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European Renewable Energies Federation

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Case study: The Benefits of Small Hydropower

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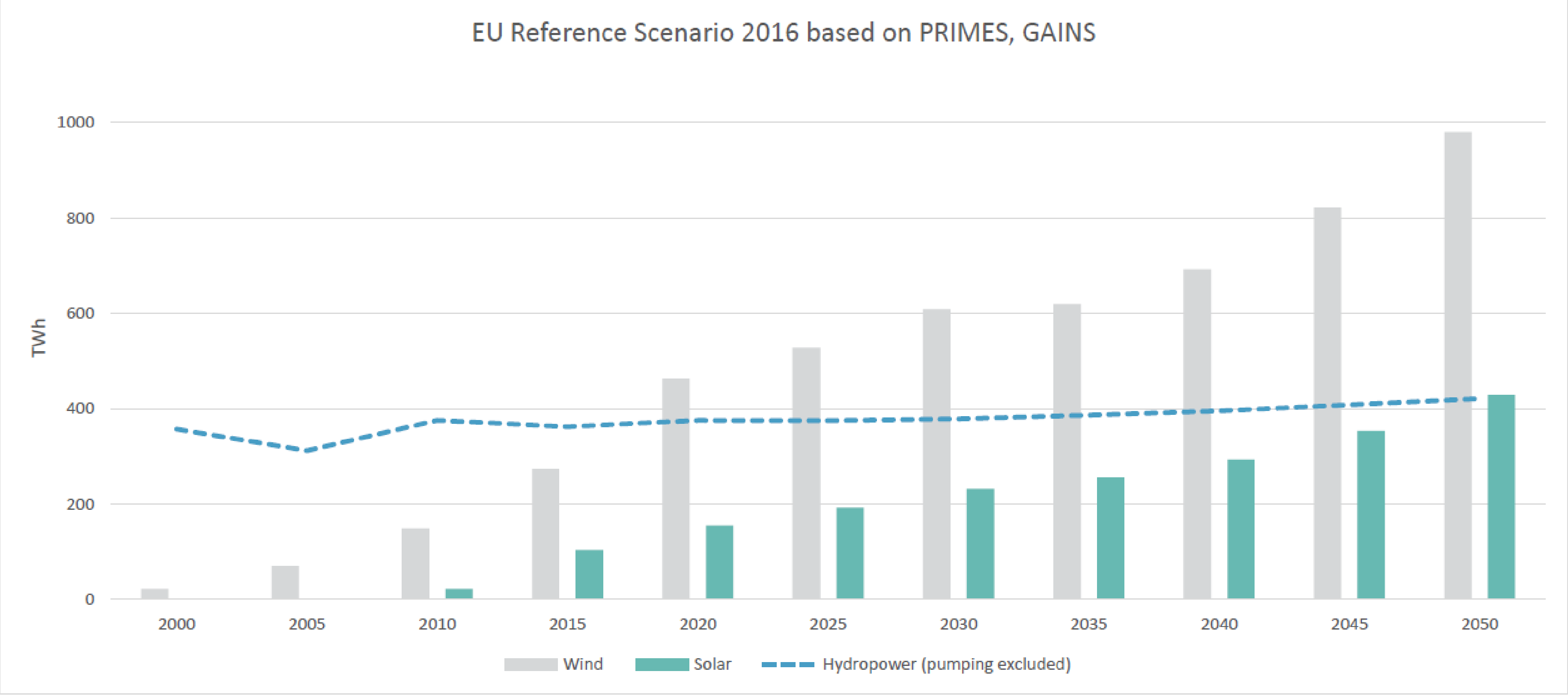
Hydropower in Europe today and in the future (EREF)

