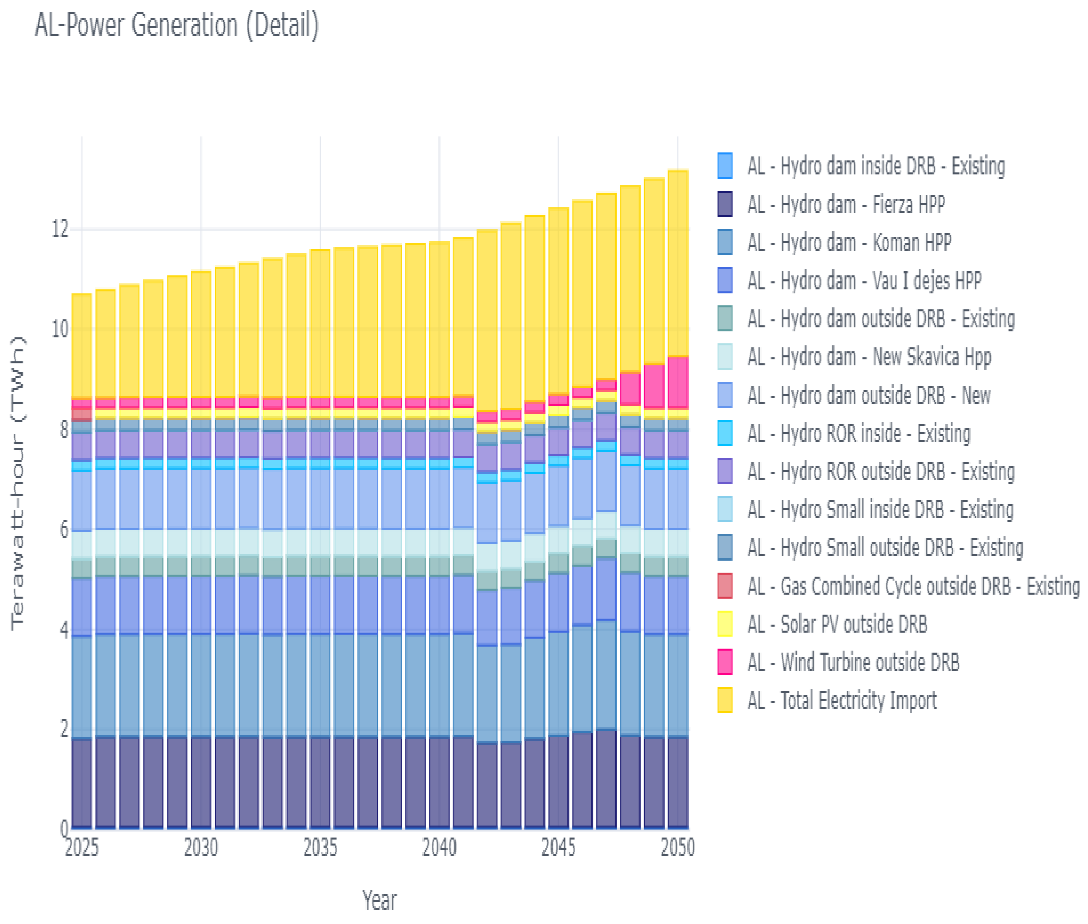
Month	hist_level(m)	New_level(m)	diff(m)
1	279	290	**11**
2	276	290	**14**
3	280	292	**12**
4	285	296	**11**
5	290	296	**6**
6	296	296	**0**
7	293	296	**3**
8	286	296	**10**
9	275	296	**21**
10	272	290	**18**
11	276	290	**14**
12	279	290	**11**



Insights can be driven at:

- The Basin Level
- The National Level





Hands-on exercise:

- In the breakout groups,
- Based on the insights shared in today's presentations, your valuable knowledge in the region and the insights shared in the (**Drin_CB.html**) file; we would like you to **work with your team** and **answer (1-3) of the questions** shared in the (**Drin_CB.html**) file.
- Group discussion: 20-25 min.
- Report back in plenary: 10-15 min.
- Three groups:
  - Groups1 and 2: Albania
  - Plenary : North Macedonia

Hands-on exercise:

#	Group 1	Group 2	Plenary
1	Albi Islami	Eblerta Ajeti	Toni Markoski
2	Euglert Beshello	Aleksandra Dorri	Slavko Milevski
3	Fatjon Zekaj	Djana Bejko	Marjan Glavinceski
4	Elgi Haxhiraj	Elio Voshtina	Vignesh Sridharan
5	Elton Radheshi	Arbesa Kamberi	
6	Enerida Markokaj	Orland Muca	
7	Artur Mustafaraj	Eriona Gega	
8	Jonida Rika	Alban Doko	
9	Fationa Sinojmeri	Francesco Gardumi	
10	Youssef Almulla		

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