

**University of Science and Technology of Hanoi**  
**Renewable Energy Department**  
**Clean Energy and Sustainable Development Lab**



**Control and Grid synchronization for PV system, case study : a low-voltage distribution grid in vietnam**

**NGUYEN Xuan Truong, Nguyen Dinh Quang**

# CURRICULUM VITAE

## EDUCATION

### Engineer

- **Electrical engineering** (Génie électrique) – Francophone University Association (AUF scholarship) – from Hanoi University of Science and Technology

### Master of research

- **Electrical engineering** (Génie électrique) – from Grenoble Institute of Technology (Grenoble INP - France)
- **Energy and reliability** – from University of Montpellier 2 (France)

### PhD/Docteur

- **Electrical engineering** (Génie électrique) – from University Paul Sabatier (Toulouse 3 - France)

## SKILLS

### Computer

- **Microsoft Office application** (Word, PowerPoint, Excel)
- **Electrical design/simulation** (CAO-Electronic Protel, Matlab simulink, ATP-EMTP, EUROSTAG, PEANUTS)

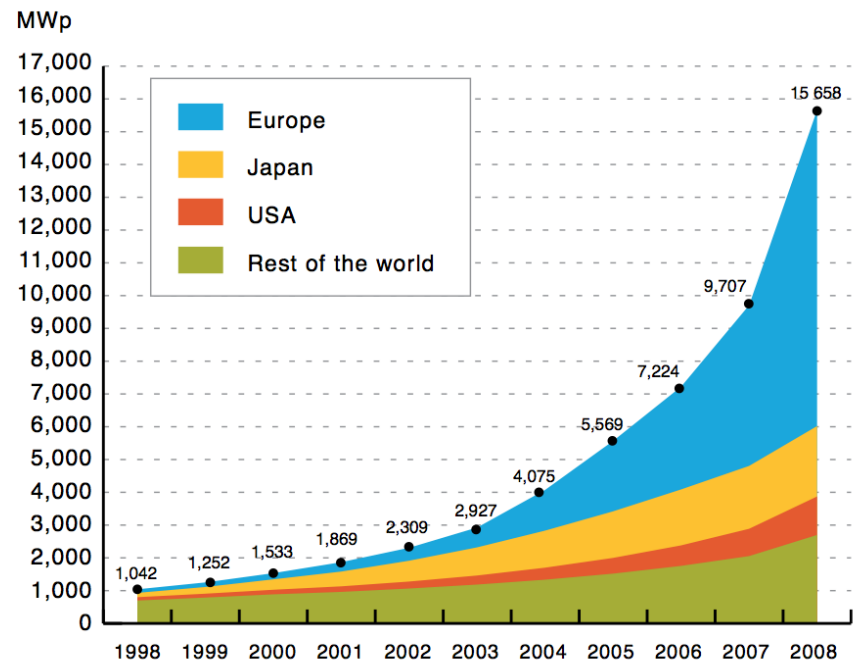
### Organization

- **Social activities** (seminar, reunion, conference, gala)

- **Challenge :**
  - World energy consumption increases 2%/ year => exhaustion of fossile source
  - Production of energy ensured by fossil source : rarer and more expensive; emission of CO<sub>2</sub>
  - Developed countries : energy produced from RE (promotion and exploitation in the future potential of RE)
- **PV energy :** promising source without CO<sub>2</sub> and limitless energy source, noiseless operation

