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FLOATING PHOTOVOLTAIC SYSTEMS IN ITALY: CHALLENGES AND FUTURE PROSPECTS IN AN UNCERTAIN REGULATORY FRAMEWORK

PLÁVAJÚCE FOTOVOLTAICKÉ SYSTÉMY V TALIANSKU: VÝZVY A VÝHĽADY DO BUDÚCNOSTI V NEISTOM REGULAČNOM RÁMCI

Francesco TEDIOLI*

1 The Potential of Floating Photovoltaics in Italy

The primary distinction between floating photovoltaics and land-based systems is the placement of the panels on floating platforms(1). The lack of ground anchoring allows these installations to adapt dynamically to the variable conditions of the aquatic environment(2). Some systems are designed to follow fluctuations in water levels, thereby ensuring continued functionality despite variations of several meters. In the event of a depleted

1 The inclinations of the modules are constrained to a narrow range (5–10°) in order to optimise the installed power on the supporting floats and to mitigate risks in the event of strong winds or extreme weather conditions.

2 The initial European countries to implement this particular installation method were Norway (with an offshore plant situated to the east of the municipality of Frøya in Trondheim), Portugal (with the Alqueva plant, which currently represents the largest installation of its kind in Europe), and Italy, where a 500 kW floating photovoltaic plant was constructed in Bubano (between Bologna and Imola).

Abstract (EN)

In recent years, floating photovoltaics (FPV) has emerged as a highly promising solution for integrating renewable energy production into the global energy landscape. This innovative technology involves the installation of solar panels on floating platforms, offering a number of advantages over traditional land-based photovoltaic systems. First and foremost FPV enables the use of existing water surfaces, such as artificial reservoirs, lakes, and basins, thereby overcoming limitations related to the availability of agricultural or urban land. This feature is particularly pertinent in geographic contexts characterised by high population density and limited land availability, as is the case in many regions of Italy. Furthermore, floating photovoltaics offer a number of additional environmental benefits. The shading effect of the solar panels on the water surface significantly reduces evaporation, thereby preserving a valuable resource like freshwater, which is particularly important in areas prone to drought. Additionally, the natural cooling effect of the water enhances the efficiency of the photovoltaic panels, increasing the production of electricity.

Abstrakt (SK)

V posledných rokoch sa plávajúca fotovoltaika (FPV) ukázala ako veľmi sľubné riešenie na integráciu výroby obnoviteľnej energie do globálneho energetického prostredia. Táto inovatívna technológia zahŕňa inštaláciu solárnych panelov na plávajúce plošiny, ktoré ponúkajú množstvo výhod oproti tradičným pozemným fotovoltaickým systémom. FPV v prvom rade umožňuje využívať existujúce vodné plochy, ako sú umelé nádrže, jazerá a povodia, čím prekonáva obmedzenia súvisiace s dostupnosťou poľnohospodárskej alebo mestskej pôdy. Táto vlastnosť je obzvlášť dôležitá v geografických súvislostiach charakterizovaných vysokou hustotou obyvateľstva a obmedzenou dostupnosťou pôdy, ako je to v prípade mnohých regiónov Talianska. Okrem toho ponúka plávajúca fotovoltaika množstvo ďalších environmentálnych výhod. Tieniaci účinok solárnych panelov na vodnú hladinu výrazne znižuje vyparovanie, čím zachováva cenný zdroj, akým je sladká voda, čo je obzvlášť dôležité v oblastiach náchylných na sucho. Okrem toho prirodzený chladiaci efekt vody zvyšuje účinnosť fotovoltaických panelov, čím sa zvyšuje produkcia elektriny.

Keywords (EN)

floating photovoltaics, solar panels, italian legislation

Kľúčové slová (SK)

plávajúca fotovoltaika, solárne panely, talianska legislatíva

* Mantova University, Italy

reservoir, the structures remain operational, thus ensuring the uninterrupted generation of energy.

The integration of floating photovoltaic panels with hydroelectric power plants represents a promising avenue for the advancement of renewable energy production[3], offering a synergistic approach that can enhance the efficiency and resilience of energy generation. In this context, experimental solutions have been tested that involve the use of solar-powered pumping turbines to elevate water, thereby improving the efficiency of the hydroelectric system[4]. This combination not only optimises the use of water surfaces but also stabilises energy production, as photovoltaic energy can be used to pump water during daylight hours and release it to generate electricity in the evening or during peak demand periods. Such hybrid systems also help reduce evaporation from reservoirs, maintaining more consistent water levels and enhancing overall water resource management.

