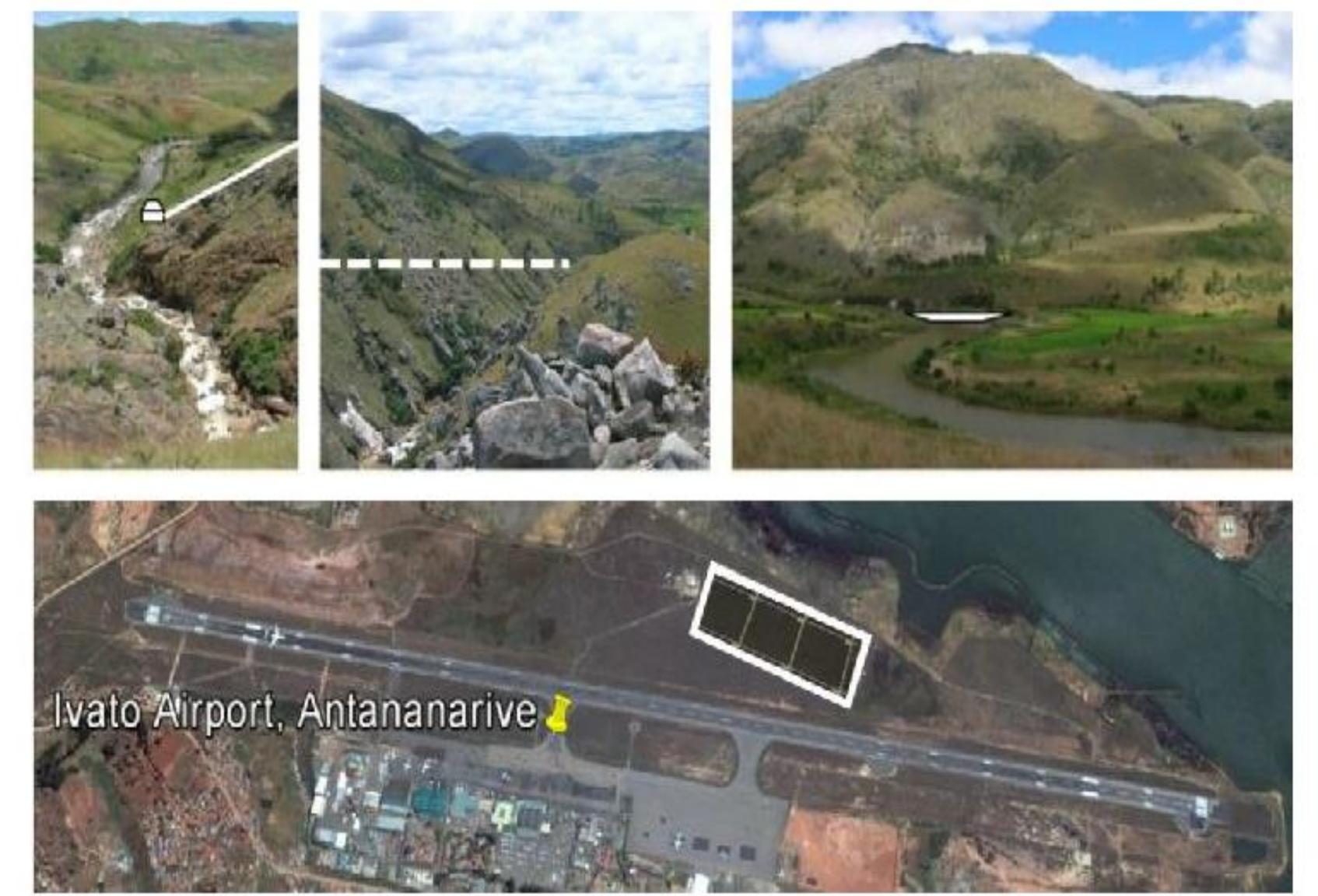


# Combined hydroelectric and solar power plant project at Talaviana and Ivato



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## Introduction

Access to electricity remains low in Madagascar, those who have access, get their energy mainly from diesel. However, the potential of renewable energies is extremely large, it is one of the richest countries in terms of solar and hydro power potential. Combining solar PV and hydro power would allow to satisfy the electricity demand during the day with solar PV and during the night with hydro power. The hydro power plant which will be located on the Manandona river could store water in a reservoir and shift the hydropower production to the evening to meet the peak power demand.

