FTCC PHOTOVOLTAIC PLANT

Floating Tracking Cooling Concentrating PV Plant

Photovoltaic systems can make a significant contribution to renewable energy production but their efficiency is severely limited by their cost, that remains high and by their environmental impact. Our proposal is to use already existing water reservoirs, intended for industrial or agricultural uses, to install photovoltaic floating plants. This will accomplish a substantial cost reduction thanks to the following features:

- a very low cost tracking system
- an efficient cooling of the panels using water sprinklers

the presence of a set of reflectors to concentrate the incoming radiation with the subsequent increase of the energy yield of the plant.

We call these plants FTCC, an acronym of the keywords that characterize them: Floating, Tracking, Cooling, Concentrating.
A first plant based on these concepts has been implemented in Suvereto (Livorno) and is nearing completion. The tracking system has been recently installed.
A 30 kWp pilot plant has been built in Colignola (Pisa) featuring a configuration with flat reflectors, leading to a geometric gain of a factor slightly greater than 2.

Figure 1 Pisa demonstrator

Figure 2 Suvereto plant (Terra Moretti holding)

The design of the reflectors can be optimized to obtain a concentration gain up to a factor of 20. This results in a further cost reduction and gives a great economic advantage because it opens the access to the energy incentive in Chapter IV of the Fourth Conto Energia..

The advantages compared to a ground plant

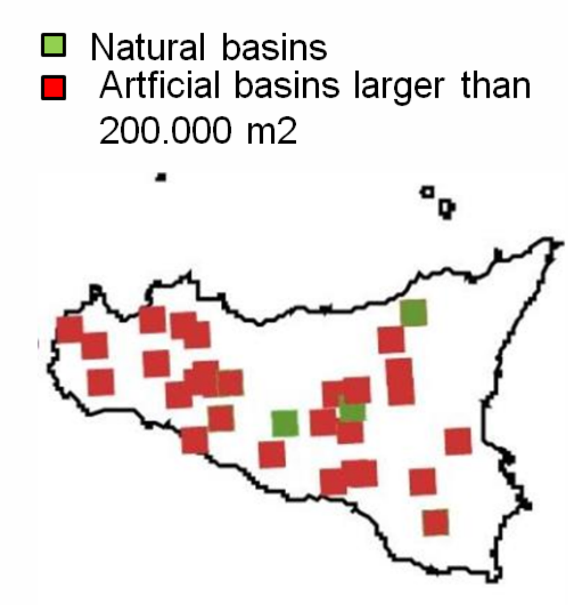
Reduced costs

The solution with flat reflectors coupled to tracking and cooling reduces costs by about 20% per kWh compared to a fixed ground plant.
In fact, such systems offer the following advantages (calculated here for the Pisa latitude):
• the tracking system with a panel slope of 5 ° gives an annual yield of 1120 kWh per kWp;
• the reflector system increases by 60% the energy yeld,that rises at 1800 kWh / year;
• the cooling system using the water of the basin increases the efficiency by about 15%, bringing the annual yield to 2060 kWh per kWp.
This should be compared with the optimal performance of a ground plant which is about 1170 kWh per kWp. Our system thus increases the produced energy by more than 75% .
In conclusion, the platform cost is more than compensated by the lower costs connected with the reduction of the active photovoltaic surface and with the gain induced by tracking and cooling. The same calculation made for Sicily leads to greater returns.

Availability of surface areas

Natural or artificial basins used for industrial purposes, for irrigation or water supply are available nearly everywhere.
For example, in Sicily there are present reservoirs for a total of 75 km squared. In addition, since

the basins are often equipped, protected, and wired they are ideally suited for installation of a photovoltaic system.
Finally, a further significant advantage is the reduction of evaporation due to the water coverage.