In comparison to land-based installations, floating photovoltaic panels offer a number of benefits[5]. The occupation of land is effectively eliminated, installation and dismantling operations are completed in a shorter time and with less environmental impact, and the cleaning of the modules is facilitated due to easier access to water surfaces. It is important to note, however, that the initial investment costs (CAPEX) for these solutions are typically around 10% higher than for traditional photovoltaic parks with the same installed capacity. This is due to the need for floating structures and specialised anchoring systems.

Consequently, floating photovoltaics represent an effective solution to land use issues, which is particularly significant in countries such as Italy, where urbanisation is highly dense. Furthermore, the system benefits from natural cooling due to the presence of water, which enhances the panels' energy efficiency[6].

However, the nature of floating photovoltaics gives rise to a series of regulatory issues that must be addressed to ensure proper implementation. These include the management of state property concessions, environmental impact considerations, water resource protection, and the framework for the required authorisations.

2 Solar Energy in Quarries: a New Frontier

In Italy, a number of floating photovoltaic (FPV) projects are currently undergoing the final stages of authorisation, with an estimated total capacity of several hundred MW[7]. This market segment is developing primarily in former private quarries in Northern Italy, concentrated along the Po Valley[8], where numerous artificial basins provide ideal conditions for the installation of floating systems. The choice of these areas allows for the reclamation of disused sites, utilising surfaces already altered by extraction activities and thereby reducing the environmental impact associated with the use of new land.

In recent years, the National Association of Stone and Related Producers (Anepla) has initiated discussions with its members and FPV operators to explore the potential offered by installing solar systems on quarry water surfaces, whether disused or still active. The objective is to assess how these areas can be sustainably repurposed, integrating new functions with traditional extraction activities.

The motivations driving extraction companies to develop floating photovoltaics are closely linked to the geological characteristics of many areas of the country, particularly the Po Valley, where water-saturated alluvial deposits are a constant presence. In these zones, excavation activities quickly encounter aquifers and saturated deposits. Once extraction is complete, the sites can be environmentally restored and converted for new purposes, such as renewable energy production, thereby transforming quarries into multifunctional spaces with an increasingly "green" footprint.

3 The municipality of Sella Giudicarie, located within the province of Trento, is the site of a recently constructed floating photovoltaic facility situated within a hydroelectric reservoir, marking the inaugural installation of this particular configuration in Italy.

4 It is important to acknowledge that operating on dams presents a significant challenge. Effective collaboration with the dam operator is essential, yet their interests may not always align with those of the photovoltaic plant operator.

5 For further information on this topic, please refer to the following source: Almeida et al. (2022), pp. 246–249; Pimentel Da Silva et al. (2018); Reindl (2018), pp. 18–23; Veyis Neo, (2017), pp. 10–11; Cazzaniga et al. (2017), pp. 48–57.

6 FPV systems can achieve 5–10% higher efficiency compared to land-based installations, thanks to the cooling effect of the water.

7 The installed capacity of these facilities is typically modest, ranging from 5 to 10 MW. However, there are instances where the capacity exceeds 30 MW.

8 The technical potential for electricity generation from FPV on Italian lakes is estimated to range between 22.4 and 27.5 TWh/year, with a capacity between 19 and 26.5 GW.

Regulatory developments[9] have given a decisive boost to this new frontier. Recent legislative amendments[10] have enabled the installation of floating photovoltaic arrays on quarry water basins, thereby facilitating the integration of mining activities with the generation of energy.

The utilisation of water surfaces for the installation of solar panels presents a number of significant advantages. Firstly, it does not consume land, which is a valuable and often scarce resource. Secondly, it enables zero-emission energy generation, which is an important consideration in the context of climate change[11]. Thirdly, it offers extraction companies the opportunity to diversify their activities, with savings on energy costs. Nevertheless, this solution is not universally applicable. For instance, the installation of floating photovoltaics is not feasible in marble quarries. Conversely, the Po Valley, where approximately 50% of the quarries in Lombardy contain bodies of water, offers optimal conditions.