## Objectives

- Validate the energetic potential of hydro and solar power plant
- Analyse if it is technically and economically possible to install these power plants in the planned area
- Determine an optimal volume and capacity for the reservoir

## Hypothesis

- Volume calculations for the reservoir can be done with QGIS and DEM data
- Installation efficiency is 80% for hydro power plant and 15% for solar PV cell
- There is a proportionality according to the surface of the catchment basins

## Results

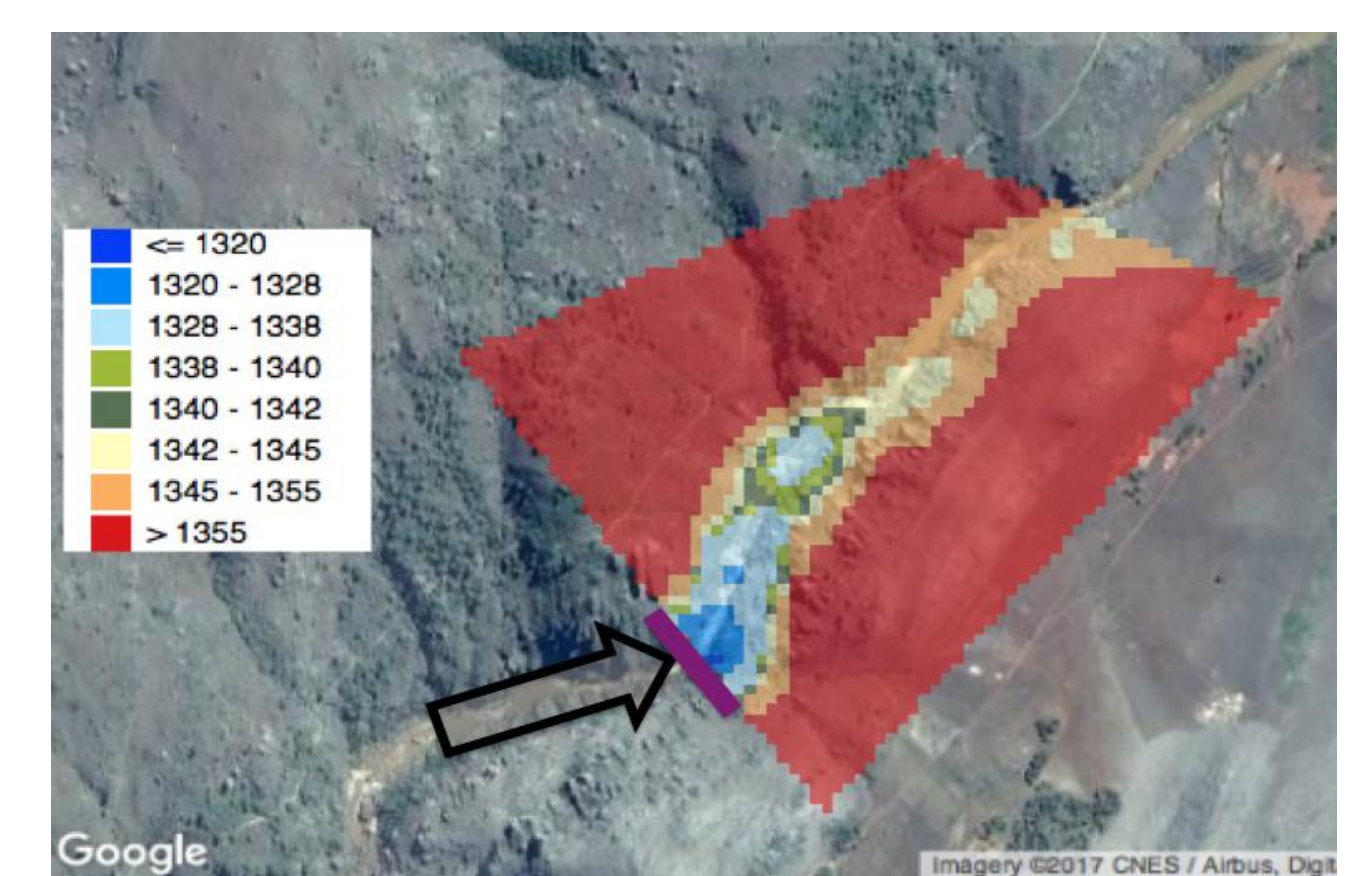
### Topography

- Assumptions for the volume of the flat area in front of the gorge needed to be done as the quality of data (10 x 10 m) was not sufficient
- For the volume of the gorge only volume between 1328 and 1338 m was considered to have enough space for the bottom outlet and the dead volume as well as to account for the uncertainty of the data