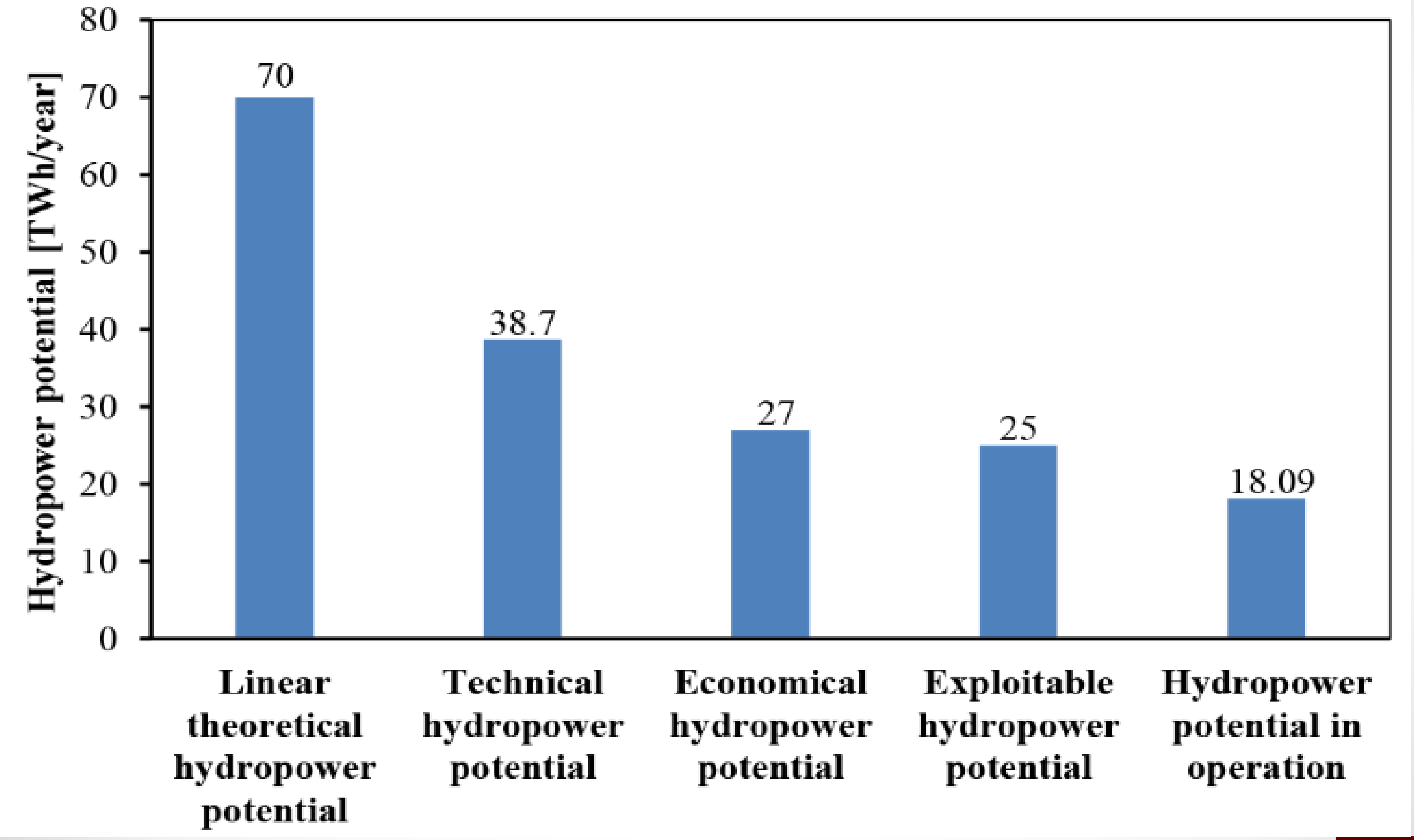
Accelerated development of variable renewables (wind, PV): historical and predicted net electricity generation in the EU-28



Water resources in Romania

- The Atlas of Water Cadastre in Romania lists and code 4,864 rivers with catchments over 10 km^2 and more than 5 km in length, resulting in a total length of these watercourses of over 78,905 km.
- Romania has an installed capacity in hydropower of approximately 30% of the total electricity generating capacity.
- Even if the hydropower potential is quite large, currently only around 6.8 GW are used, representing approximately 50% from the total hydropower potential.
- The highest rate of using the water energy potential is recorded in Banat River Basin, over 90%, followed by Olt River Basin with 84%, while the lowest rate is the one of Jiu River Basin, only 18%.