It is evident that a novel form of collaboration is emerging, whereby extractive companies and energy sector firms are joining forces to capitalise on the potential of this nascent market. This strategic alliance is driven by the recognition that the expansion of renewable energy production and the ecological transition represent significant opportunities for growth and contribution.

3 The European Regulatory Framework

At the European level, the regulation of floating photovoltaics is primarily guided by the Renewable Energy Directive 2018/2001 (RED II)[12], which establishes a unified framework for the promotion of energy derived from renewable sources[13]. The directive explicitly encourages Member States to develop national plans to promote renewable energy, including innovative solutions such as floating photovoltaics. The principal objective is to provide incentives for the utilisation of these technologies in areas with minimal environmental impact, such as existing water surfaces, through the implementation of a flexible regulatory framework that facilitates their installation.

Additionally, the Water Framework Directive (2000/60/EC)[14] is of particular significance with regard to floating photovoltaics, as it establishes the regulatory framework for the management and protection of water resources in Europe. This regulatory framework establishes rigorous criteria for maintaining the "good ecological status" of surface waters, stipulating that FPV installations must not compromise the quality of the aquatic ecosystem. To this end, specific requirements have been defined to assess and prevent any negative impacts, ensuring the sustainable use of water surfaces and minimising risks to biodiversity[15] and the environmental functions associated with water resources.

4 Italian Legislation

In Italy, the legislation on floating PV falls within the broader context of renewable energy regulation and the use of public water resources. At present, Italian law does not provide a specific framework for floating photovoltaics, but various provisions can be identified that indirectly regulate their installation and management.

4.1 The National Integrated Energy and Climate Plan

The National Integrated Energy and Climate Plan (PNIEC)[16] is the strategic planning tool through which

9 The three regulatory amendments, endorsed by industry associations, pertain to the utilisation of quarry areas for the erection of photovoltaic facilities. The initial amendment broadened the streamlined authorisation process (PAS) to encompass installations of up to 20 MW, encompassing "portions" of quarries that have ceased to be viable for extraction purposes. This was achieved by amending Article Paragraph 6, Article 6. IX *bis* of Legislative Decree 28/2011. The second amendment expanded Article 20, paragraph VIII, of Legislative Decree 199/2021 to include portions of abandoned quarries and mines as immediately suitable areas for renewable energy installations. Finally, Article 9 ter of Legislative Decree 17/2022 was amended to allow the simplified authorisation procedure (PAS) for active quarries, permitting floating photovoltaic installations up to 10 MW on water bodies.

10 For further information on this topic, please refer to the following paragraphs.

11 For a review of international experiences, please refer to: Song et al., (2016), pp. 10.

12 For an analysis of the European Union's Directive (RED II), see Schmid, et al. (2019), pp. 110–119; Leal-Arcas (2020), pp. 45–78; Czarnecki et al. (2021), pp. 190–205; Becker et al. (2021), pp. 110595.

13 In Italy, see Romano et al. (2022) pp. 105–130; Zanchini (2020), pp. 45–60; Giannini (2021), pp. 124–138.

14 Rinaldi (2003), pp. 129–135; Wollmann (2005), pp. 413–432; Hermans (2008), pp. 42–56; Luciani (2010), pp. 1449–1463; Kallis (2010), p. 323.

15 See Wyatt et al. (2024), pp. 602-609, which highlights the potential of floating photovoltaics (FPV) to complement and replace hydropower in the energy transition in Africa. In addition, floating platforms can create micro-habitats for certain aquatic species, such as phytoplankton and zooplankton, thereby enhancing the biodiversity of aquatic ecosystems.

16 On July 1, 2024, the Ministries of Environment and Energy Security and Infrastructure and Transport submitted the final text of the PNIEC to the European Commission, confirming the objectives achieved in the initial proposal sent in June 2023. In some cases, even the EU targets, particularly those related to renewable energy, were exceeded.

Italy defines its objectives and development paths in the energy sector. Drafted in line with European Union directives, the PNIEC covers the period 2021–2030 and places particular emphasis on the development of renewable energy sources and technological innovation to promote energy transition[17].

Although the PNIEC does not include a section explicitly dedicated to floating photovoltaics, it recognises the importance of increasing renewable generation capacity through the use of unconventional surfaces. This approach is in line with the need to maximise the use of available resources without competing for agricultural or urban land – an essential factor in a country characterised by high population density and limited availability of open land.