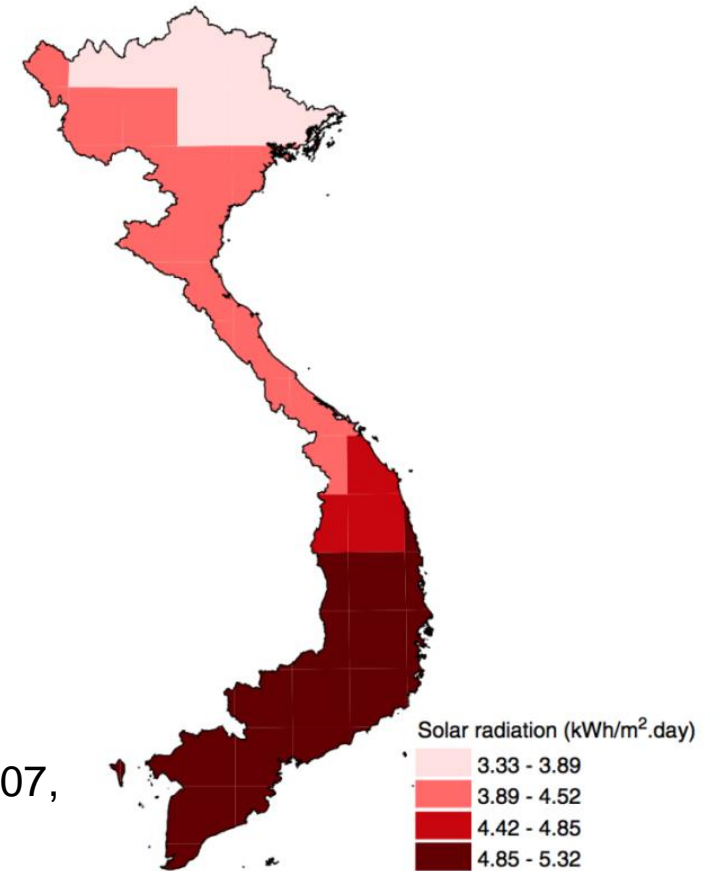
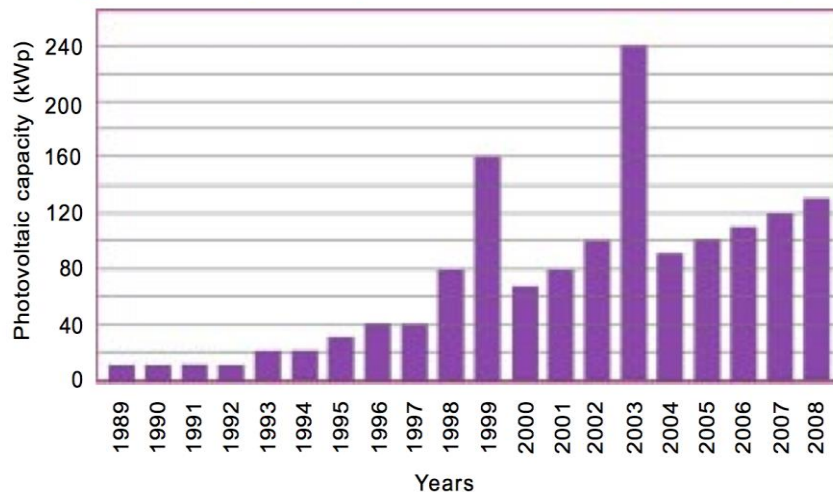
- **Evolution of global PV cumulative installed capacity 2000 – 2008**  
(source : EPIA)