Values of different types of hydropower potential in Romania



Hydropower plants in Romania

- Romania has 136 years experience in hydropower:

  ~6.800 MW installed capacity in:

  110 HPPs (~6,200 MW), owner HIDROELECTRICA and

  470 SHPPs (~600 MW); installed capacity at most 10 MW),

  from which:

  ~100 owner HIDROELECTRICA and ~370 other companies.

- First SHPP in Romania is Peleș, built on Peleș river in 1884, for lighting the Peleș castle gardens, summer residence of Romania kings, built by the first king, Carol I (1866-1914), in the period 1873-1884.

HIDROELECTRICA owns:

- 104 dams of which 89 large dams (height > 10 m and the volume > 1 Mm^3),

out of which:

8 have height >100 m, the highest being Gura Apelor dam with height = 168 m;

6 have the vol >100 Mm^3, the largest storage is Portile de Fier I, vol=2,100 Mm^3;

- ~ 350 km of headraces and tailrace tunnels;
- ~ 750 km underground under-pressure or free-level galleries;
- ~ 650 km contour dams (dykes) at the storages with a permanent retention;
- 143 secondary catchments;
- 129 buildings of HPPs with installed capacities over 4 MW.

The EU Energy Union: transformation of Europe's energy system (EREF)



- Current status: fossil fuel and nuclear based, national, central energy system with oligopolies
- Transformation to: renewable energy and energy efficiency as centre piece for a new EU energy system
- Creation of an integrated European energy market
- Decentralised and flexible energy system with multitude of independent power producers, paired with large scale RES provider
- Regional cooperation and projects
- Demand-side management
- Storage

Benefits of hydropower for the new energy system (EREF)

- Hydropower offers whole range of system services
- Hydropower is THE flexible tool in the system without CO_2 emissions in operation
  - Back-up and reserve capacity
  - Quick-start and „Black-start" capability
  - Regulation and frequency response
  - Voltage support
  - Spinning reserve
- Energy storage
- Hydro Pump Storage is currently the most cost-efficient form of energy storage and cost-efficient way of providing flexibility

Key topics of EU Energy Union for SHPPs (EREF)



- 2030 renewable energy target
- Prosumer, energy communities and cooperatives
- Decentralisation
- Regional cooperation
- **Storage and balancing**
- **Intraday and common balancing markets**
- **National remuneration schemes for SHPPs**
- Priority access and dispatch
- Structured phase out of conventional and nuclear power

Key topics of Water Framework Directive for SHPPs (EREF)

- Permits for new power plants
- No-go areas vs. site specific approach
- Investments for environmental impact assessment and mitigation measures
- Residual flow obligations

The EU small hydropower sector (EREF)

- More than 35,000 direct jobs
- Around 4,200 enterprises
- Ca. € 3 billion of annual turn-over
- Produced electricity for more than 13 millions households
- Corresponds to around 8% of electricity produced by renewables
- Avoidance of ca. 29 millions tons of CO_2
- Development potential

Potential future of (small) hydropower operations (EREF)

- SHP in EU: active market with possibilities for mergers and acquisitions
- However: current framework conditions at EU and national levels hardly provide incentives and business cases to invest in new plants
- Existing plants:
  - Necessity for efficiency measures
  - Upgrading and refurbishment of existing plants with new technology and environmental mitigation measures

Potential future of (small) hydropower operations (EREF)



- Different operation schemes for hydropower plants
- Potential business case for new energy market design: combination of hydropower and battery storage
- Most likely: flexibility as priority until 2030
- Most likely: storage and pumped storage (between 2030 and 2050)
- Prerequisite for hydropower storage: increased inter-connections between European regions
- Remuneration for other hydropower services (balancing, grid services, etc.)?