In fact, the plan aims to promote the diversification of renewable technologies, a strategy that includes the enhancement of solar energy in innovative contexts such as artificial reservoirs, quarry lakes and public water surfaces. This approach not only promotes the increase of renewable energy production, but also facilitates the reduction of evaporation from water bodies and contributes to the conservation of water resources. In the short term, floating photovoltaic technology can contribute through installations on water bodies with lower environmental value and low hydraulic and structural risk[18].

Furthermore, the PNIEC encourages the consideration of the integration of floating photovoltaics as a versatile technological solution capable of supporting national objectives for the reduction of greenhouse gas emissions and the improvement of energy efficiency. In this context, floating photovoltaic installations become strategic allies in the circular economy and ecological transition, helping Italy to move towards a more sustainable and resilient energy system.

Finally, the plan emphasises the importance of research and development of new technologies and the need for a clear and appropriate regulatory framework to facilitate the implementation and social acceptance of such innovations. The PNIEC thus acts not only as an operational framework, but also as a platform for ongoing dialogue between institutions, the private sector and civil society to ensure that energy policy effectively addresses current environmental and economic challenges.

4.2 Regulations on State Property Concessions

A crucial aspect of the legal regulation of floating PV in Italy concerns the use of water resources, which are predominantly public property[19]. These areas, whether maritime, riverine or lacustrine, require careful management and specific rules for granting rights of use when implementing infrastructure such as floating photovoltaic (FPV) systems.

More specifically, according to the Italian Navigation Code[20], the occupation of public areas for productive purposes is subject to authorisation by the competent authorities. This authorisation process is essential to ensure that the installation and operation of FPV systems comply with existing regulations, avoid conflicts with current uses of water resources and minimise environmental impact.

The granting of state ownership concessions for floating photovoltaic installations must include a detailed analysis of existing uses of water resources to verify compatibility with local ecosystems and water-dependent socio-economic activities such as irrigation, fishing, and tourism. It is essential that the permitting process adopts an integrated approach aimed at avoiding negative impacts on biodiversity or the local economy, through a thorough analysis of environmental conditions and the implementation of mitigation measures to protect existing water uses.

The competence to grant these concessions is often divided among different administrative bodies, including regional and local authorities, each with its own regulations and operating protocols. This fragmentation of the regulatory framework results in significant delays and uncertainties for industry operators, who face lengthy authorisation procedures.

In order to address these complexities, it is therefore essential to promote inter-institutional coordination aimed at standardising administrative practices as far as possible and facilitating the integration of new technologies, while respecting sustainability objectives. It is clear that effective and simplified concession management could speed up the transition to greater use of renewable energy sources, such as floating photovoltaics, without compromising environmental health and territorial cohesion. In other words, while floating photovoltaics offer significant potential for

17 Berti et al. (2023), pp. 27–54; Cusano (2022), pp. 150–179; Vetrò (2022), pp. 53–104; Amorosino (2021), pp. 133–142.

18 This again refers to irrigation basins, flooded quarries and industrial reservoirs.

19 On this topic, Fulciniti (2023), pp. 301–336; Musi (2023), pp. 189–203.

20 In addition to Art. 524 of the Italian Maritime Navigation Regulations and Art. 36 of the Italian Navigation Code, see the provisions of Art. 12, par. III of Legislative Decree 387/2003 for the authorisation of the installation of offshore facilities and infrastructure.

sustainable energy production in Italy[21], the success of its implementation depends heavily on a solid and well-structured regulatory framework that effectively balances environmental, economic and social needs across the territory.

4.3 Environmental Impact Assessment

The installation of large-scale floating photovoltaic (FPV) systems requires a rigorous Environmental Impact Assessment (EIA)[22], in accordance with Legislative Decree 152/2006 (Italian Environmental Code). This process is mandatory for projects that could have a significant impact on the environment[23]. Floating photovoltaic installations often fall into this category, especially when they involve large bodies of water.

The EIA must assess a number of environmental issues, including:

- Impact on aquatic ecological communities: the interaction of floating platforms with marine and freshwater ecosystems, including changes in light and oxygen conditions in the underlying waters and changes to natural habitats[24].
- Release of contaminants: assessment of the risk of release of contaminants from the materials making up the platforms or from potential degradation processes, including chemicals used to maintain and clean the platforms.
- Management and protection of fish fauna: analysis of potential impacts on local fish populations, with particular attention to protected species, population dynamics and existing fishing and aquaculture practices.
- Environmental monitoring and mitigation: Implementation of long-term environmental monitoring plans to detect and mitigate any emerging negative impacts. This will include the installation of sensors to monitor water quality and the structural integrity of the platforms.