**Grows exponentially, 2013 (140 GW of PV installation)**



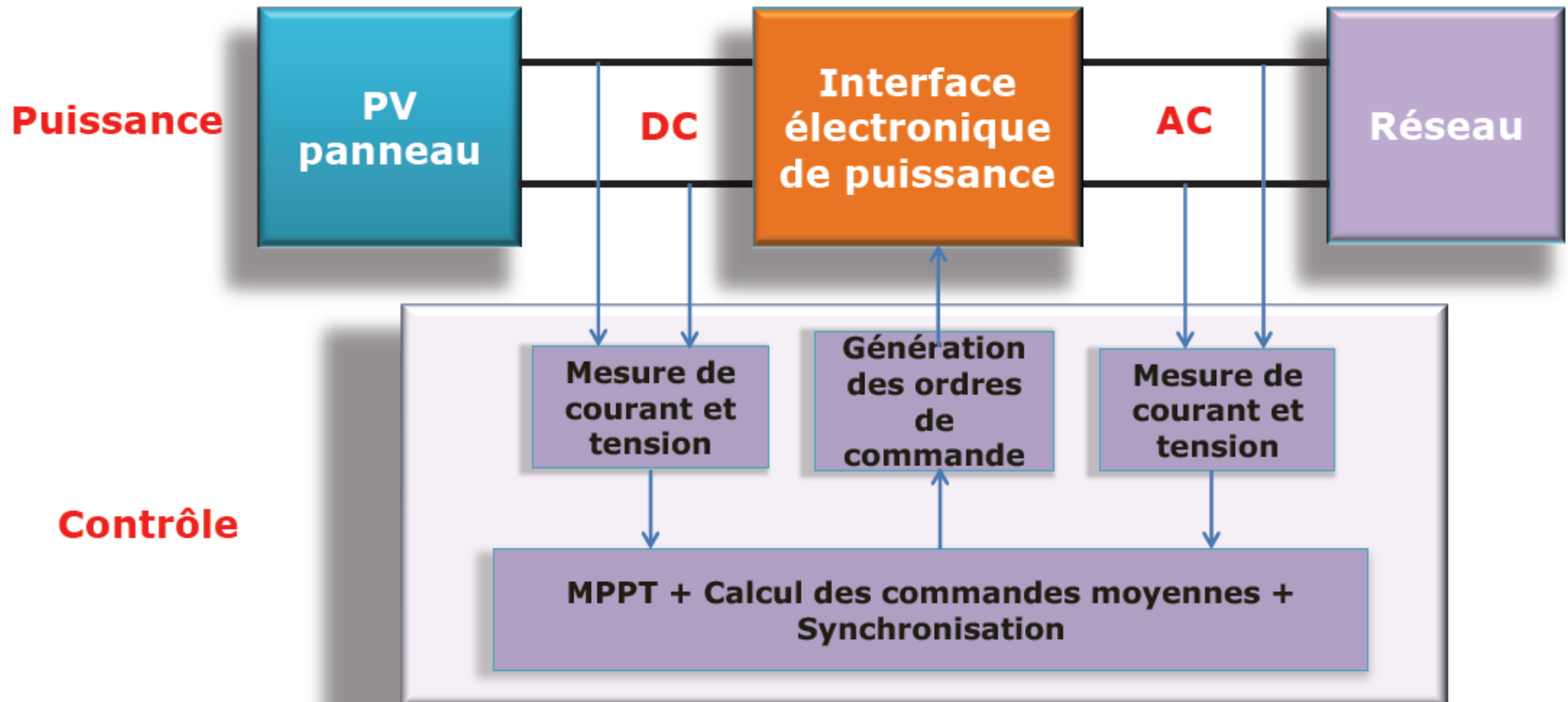
- **Potential of PV energy in Vietnam (source : renewableenergy.org.vn)**
- Having of good constant solar source with roughly 2000-2500h of sunshine/ year
- Solar radiation for energy production can total up to 1744,5 kWh/m<sup>2</sup>/year, current use 3000 kW
- At present, the total installed : 650 kW (5000 sites around the country)

