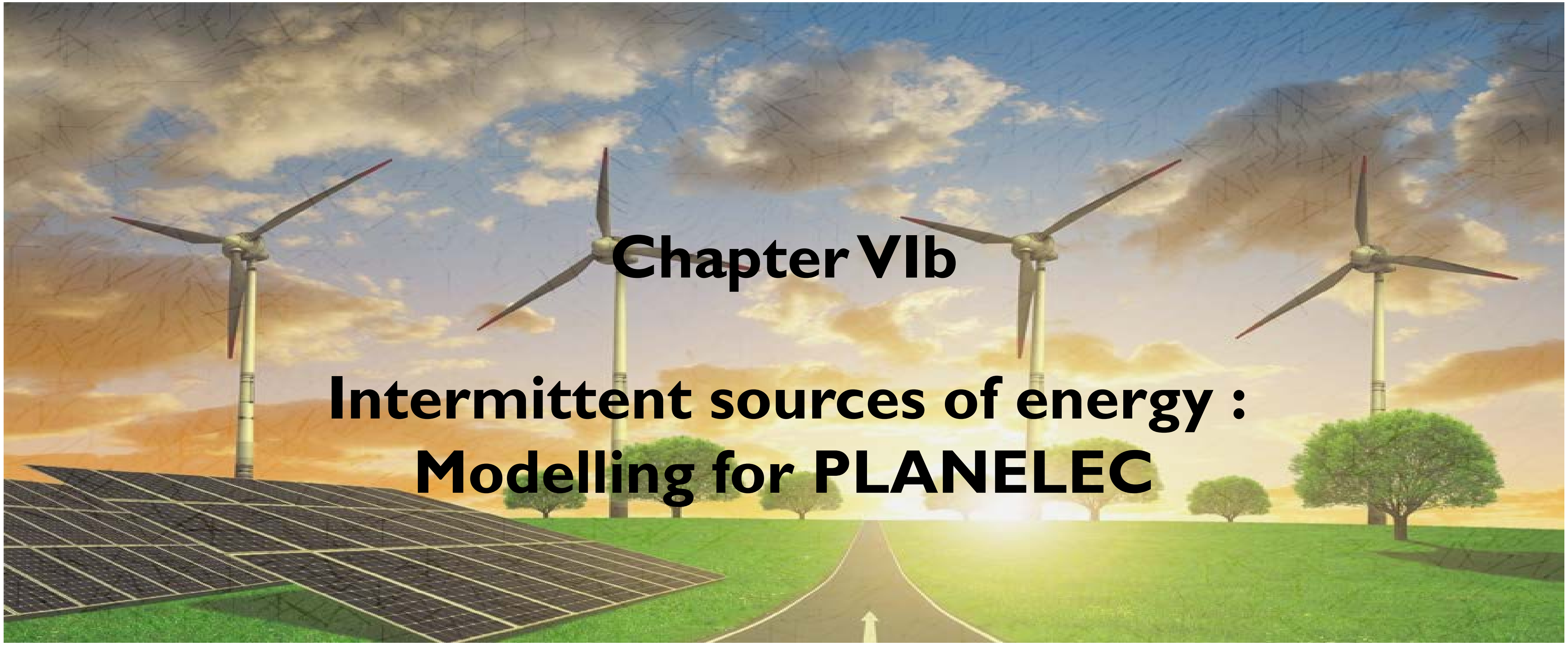
ENERGY PLANNING : MODELLING AND DECISION SUPPORT



Chapter VIb

Intermittent sources of energy : Modelling for PLANELEC

LEARNING OUTCOMES OF THE COURSE 6:

- Model the sources of intermittent energy in sight of planning for a long term adjustement between demand and supply of electrical energy
- Application in the case study

-CONTENT-

6b.1. THE LIMITS OF THE PROBABILITY CONVOLUTION APPROACH

- The probability function representing the variability of electricity demand is simplified because it does not consider autocorrelations
- Another strong hypothesis is the independence between random variables that represent the demand and supply of electrical energy
- **Alternative**: chronological curve or load curve therefore a time series model
- **Taking into account the correlation between demand and supply**: modelling too complicated to be used for long term planning

6b.2. SIMPLIFIED MODELLING IN THE CASE OF SOLAR PHOTOVOLTAIC

- Solar radiation is generally high during peak hours and low during off-peak hours, the same applies for electrical energy demand

- Thus, modelling intermittence in models such as PLANELEC needs an important simplification: the de-correlation between electricity demand and supply