Advantages of HPPs

- Renewable energy supply without the direct emission of CO_2 and with energy pay-back during its technical lifetime
- Very good efficiency
- Flexible and timely response to peak energy demands; production can be easy adapted to the demand
- In-country energy, creating jobs and financial resources in remote areas (taxes and concession fees)
- Improvement of infrastructure along with potential for recreational and tourism activities
- Contribution to flood and drought protection
- Facilitating navigation on the large rivers in Europe

Advantages of SHPPs

- From an operational point of view – ease of operation resulting from the introduction of remote monitoring and control, with the scope of reducing the personnel involved in operational activities that are limited to ordinary and extraordinary maintenance.
- It is sometimes convenient to build pico-facilities, to provide energy for shelters or isolated dwellings, for example. Small watercourses, creeks and streams are exploited with minimally invasive applications that become part of the natural environment with small civil and/or control works that manage to contribute a few kW, which is often enough to power a refrigerator, a radio or the lighting in a shelter or cabin.
- Energy recovery. Wherever there are dissipative systems, such as control points and flow regulation (disconnection tanks, spillways, sleepers, dividers, gates) with water drops, a turbine for the recovery of current energy can be installed.

Advantages of SHPPs

- Minimal environmental impact: zero emissions of CO_2;
- High energy efficiency (about 80-85%);
- Continuous source of energy that allows the reduction of supply from sources subject to significant fluctuations in price, such as fuels;
- Reliable, mature technology and competitive costs;
- Approval and licensing processes that are generally simpler than those for large-scale facilities;
- Relatively short construction times.

Potential for development for SHPPs:

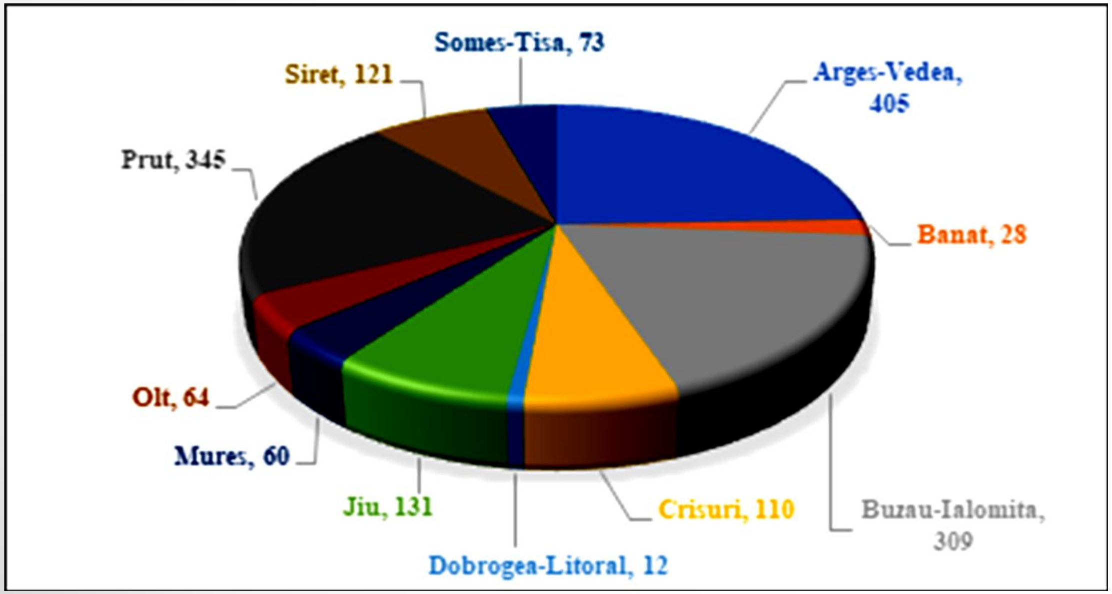
- Rehabilitation, refurbishment, modernization
- Hidden hydro – add SHPPs in existing infrastructure for water use
- New green field projects ?