**PV development in Vietnam 1989 - 2008**

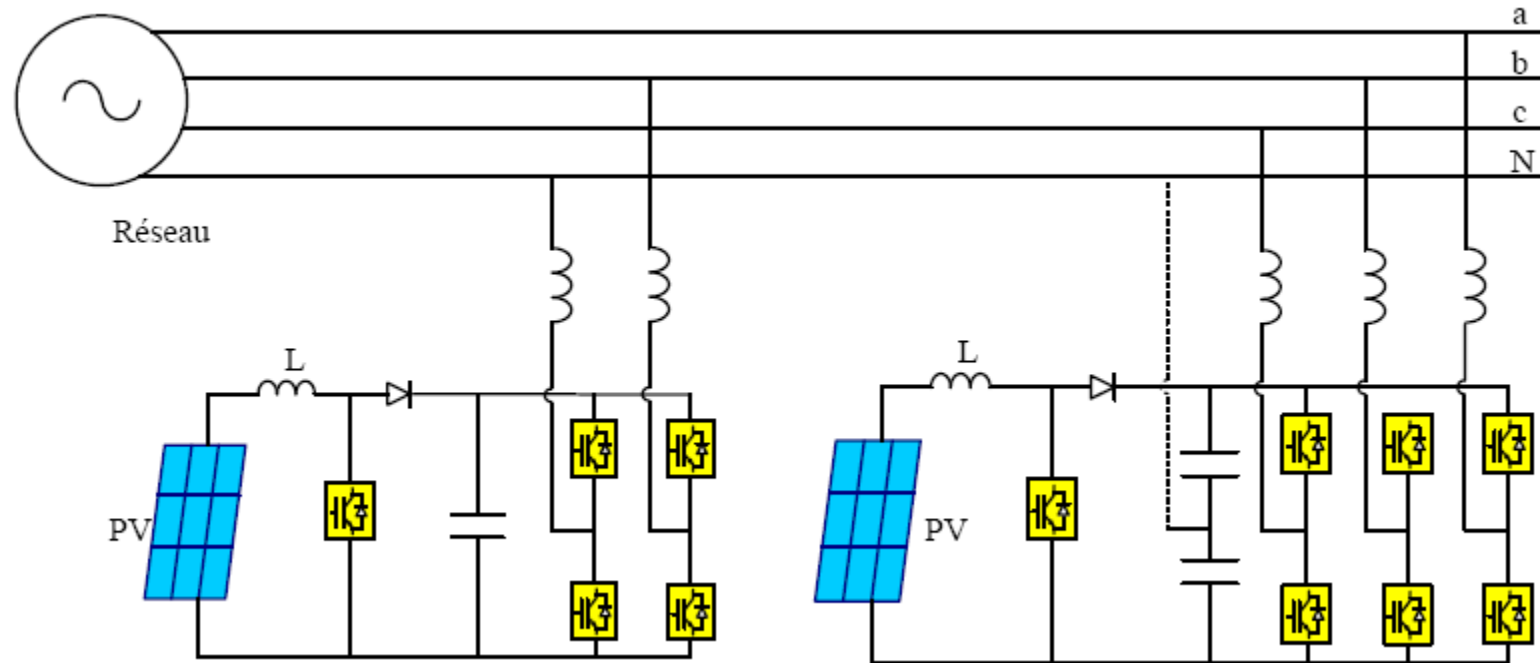


- **Government policy**
- Much plant to increase budget for RE (VII plant, ... 2007, 2011)
- Support mechanism for RE/PV : law , decree