Sicily artificial basins	10^6 m^2
Arancio	3,7
Garcia	5,1
Lentini	10,0
Nicoletti	1,6
Ogliastro	14,0
Piana degli Albanesi	3,3
Poma	3,6
Pozzilo	7,8
The eight larger basins	**49,1**
Total (31 basins)	**74,9**

Figure 1 Basins availability in Sicily

Figure 2 Mazzorenello basin (Ragusa).

The availability in Italy of basins with a surface larger than 20 hectares has been established by CNR and is shown in the map below. Artificial basins are indicated in red and natural ones in green.

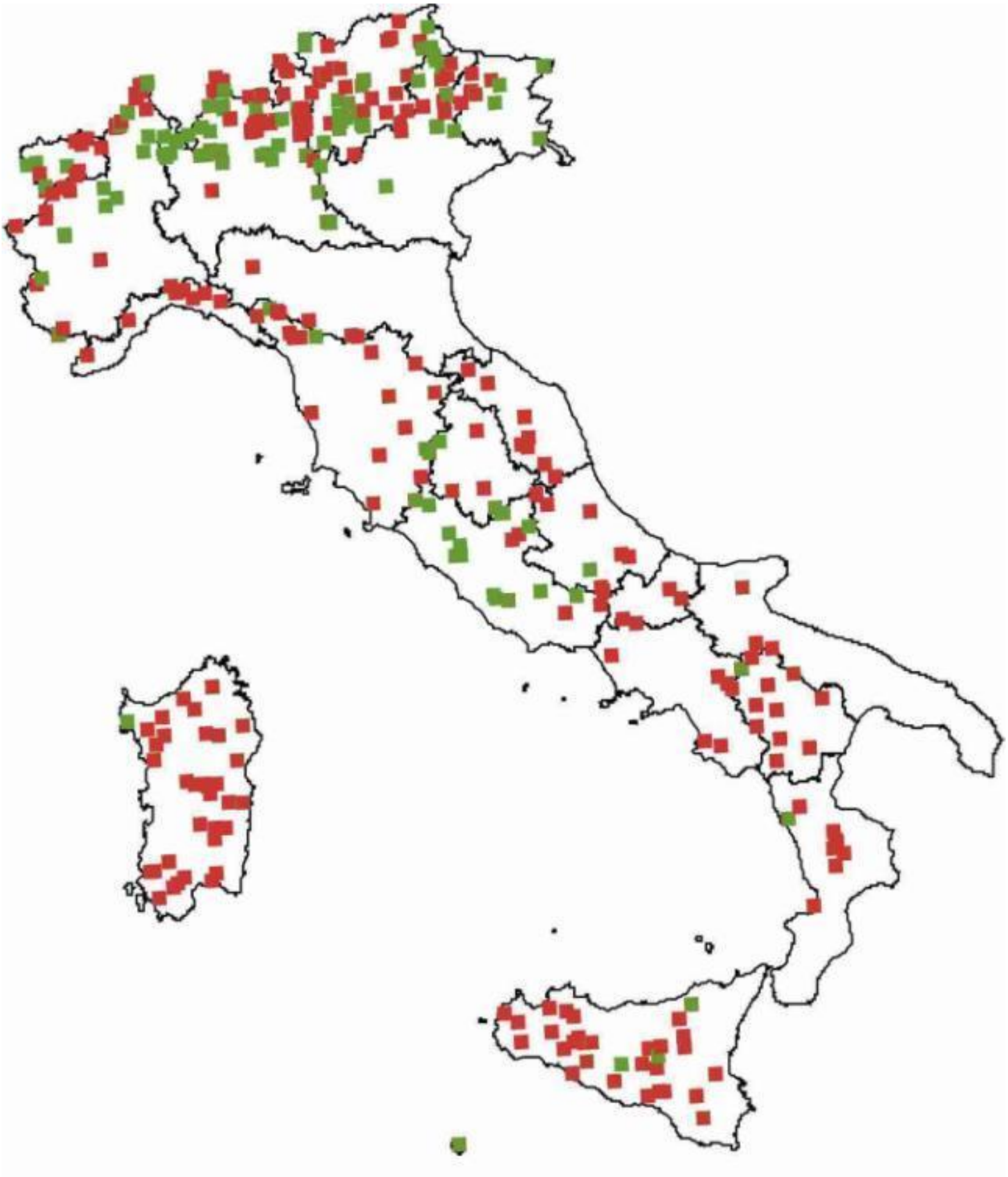


Figure 3 Artificial basin (red) and natural basins (green) larger than 200.000 m^2

Doubling the capacity of hydroelectric reservoirs

Additional benefits are possible when using hydroelectric reservoirs, in particular those provided with pumping units.