Hidden Hydro

Prepared in UPB with: Liana Ioana Vuta, Gabriela Elena Dumitran, Mihaela Amalia Diminescu, Eliza-Isabela Tica

- Since the possibilities to develop new large hydropower plants are limited (few spots available, environmental issues and limitations, etc.) focus have shifted to new, minimally invasive opportunities for hydropower developments, which are hidden in plain sight.
- Today, there are many new hydroelectric systems which can be used in existing structures (e.g. non-powered dams or pipelines) to provide electricity.
- This paper presents an estimation for the gain of energy that can be obtained by empowering existing non-powered dams in Romania.

- The 50% of the hydropower potential currently unexploited are mainly due to relatively high costs of large hydropower developments and to environmental restrictions which become more and more drastic.
- Romania has over 1,600 water storage facilities which are not currently used for electricity production and the water volume corresponding to these facilities is of 1,621 Mm^3.



Number of permanent water storage facilities in Romania

- Gross head varies greatly, from 2 to over 40 m, but most of the facilities have a gross head of 3 to 7 m.

METHOD

- In order to compute the quantity of energy corresponding to these existing permanent storage facilities has been used the equation of the theoretical linear hydropower potential for a river reach:

$$E_{b_{1\text{-}2}} = 0.002725 \cdot V \cdot H_{b_{1\text{-}2}} \text{ [kWh]}$$ (in terms of energy)

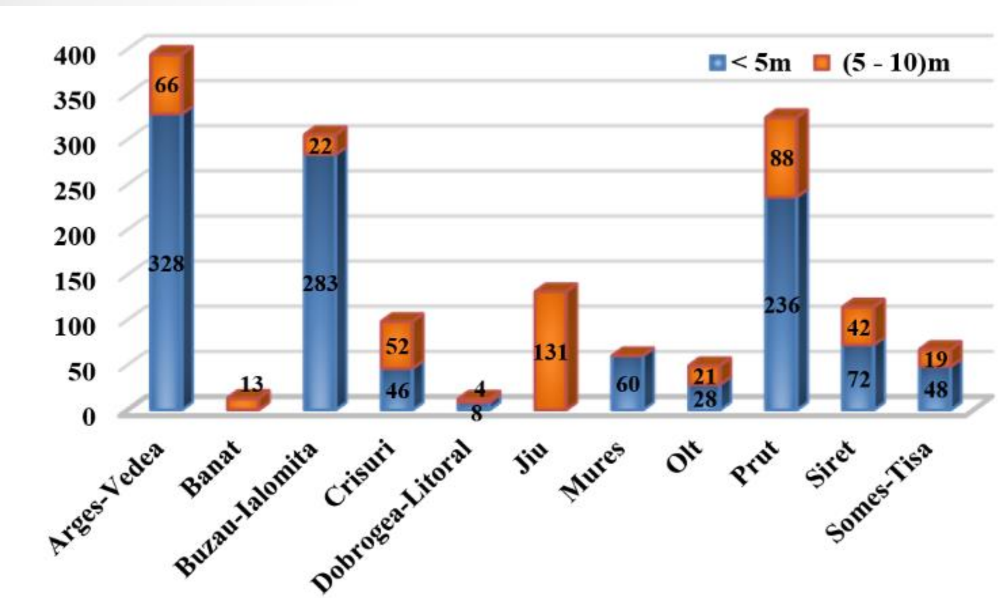
$$P_{b_{1\text{-}2}} = 9.81 \cdot Q_{1\text{-}2} \cdot H_{b_{1\text{-}2}} \text{ [kW]}$$ (in terms of power)

where: $E_{b_{1-2}}$ is the mean gross energy on a river reach 1-2, in [kWh],
V – volume of water for mean hydrological year, in [m^3],
$H_{b_{1-2}}$ – gross head, in [m],
$P_{b_{1-2}}$ – the mean gross power on the river reach, in [kW],
Q_{1-2} – mean flow over the river reach, in [m^3/s].