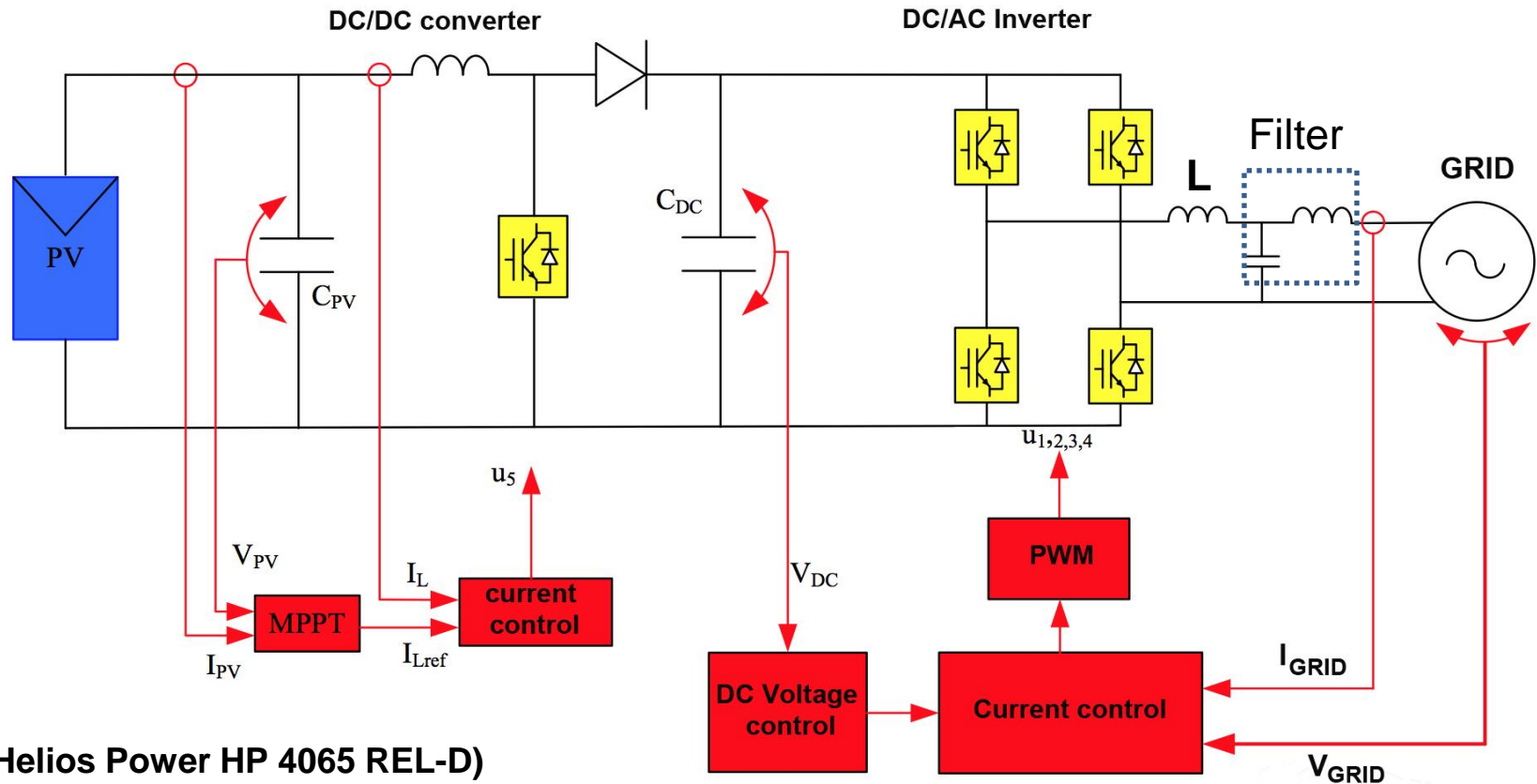
- PV energy :**
  - PV cell converts light energy (solar irradiance) into electrical energy
  - PV cell generate DC voltage and this DC voltage converted into AC by using power electronics inverter