### Hydrology and Solar PV

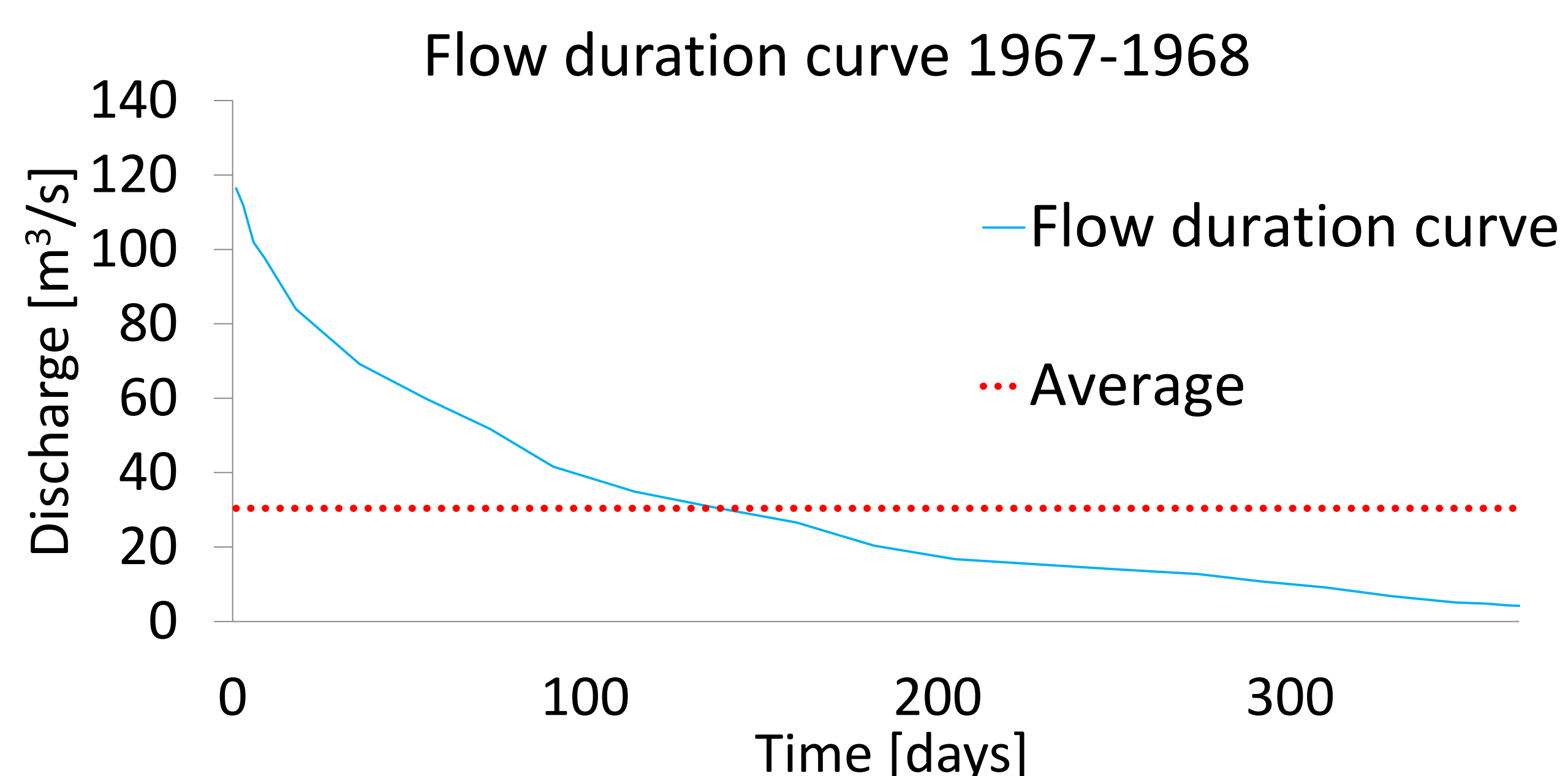
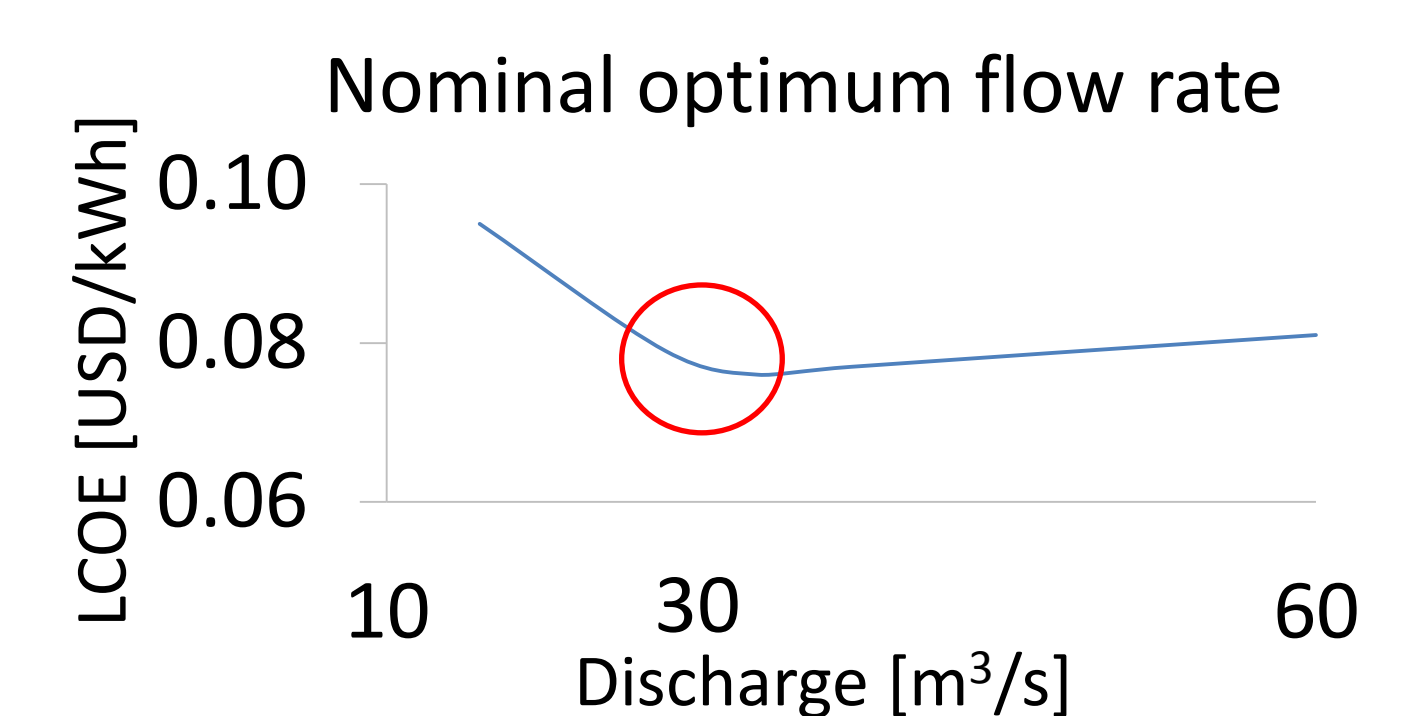
- Historical discharge data is used from the measurement station Sahanivotry hydro power plant that is located on the upstream of the Manandona river
- Annual discharge average is 30.4 m<sup>3</sup>/s between 1963-1980
- Yearly irradiation average is 446 kW/m<sup>2</sup>