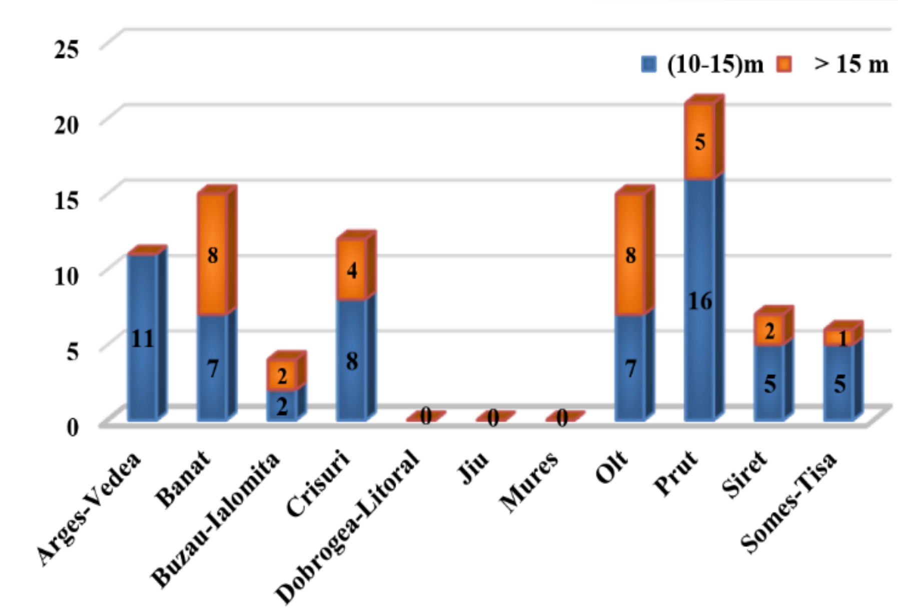
- These equations, amended with a mean efficiency for transforming hydraulic energy in electricity, can be used also to assess the energy which can be obtained by using the existing permanent storage facilities unpowered yet.

RESULTS AND DISCUSSIONS

- There are over 1,600 permanent storage facilities in Romania which currently are used for multiples purposes, but not for energy production.
- Their distribution on river basins considering the height of dams is presented in figures a) and b).



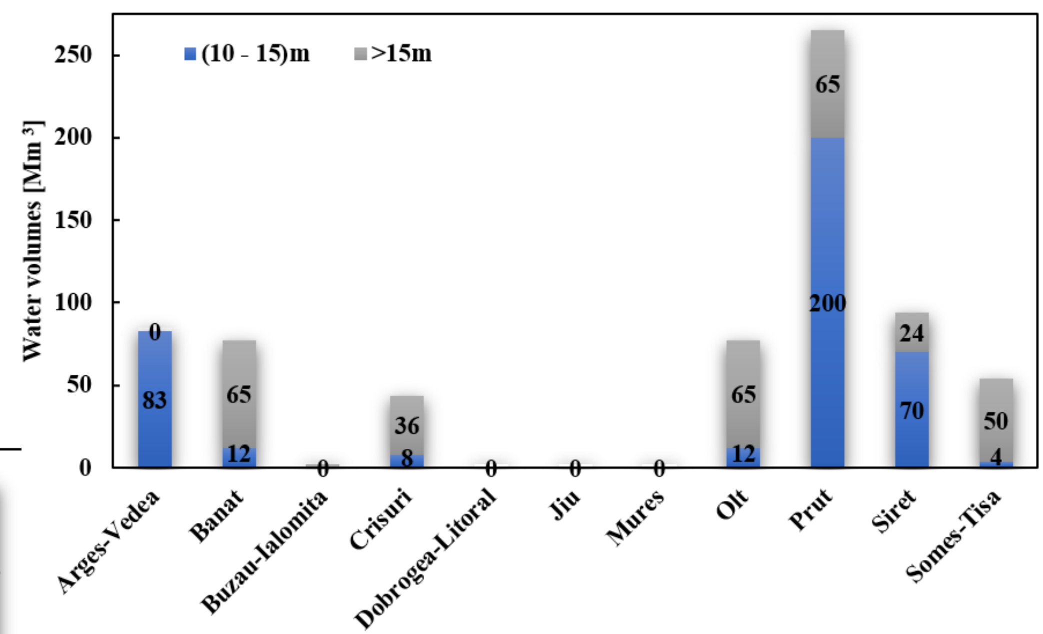
a) Distribution of dams up to 10 m height, on river basins