It is thus incumbent upon the relevant authorities to conduct a meticulous examination of the associated environmental risks and to guarantee that FPV projects are designed and implemented with technical solutions that minimise environmental impact, while also optimising energy efficiency and sustainability.

5 Incentives for Floating Photovoltaics

In line with European decarbonisation targets[25], Italy has developed various measures to promote the installation of renewable energy systems, including floating photovoltaics. The incentives currently available are both economic (incentive tariffs, tax deductions) and regulatory (bureaucratic concessions or procedural simplifications).

5.1 The FER 2 Decree

The FER 2 decree[26] represents a significant step forward in the regulatory framework for incentivising the use of renewable energy in Italy, with a focus on emerging and innovative technologies such as floating photovoltaics. This decree updates and extends the measures provided for in FER 1, introducing new support mechanisms[27] for the installation of photovoltaic systems on water surfaces such as artificial reservoirs, quarry lakes and agricultural ponds.

The decree recognises floating photovoltaics as a technology of significant interest for energy innovation, given its ability to use non-traditional surfaces for energy production[28].

Special funds will be made available to support investment in floating photovoltaics, particularly in areas facing significant environmental challenges such

21 Photovoltaics on inland water has a technical and economic potential of 7–10 GW.

22 The EIA is an administrative procedure designed to give an opinion on the environmental impact of certain projects and activities. Specifically, Art. 4, par. IV, letter B, of Legislative Decree 152/06 "identifies, describes and assesses... The direct and indirect effects of a project on the following factors – human beings, fauna and flora; – soil, water, air, climate, landscape; – material assets and cultural heritage; – the interaction between the above factors".

23 See Scuto (2023), pp. 1056–1065; Spuntarelli (2023), pp. 59–95; Giarmanà (2022), pp. 30–53.

24 Some studies have shown that FPV can even contribute to the creation of habitats for certain aquatic species, thereby promoting the biodiversity of aquatic ecosystems. However, it is important to emphasise that the impact on biodiversity may vary depending on the specific characteristics of each site and the species present, and a case-by-case assessment is required. On this subject, see Pouran et al. (2022), 11.

25 Bruti Liberati (2022), pp. 3–12; Cavalieri et al., (2022), pp. 409–465.

26 The decree, which came into force on 13 August 2024, encourages the construction of renewable energy plants that are innovative or have high operating costs. These include plants powered by biogas and biomass, thermodynamic solar, geothermal, offshore wind, floating photovoltaics both offshore and on inland waters, and plants powered by tidal, wave and other forms of marine energy, which are innovative and have a low impact on the environment and the territory.

27 The measure, which will remain in force until 31 December 2028, will be financed by a levy on final consumers' electricity bills. The maximum amount earmarked for financing is € 35.3 billion.

28 One of the primary objectives is to achieve a total installed capacity of 4.6 GW by 2028.

as water scarcity. These incentives not only support photovoltaic systems installed on artificial basins or unused water surfaces but also contribute to renewable energy generation and sustainable water resource management[29]. In this context, the incentives can cover both the costs of implementing the systems and the adoption of advanced technological solutions, thus ensuring minimal environmental impact.

In particular, a competitive bidding mechanism has been established, whereby an incentive tariff is awarded on the basis of the plant's capacity and the project's level of innovation. Projects that integrate environmental mitigation technologies, such as the reduction of evaporation[30] from water bodies or combined use with irrigation or water treatment systems[31], are accorded particular importance.

Additionally, the FER 2 Decree introduces procedural simplifications to facilitate the installation of floating panels. These include the possibility of using the Simplified Authorisation Procedure (PAS) for installations on public water property. It is important to note, however, that the application of the Simplified Authorisation Procedure (PAS) for private basins still presents ambiguities and may be subject to varying interpretations, especially in the context of disused quarries. This uncertainty requires regulatory clarification to ensure consistent and uniform management of authorisations. Despite these issues, the legislation is aimed at simplifying and accelerating authorisation procedures, thereby reducing bureaucratic constraints.

5.2 The FER X Decree

The FER X Decree, which is currently awaiting approval[32], aims to further expand support for renewables, with new provisions that could include more favourable conditions for floating photovoltaics, especially in offshore settings.