■ On - Grid :



On - Grid : Single phase → topology is widely used in PV inverters marketed

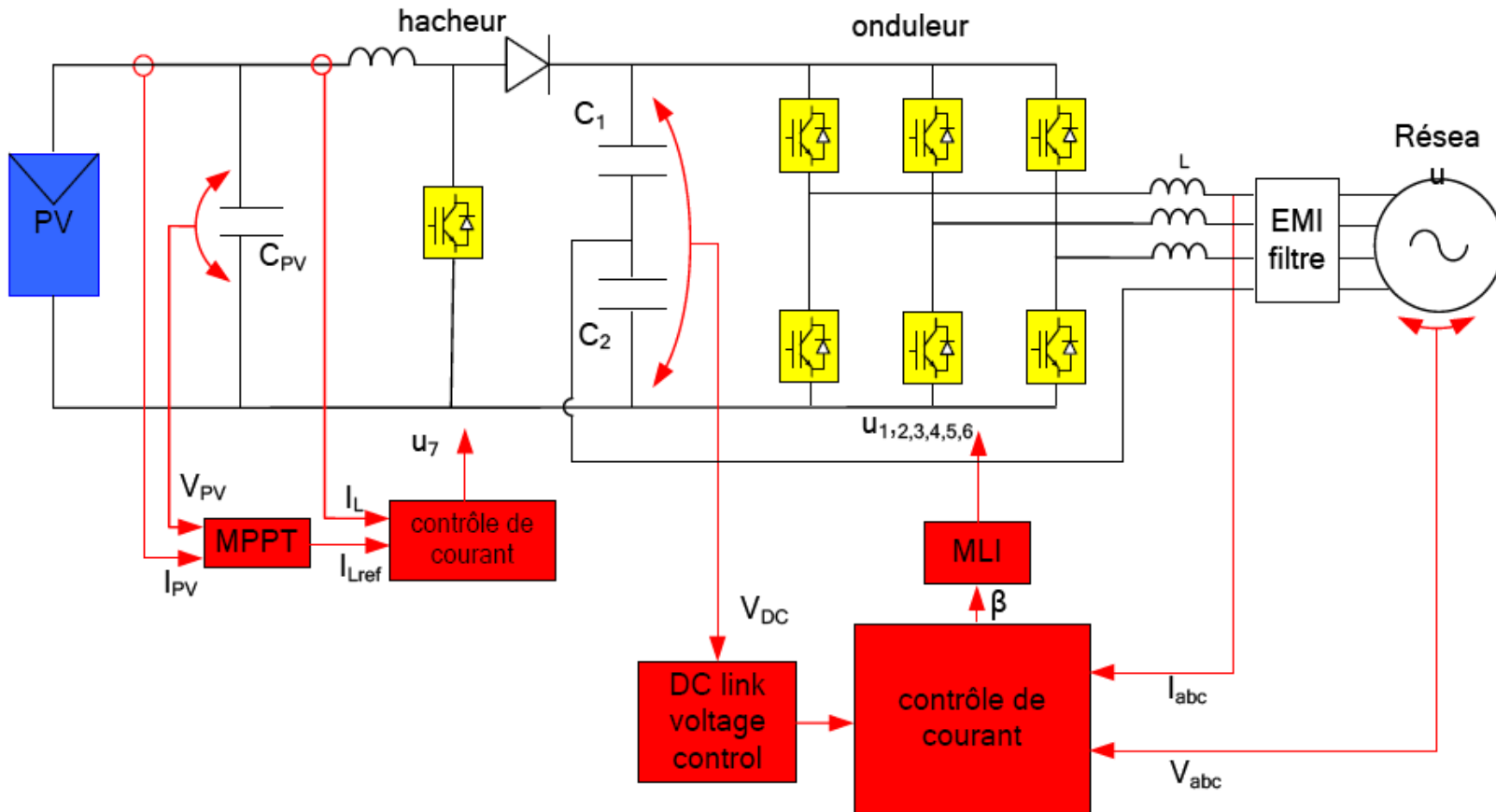


- RIELLO (Helios Power HP 4065 REL-D)
- AROS type Sirio 4000; SCHNEIDER type SunEzy 2000,4000,400E
- SMA type Sunny Boy 2100TL
- SPUTNIK type Solarmax 2000C/3000C
- SPUTNIK type Solarmax 2000S/3000 S
- SPUTNIK type Solarmax 4600S/6000 S

▪ DC/DC

- Boost converter : amplifies the input voltage DC
- IGBT : convert DC current to AC current using the pulse width modulation technique

- On - Grid : Three phase → topology is widely used in PV inverters marketed





- **Condition → standard given by the power company**
- **Safety** : the inverter must disconnected to grid if the grid is dead
- **Accident** for person & damage for equipement connects to grid : voltage dectector & current detector
- **Nominal specification of inverter voltage** : value (voltage AC, frequency, harmonic, shfting phase

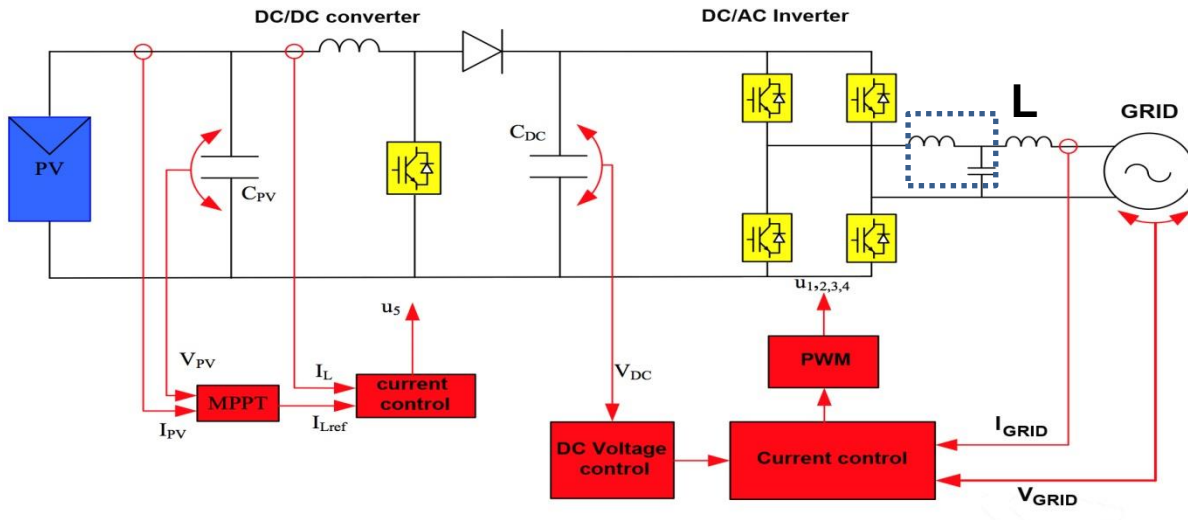


If those factor strays too far of grid's specification → inverter must also isolate to grid