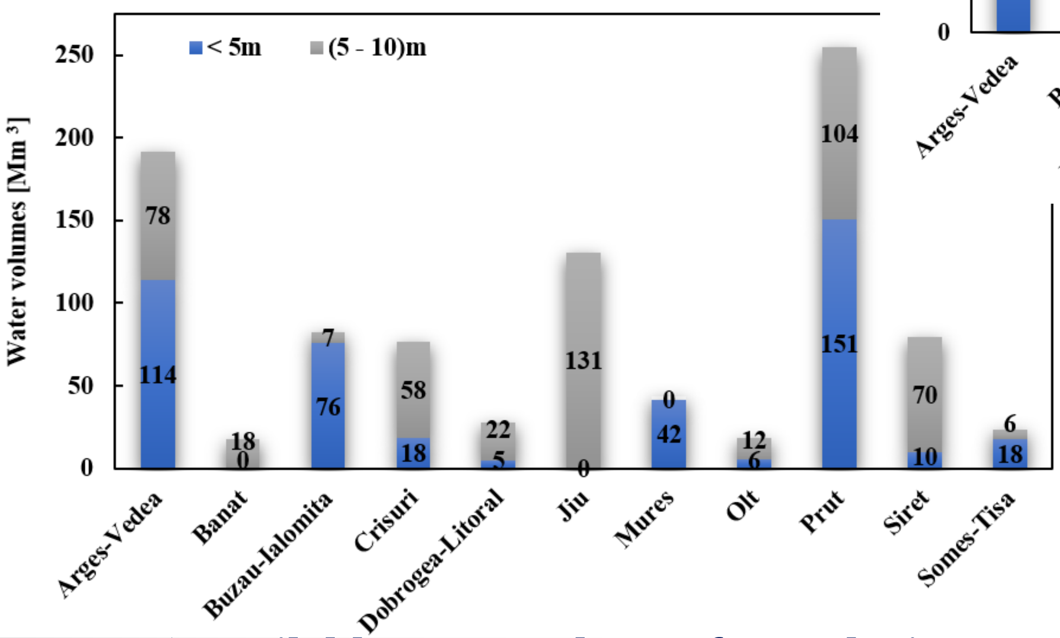
b) Distribution of dams over 10 m height, on river basins

RESULTS AND DISCUSSIONS

- The volumes of water available on every river basin, for different dam's heights is presented in figures a) and b).