The decree specifically seeks to support large-scale projects and promote the development of installations with direct access to incentives or through competitive auctions, depending on the plant's capacity. Incentives are made available directly to installations with a capacity of up to 1 MW (up to a total limit of 10 GW). Installations with higher capacities must participate in auctions until 2028, with a quota reserved for photovoltaics of 40 GW out of a total 57.15 GW.

The implementation of floating installations may also be enhanced by the application of preferential criteria, such as the construction of pre-designated suitable areas ("aree idonee") or the incorporation of energy storage systems.

The objective of the FER X Decree is to streamline authorisation procedures and implement indexation mechanisms to adjust auction prices for inflation. However, it is crucial to acknowledge that in the event of delays in the commissioning of the installations, a price reduction or loss of incentives is anticipated if the delays are excessively prolonged. This approach is designed to guarantee the efficacy of projects and encourage a prompt commencement of installations in the renewable energy sector.

6 The Drought Decree: Further Impetus for the Development of Floating Photovoltaics

The "Drought Decree"[33], which was introduced in order to address the water emergency in Italy and to promote sustainable resource management, introduces a number of important innovations in the field of renewable energy. Of particular note is the decree's

29 The incentive scheme comprises a quota of 50 MW and a reference tariff for plants with a capacity exceeding 1 MW, which is set at 75 euros per MWh (90 euros for plants with a lower capacity).

30 The installation of a 6 MW floating photovoltaic plant on the basin of Enel's power plant, situated in the Anapo river valley (Syracuse), has the potential to result in a reduction in evaporation of 20–30%. This equates to an estimated 100,000 cubic metres of water gained over the course of a year, given that the plant occupies approximately 15–20% of the basin's surface area.

31 The FER 2 decree emphasises the importance of environmental sustainability, promoting projects that combine energy production with the protection of natural resources. Plants that offer innovative solutions to minimise the impact on aquatic ecosystems, such as the use of non-polluting materials or easily removable modular structures, score higher in tenders, increasing their chances of accessing incentives.

32 The "Incentive Regime for Renewable Energy Installations Decree" (commonly known as the "FER X Decree") is a recently proposed legislative measure that aims to facilitate the construction of facilities for the production of energy from renewable sources, including floating photovoltaics. It is important to note that the FER X Decree implements Articles 6 and 7 of Legislative Decree 199/2021, which establish the rules for incentivising installations over 1 MW through reverse auctions and smaller installations below 1 MW. Furthermore, the incentives extend to installations in self-consumption configurations, energy communities, and those built on agricultural land.

33 D.l. April 14, 2023, no. 39, Urgent provisions for addressing water scarcity and for strengthening and upgrading water infrastructure, converted with amendments by L. June 13, 2023, no. 68. In the literature, see Musi, *op. cit.*, p. 190.

encouragement of the use of water surfaces for floating photovoltaic installations. The decree encourages the use of both artificial and unused water bodies, such as reserve tanks and artificial lakes, for renewable energy production. This approach allows for the dual utility of these installations, in that they can be used to generate clean energy and to reduce water evaporation.

One of the principal aims of the measure is to facilitate the installation of photovoltaic systems on water surfaces by reducing the complexity of the associated bureaucratic procedures. In particular, the measure provides for exemptions from local regulations with a view to streamlining the authorisation process and thereby reducing the waiting time to obtain the necessary permits. The Extraordinary Commissioner for the Water Crisis is responsible for coordinating this process and providing assistance to companies and local authorities in implementing the projects.

In particular, floating photovoltaic installations with a capacity of up to 10 MW are subject to a simplified authorisation procedure, provided that the relevant provisions on EIA and water resource protection are respected. For installations exceeding 10 MW, the single authorisation procedure applies, while tax regulations concerning the excise duty on electricity remain unchanged.

Furthermore, the decree places a premium on installations that integrate renewable energy production with water resource management, with a particular emphasis on those that can assist in mitigating basin evaporation or that can be combined with irrigation or water treatment systems. These projects, which are regarded as being of strategic importance in addressing the effects of drought, are afforded the benefit of accelerated concession allocations.