1st step: Generating the time series of photovoltaic production

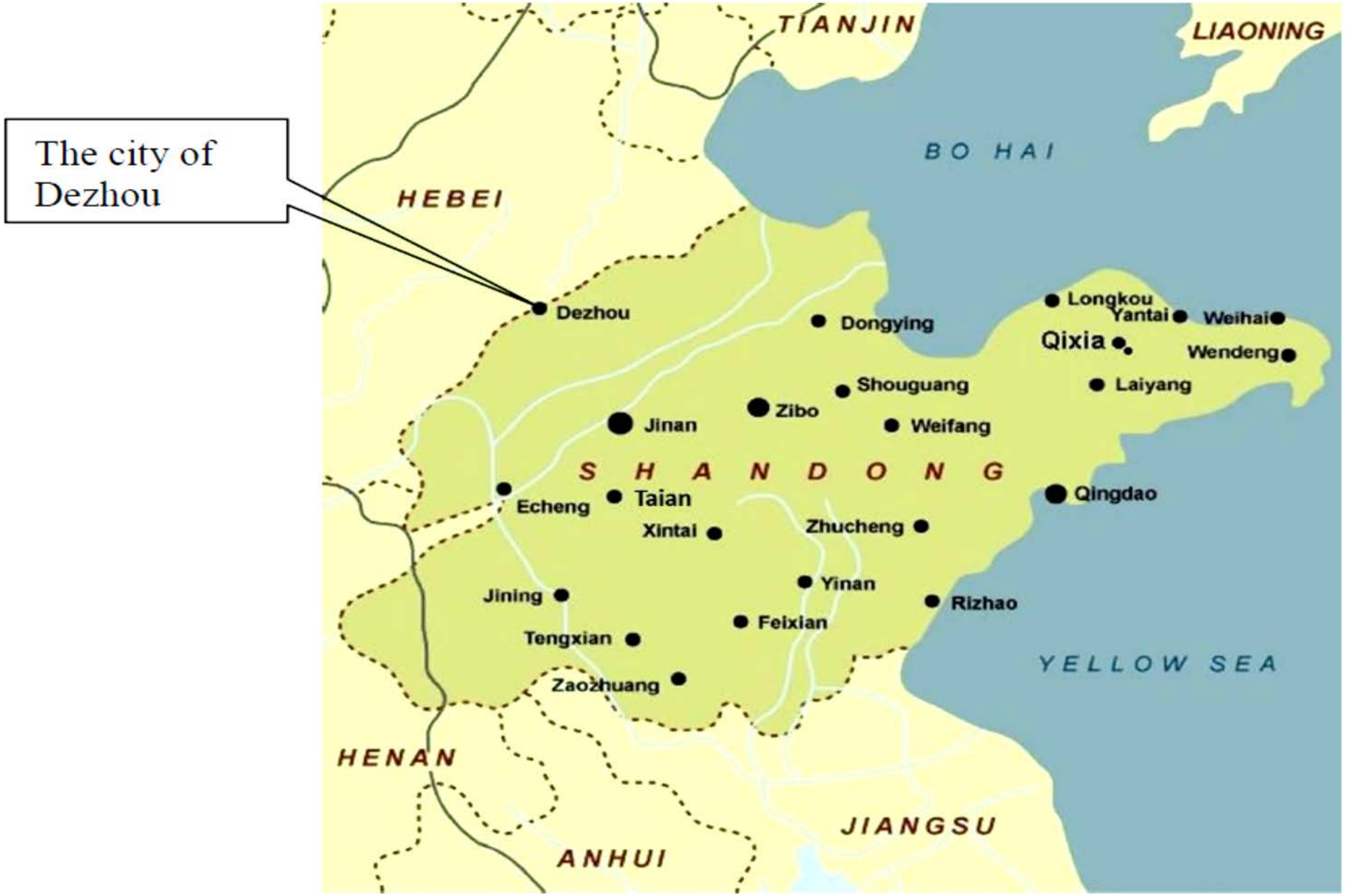
2nd step: Modelling the time series with Bernoulli's law of probability