	Volume flat area [m <sup>3</sup> ]	Volume gorge [m <sup>3</sup> ]
Level at 1338 m	560'000	78'000
<b>Total Volume</b>	<b>640'000</b>	



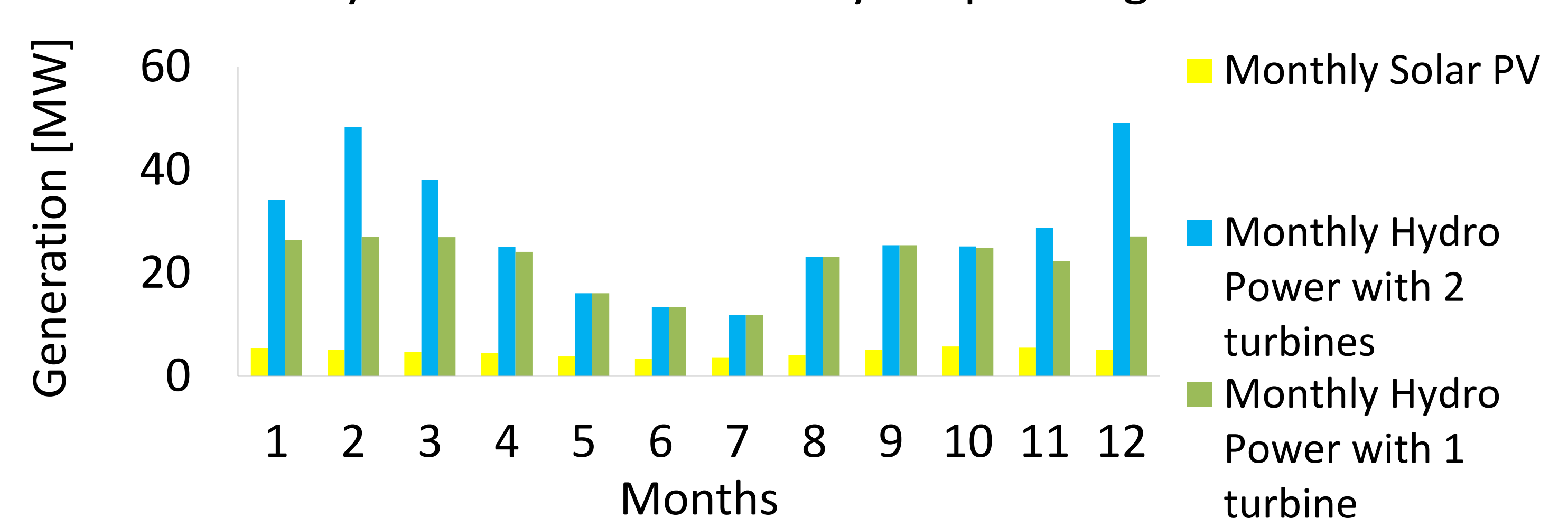
Picture on the right proposed placement of the reservoir and the dam shown in violet (volume of plane area is not shown).

Nominal optimal flow rate [m <sup>3</sup> /s]	30
Residual Flow [m <sup>3</sup> /s]	1.45
Difference in altitude between up and downstream water [m]	108



	Annual mean production [GWh/year]	Annual mean power [MW]
1 turbine	146	24
2 turbines	195	32
3 turbines	210	38
Solar PV	39	5

### Monthly mean solar PV and hydro power generation



### Economy

- LCOE calculation of the combination of hydro and solar PV

Reimbursement to the bank in 10 years	
LCOE solar PV [USD/kWh]	0.11
LCOE hydro power [USD/kWh]	0.07
LCOE solar PV and hydro [USD/kWh]	0.08
Diesel [USD/kWh]	0.5

## Conclusion

- The estimated minimum volume that can be stored in the reservoir is 640'000 m<sup>3</sup>
- Hydro power is sized to 32 MW with two turbines and the solar PV is sized to 5 MW
- Solar PV area should increase in order reach a higher electricity generation, limiting factor for the combination is the area of solar PV and not the volume of the reservoir
- LCOE for the combination of solar PV and hydro power for a reimbursement period of 10 years is 8 cts/kWh that is much lower than the diesel price (50 cts/kWh)

## Acknowledgements

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