In order further to stimulate the development of floating photovoltaics, the Drought Decree has allocated extraordinary funds to support innovative and sustainable projects, especially in areas most affected by the water crisis. These funds, managed by the Extraordinary Commissioner, are intended to encourage investments in installations capable of addressing water scarcity and promoting the adoption of advanced technologies for energy production.

7 Offshore Floating Photovoltaic Systems

The present analysis has concentrated on floating photovoltaic systems installed on artificial basins and inland water surfaces. However, another area of development concerns offshore installations. These solutions, located off the coast, utilise open marine resources to produce renewable energy, providing an alternative to the use of inland basins. In this context, offshore floating photovoltaics allow for reduced use of terrestrial land while capitalising on vast maritime areas, integrating with other marine activities such as fishing and navigation, and optimising available space[34].

The installation of offshore floating photovoltaics necessitates the implementation of integrated management and maritime spatial planning in order to guarantee the harmonious coexistence of diverse marine space utilisation[35]. It is therefore imperative that these systems are incorporated into a framework of "zoning" that ensures the sustainable utilisation of marine resources, circumvents potential conflicts with other economic activities and complies with the limitations set forth by international law. In particular, Directive 2014/89/EU mandates that Member States adopt maritime spatial management plans that consider the requirements of energy development, such as offshore photovoltaics, in a manner that is consistent with environmental protection.

In Italy, the legislative framework governing the installation of offshore floating photovoltaic systems is set out in Legislative Decree of 17 October 2016, no. 201[36], which establishes the Exclusive Economic Zone (EEZ)[37]. The regulatory framework was further reinforced by the enactment of Law No. 91 of 14 June 2021, which conferred upon the Italian state the right to exploit marine resources, including energy resources, within the 200 nautical mile limit. This legislation permits the installation of offshore photovoltaic systems, provided that they respect the marine environment and do not interfere with other activities, such as fishing or navigation.

The installation of offshore floating photovoltaic systems offers a number of advantages, including the capacity to utilise vast areas of maritime space and reduce the pressure on coastal land. However, it also presents a number of challenges, including the necessity to balance competing interests for the use of marine space and the potential environmental impact on aquatic ecosystems[38].

34 For a more detailed account, please refer to Befani (2024), pp. 59–118.

35 In accordance with Article 60 of the Montego Bay Convention, artificial islands and installations are not considered to possess the status of islands and do not affect the existing territorial delimitation. The coastal state may, therefore, establish safety zones to protect these structures by incorporating them into maritime state property.

36 On the subject, see Moliterni (2023), 171–201; Carnimeo (2023), pp. 5–45.

37 Cf. Leandro (2021), pp. 1081–1087.

38 In this regard, floating offshore photovoltaics must comply with rigorous environmental sustainability criteria and ensure minimal impact on marine ecosystems, as required by international maritime law.

8 Challenges and Future Prospects

Floating photovoltaics represent an innovative and sustainable option for renewable energy production, offering significant advantages in terms of energy efficiency and environmental impact. The favourable economic incentives and policies in Italy bode well for the growth of this technology. However, to ensure balanced development, careful planning is needed for the integration of such installations, with a view to protecting water resources and ensuring consistency between energy and environmental policies. The implementation of procedural simplifications, economic incentives and extraordinary funds can stimulate the adoption of innovative solutions that contribute to the energy transition and the sustainable management of natural resources.

Notwithstanding the plethora of advantages, considerable obstacles persist. Chief among these is the dearth of precise and consistent national regulations, which renders the authorisation process for floating photovoltaic systems opaque and convoluted. Furthermore, the competition between disparate utilisations of water resources necessitates meticulous planning and collaboration amongst the relevant authorities to achieve a harmonious equilibrium between energy, environmental, and socio-economic requirements.

Italy, with its extensive network of artificial basins and growing commitment to renewable energy, offers significant potential for the development of floating photovoltaics. The evolution of regulations, driven by the need to accelerate the energy transition, should encourage the adoption of this technology. Moreover, updating national and regional energy plans could further promote the use of water surfaces for clean energy production.

In conclusion, it is imperative that the regulatory framework evolve expeditiously to accommodate the sector's novel requirements. This necessitates the establishment of transparent and uniform national regulations that foster investment and streamline authorisation procedures[39].

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Contact address/Kontaktná adresa

Avv. Francesco Tedioli
University of Mantova
Languages for Business Administration (LaLBA)
Via Scarsellini, 2 – 46100 Mantova, Italy
francesco@tedioli.com