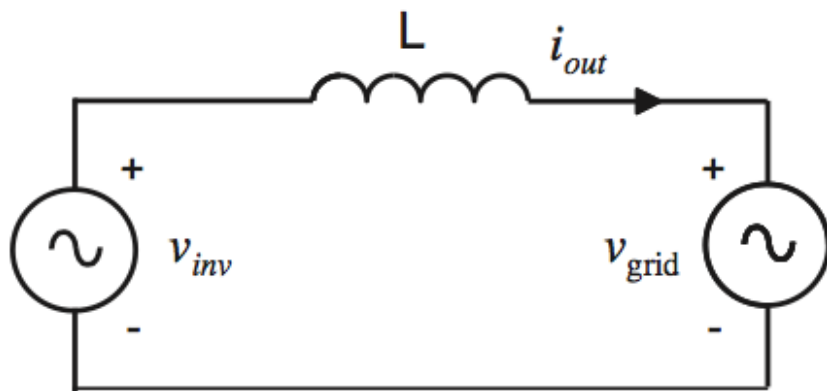
**IEEE 1547 standard (0 – 500 kVA) [ieee.org]**

- **Voltage different** : 10 %
- **Frequency different** : 0,3 Hz
- **Phase angle different** : 10°

# Condition for synchronization PV to electric Grid : single phase

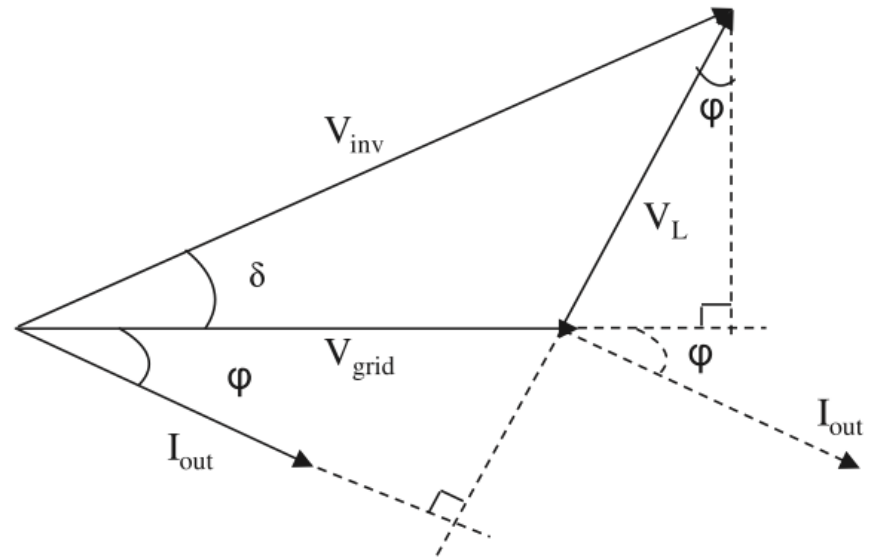


$$V_{inv} = V_{grid} + V_L$$



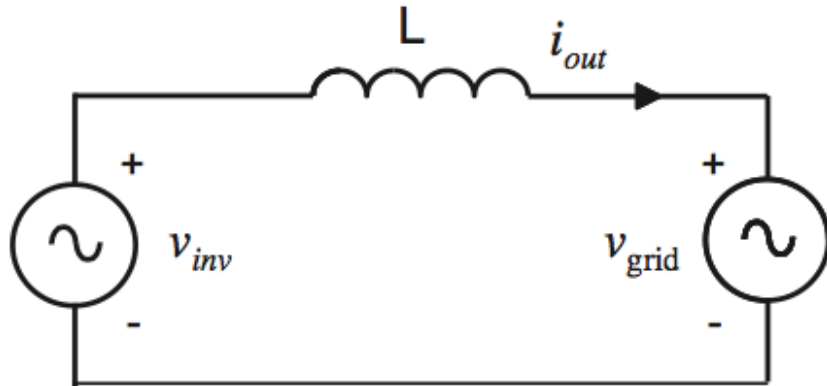
a

Equivalent electrical circuit



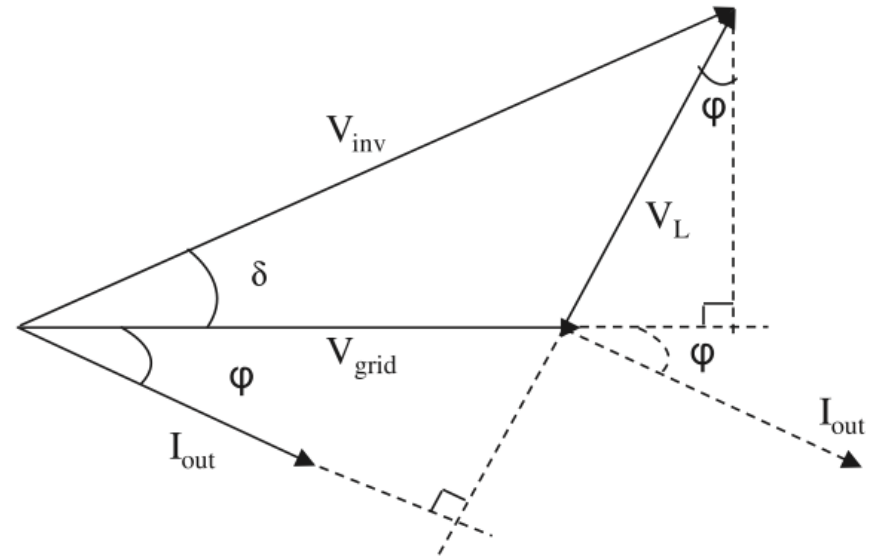
b

Phase diagram