1st step: Generating the chronicle of photovoltaic production

Generating the chronicle hours of irradiations

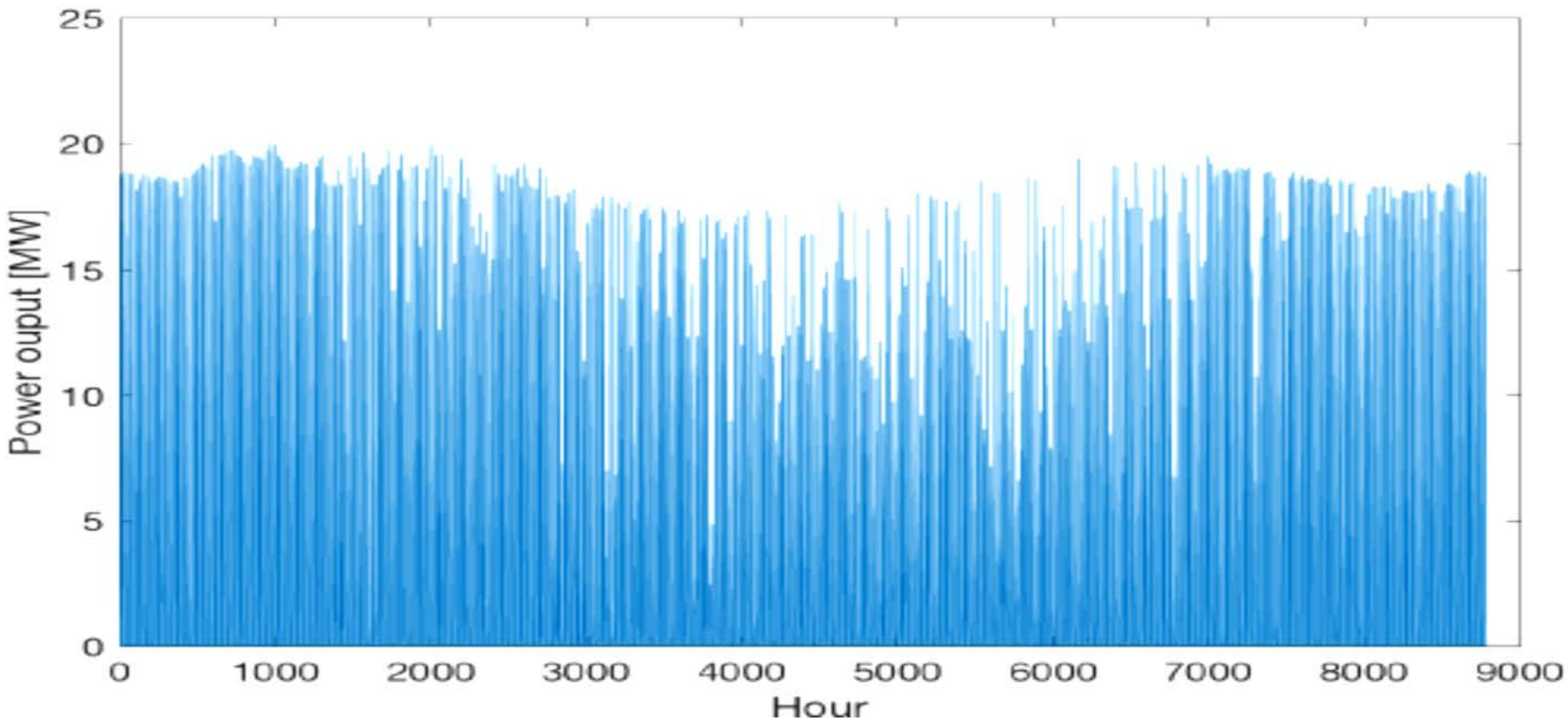
https://ec.europa.eu/jrc/en/pvgis

	CPA	
2	City	Dezhou City
3	County (District)	Qingyun County
	Subdivision	**Section**
4	SSC-CPA Unique Identification Number	001-PCDM-SDPV
5	Latitude of Project area	37.4438°
6	Longitude of Project area	116.3445°



Map showing the city of Dezhou

$$P_h = P_p \cdot \frac{I_{directe} + I_{diffuse}}{I_{STC}} \cdot \left[(1 - \alpha_{temp} \cdot (T_h - T_{STC})) \right] \cdot \prod_i (1 - \alpha_i)$$



Simulation of the production of energy from a PV central in Benin

2nd step: Modelling the chronicle with Bernoulli's law of probability

$$P_h = \begin{cases} P_{\max} & \mathrm{Prob} = \mathrm{p} \\ 0 & \mathrm{Pr}\,ob = (1 - p) \end{cases}$$

Find Pmax and p such that:

The average Pmoy and the variance of (Ph) s^2 are respected

$$\begin{cases} p.P_{\max} = P_{avg} & (1) \\ p.(\mathrm{P}_{\max} - P_{avg})^2 + (1-p).P_{avg}^2 = s^2 & (2) \end{cases}$$

Let c such that:

$$c = \frac{s}{P_{avg}}$$

c: coefficient of variation

With (1) and (2), Pmax is de

$$p = \frac{1}{1+c^2}$$

$$P_{\max} = P_{avg}(1+c^2)$$

Adjusting the specific investment cost ($/kW)

The specific investment cost has to be adjusted to the value of Pmax calculated previously by dividing the total cost of the power plant by a Power value often lower than Pp.

Illustration : Study case of a PV power plant project in southern Benin (Blaga and Gnansounou, 2020)

Data: Pp = 25 MWc

Investment cost: 39.10^{6} $

Specific cost per Wp: 1.56 $/Wp

Results:

P_{avg} = 4.2 MW

P_{max} = 12.76 MW

1 - p = 66.94% (equivalent outage rate)

Specific cost per W: 3 $/W

References:

Blaga, C., Gnansounou, E. (2020), Modelling the «intermittency additional cost» of PV plant integration in a conventional electrical generating system: case of Benin. Project «Mineur en énergie», January 2020.