b) Available water volumes for each river basin, for dams over 10 m

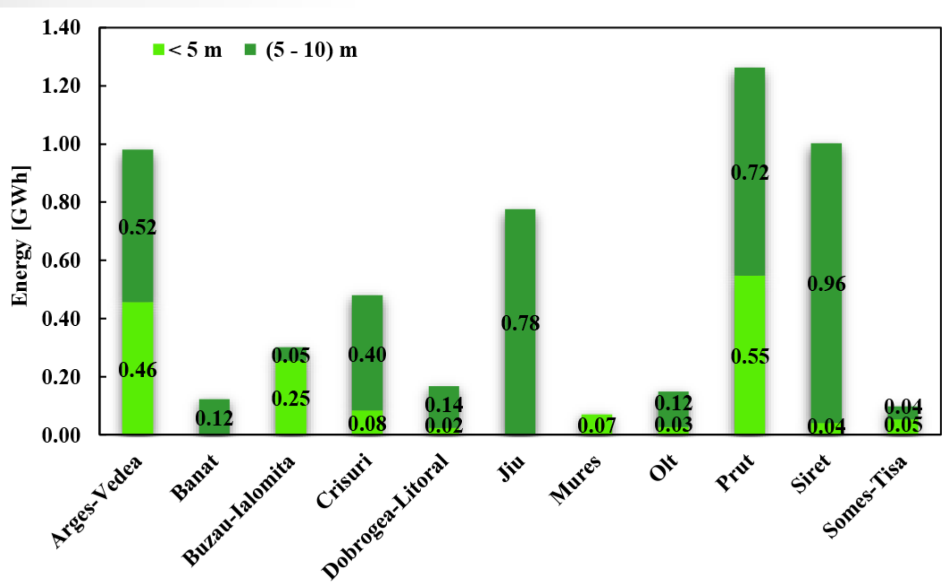


a) Available water volumes for each river basin, for dams up to 10 m

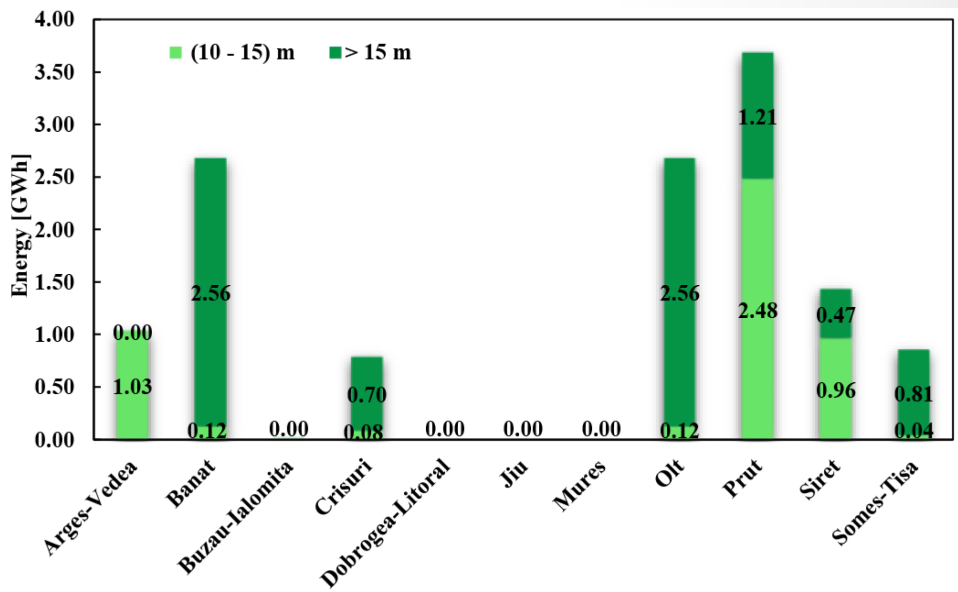
RESULTS AND DISCUSSIONS

The available water volumes and heads have been amended by reduction coefficients, of 0.5 and 0.7 respectively, chosen from experience related to existing projects, in order to avoid/diminish any miscalculations due to incorrect data and also to consider environmental aspects regulated by EU policies (e.g. environmental flow).

$$E_b = 0.002725 \cdot 0.5 \cdot V \cdot 0.7 \cdot H_b = 0.95375 \cdot V \cdot H_b / 1000 \text{ [kWh]}$$



a) Value of energy for each river basin, for dams up to 10m



b) Value of energy for each river basin, for dams over 10m

CONCLUSIONS

- Romania has a long history of hydropower generation, and suitable places to develop new large hydropower plants are not easy to find.
- One of the solutions of generating more electricity from renewable energy sources is the use of permanent water storage facilities which are not powered yet.
- The total energy gain can be, in the current assumptions, of approximately 18.6 GWh. From this, almost 50% (8.31 GWh) is given by the dams over 15 m tall, while the dams between 10 and 15 m can contribute with 4.85 GWh (27%).
- The values presented here are not to be neglected, since are based on actual characteristics of existing hydropower structures and tacking into account the EU recommendation of increasing the renewable energy production to 32% of total electricity by the end of 2030, with a clause for a possible upwards revision by 2023.

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ARmHE ROSHIA

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RENEWABLES NETWORKING PLATFORM

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Thank you !