Hydroelectric plants have a good conversion efficiency and the cost per kWh is highly competitive.

The only drawback is the reduced availability due to the water cycle that limits its use to about 1800 hours per year.
Photovoltaic has a relatively recent entry into the energy system. At present time its impact is small and its costs are non competitive. However, its current limitations can be overcome by a reduction of costs and/or by a better integration with local supplies of power. In particular, the advantages of coupling floating photovoltaic (FTCC) plants with hydropower are considerable.
In fact, the annual yield of one square meter of photovoltaic FTCC varies between 100 and 140 kWh per year depending on the climatic zone. This value takes into account the necessary spacing between panels and between platforms and at the same time, the greater efficiency and capacity of the annual collection of this type of plant.
On the other hand an analysis of existing reservoirs with pumping systems, or hydroelectric plants, shows a much greater variability when we compare the kWh produced at the surface of the basin. Depending on the geodetic jump, on the flow of the pipeline and on the hours of use per year (this is related to the width of the basin), the annual energy per square meter of basin can vary from a few tens of kWh to over 1000 kWh. A first estimate of the annual energy production, averaged over ten basins in Lombardy is 200 Kwh, a figure to be confirmed by a systematic and more accurate analysis of specific cases.
This estimate, however, shows that an FTCC system mounted on a hydroelectric reservoir could substantially increase the production of electricity.

Figure 6 Speccheri basin (Vallarsa Tn)

An FTCC system mounted on a hydroelectric reservoir also results in reduced costs and improved efficiency for the following reasons:

- The existence of a basin wired and connected to the network reduces the cost of PV installation
- The presence of a pumping system helps to store the energy produced while avoiding the problems related to exceedingly fast power variation.

- In some cases the use of inverters can avoided and solutions can be found that allow the use of direct current into the pumping systems
- Finally, it should be noted that the production of photovoltaic energy is concentrated in the summer with about three months of delay respect to the maximum hydroelectric production, with a net improvement of the network optimal use.

Figure 7 Speccheri basin: scheme of a 3 MWp FTCC plant.

Reduction of gray energy, life cycle and decommissioning.

One of the problems posed by the photovoltaic today is the high energetic cost necessary to produce PV panels. Recent estimates give a value of 5-6 MWh for the production of one silicon kWp, which suggests that the first 5 years of plant operation are spent to repay the investment made for the energy wasted in the panels' production.

A solution to this problem is the use of aluminum mirror concentrators. In fact, the energy cost of aluminum is 14 kWh per kg and 15 kg of aluminum are sufficient for one kWp. Then the energy cost is 210 kWh, i.e. about 30 times lower than that of silicon.

On the other hand, reflectors bring down the need of silicon by a factor ranging from 2 to 10 and thus provide a strong reduction of the energetic cost of the plant.

The adoption of this solution has been so far limited by the cost of tracking systems needed for plants with concentration, but the technique proposed here substantially reduces these costs and makes the plant compete.

It must be further emphasized that the life cycle of the panel is considerably increased: the aging of the panel is mainly due to thermal stresses and these are practically zero in the solution proposed by FTCC. Finally, our modular floating system does not require a fixed structure and the plant can be easily removed if necessary, leaving the natural environment completely intact with decommissioning costs less than one percent of the cost of the plant.

In conclusion, the FTCC system is minimally invasive, inexpensive in terms of energy and easy to dismantle.