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Floating PV in mountain artificial lakes: a sustainable contribution?

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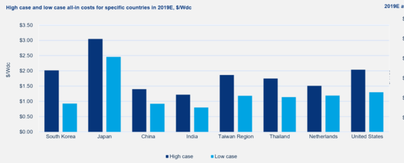
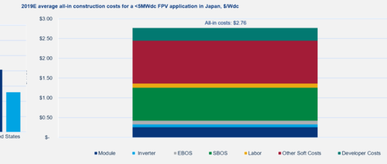
Introduction

We present an overview of the current state of research on a specific renewable technology (floating photovoltaics), whose application in artificial lakes in mountains seems promising but also requiring a careful crafting in technical, economic, social and environmental terms. We extend the current research by providing a detailed checklist of factors and potential venues of remedial means that might, lake-by-lake, maximize the positive impacts and minimize the negative ones, including by highlighting factors that might prevent its use altogether in certain lakes. This contribution is a critical reflection of the potential of a new technology, having in mind the constraints that society posed to other technologies in the past, thus it is sensitive to the need of establishing a fruitful dialogue, since the very beginning, not only among legally entitled institutions but also across a broad range of stakeholders. Accordingly, we end our contribution with a number of recommendations .

Floating PV features

Utility-scale photovoltaics (PV) is becoming the cheapest source of electricity, with record-breaking auctions around the world. Ground-mounted PV is facing resistances to land-use change in certain countries. Waterbodies, both inland and off-shore, are increasingly targeted for floating plants, from 2007 pioneers to current >1.1 GW of installed capacity, with World Bank envisaging a very fast growth in the near future. This is due to the price competitiveness of floating PV in a variety of conditions.





Scaled down to Swiss artificial lakes, for which several designs have been proposed, there are 103 lakes larger than 0.3 hectares in the country, covering **2 180.75 km²**, 45 artificial lakes (**84.48 km²**), 21 natural lakes are used as reservoir for dams (**28.63 km²**). According to Kahl et al. (2018), about 60 km² of PV surface in cities would generate 12 TWh per year, what "would replace half of the current nuclear production". In mountains, thanks to lower number of cloudy days, higher irradiance, increased ground reflectance because of snow cover, and steeper panels, which would "suffer less from soiling, due to dust, dirt and other particles" (assuming in particular vertical panels, "which rarely cumulate snow and would shed it very quickly"), this surface reduces to about **45 km²**.

From a merely quantitative point of view, floating PV can make a sizeable contribution to overall electricity production, ranging
* from 3-5 times the current level of installed PV (which produced 0.420 TWh between 1 Jan 2017 and 1 Jan 2018, equivalent to about 5 km² covered under certain conditions)
* to large share of the total demand (which in 2017 was 58.500 TWh), depending on how many lakes are involved, in which percentage they are covered and with which technology.

A lake-by-lake check list

We suggest a lake-by-lake approach in which a checklist of different criteria to be filled in order for a lake to become subject to a more extensive and detailed feasibility study, possibly leading to an investment plan and the relative funding + implementation. This checklist provides a simple, broad-ranging, non-technical tool for a first assessment of possible consideration of the lake for a Floating PV plant. Additionally it provides suggestions as for further actions depending on the conditions identified.

Summary of the check-list:

1. **Environment**
   - ***1.1. Broad characterisation of the lake*** *(artificial vs. natural vs. natural but utilized as reservoir for a dam; dimension; variability of the water level)*
   - ***1.2. Presence of geological, biological and ecosystemic idiosyncracies*** *(e.g. unique species, pristine conditions)*
   - ***1.3. Potential chemical contamination of the water by panels and/or the technological solution to sustain them***
   - ***1.4. Presence of flora and fauna in the lake***
   - ***1.5. Presence of flora and fauna in the surrounding areas of the lake and in downstream flow***
   - ***1.6. Economic utilization of flora and fauna in the lake***
2. **Climate and technical issues**
   - ***2.1. Variability of the dimension of the lake*** *(minimal, sizeable, extreme)*
   - ***2.2. Snow*** *(presence increasing - vs disturbing - the electric production and/or burdening the physical structure)*
   - ***2.3. Ice*** *(minimal vs. present in the coast but not at center of the lake vs. possibly present across the lake, including any location of the plant)*
3. **Landscape services**
   - ***3.2 Current landscape perception by local communities*** *(minimal vs. sizeable vs. the lake is a major local identity element)*
   - ***3.2 Current landscape perception by tourists*** *(minimal vs. sizeable vs. major attraction; opportunities for the plant might become an attraction in itself, for the land-art shape of its panels and/or for the waterfront it might create for pedestrians and cyclists if connected to land with a proper transit connection)*

Summary of recommendations to stakeholders

Regional authorities:
- might operate a stakeholder dialogue platform on energy and regional development, a topics of which can well be the potential of floating PV;
- this platform may request a compilation of the abovementioned check-list of one or more lakes of the region;
- may proactively enter into discussions with the national level on the subject.

Hydroplant operators might:
- participate to discussion on the energy transition, including synergies across PV and hydropower;
- inform themselves about prices, strategic and operative aspects of photovoltaics, including floating PV;
- preliminary compile the checklist as for their knowledge of the reservoirs where they operate;
- conduct pilot studies, including by placing panels and inverters in different location on the dam and over the lake at different tilts, so to generate a timeseries of data that are helpful not only to assess the technology and its revenues but also for bankability purposes and de-risking the investment;
- utilize these data either to engage in possibly vertically integrated activities or third-party investors and operators;
- initiate a stakeholder dialogue with possible conflicting interests so as to jointly discussing tests and criteria for a consensual experimentation;
- in case a positive decision about a feasibility study is taken, to carry out the study (internally and/or with external expertise);
- in case the feasibility study and the on-going consultation provide a positive assessment to take a decision about the governance structure and the decision-making process leading to technical design, funding, investment and operations;
- actively participate to regional platform and other initiative surrounding the issue, including by informing about successes and failures.

Municipalities and civil society may:
- require information about different venues for renewable power to be generated locally;
- highlight their current and perspective use of the lake-related resources;
- participate to the compilation of the checklist, including by involving experts, NGOs and academia;
- take part to stakeholder consultations and platform, including based on legal requirements;
- vote or express other ways of direct democracy on projects that are of particular significance for their territory, whose legal value will depend on legislation.

Investors may:
- operate energy desks in which the recent development of floating PV can be assessed in the light of investment criteria and priorities, as well as the deviation or concordance with other PV projects;
- verify the willingness of capital markets and specific interests in funding different sized of PV projects, including floating PV;
- establish a framework for discussing floating PV projects which in part may draw on the abovementioned checklist;
- provide seed money for pilot tests and experiments, if needed, as well as much larger funds at conventional rates and conditions for bigger projects.

Energy experts may want to:
- deepen the issues of photovoltaics and floating PV in particular;
- provide technical substance to different designs of the plant and its technologies;
- pool knowledge across different projects, lakes, and technological trajectories;
- explore overall impacts of the diffusion of floating photovoltaics in the energy debate, including in visions about 2030 and 2050.

National governments might:
- provide facilitative conditions to pilot experiments that implement participatory approaches;
- explore the potential of floating PV for their decarbonization / carbon neutrality strategies, including for the sake of the next wave of Nationally Determined Contribution under the Paris Agreement;
- leverage financial and cooperative approaches for the international diffusion of clean technologies including floating PV.

Next steps

Sharing and discussing with scholars and stakeholders the paper on which this poster draws, including its appendix on "Landscape impact of clean energy structures:
a positive contribution from arts to tourism" by Cristina Saviozzi (ITO – HES-SO Valais/Wallis).

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