a

Equivalent electrical circuit



b

Phase diagram

$$v_{inv} = \sqrt{2} \cdot V_{inv} \angle \delta$$

$$i_{iout} = \sqrt{2} \cdot I_{out} \angle \varphi$$

$$V_L = jX_L I_{out} = j\omega L I_{out}$$

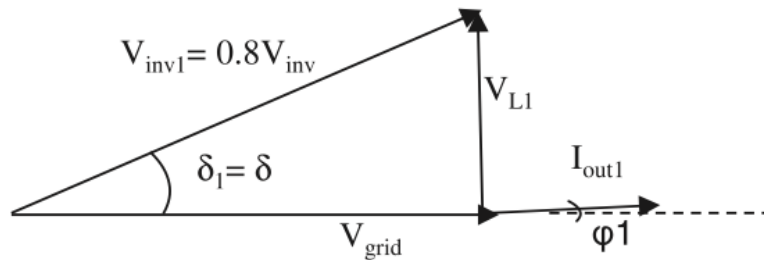
$$\varphi : I_{out} \quad V_{grid}$$

$$\delta : V_{grid} \quad I_{out\_inverter} \longrightarrow$$

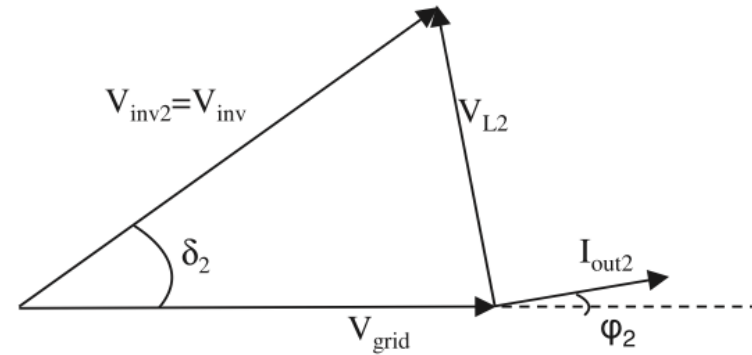
Shift phase between inverter output current and grid voltage  $\rightarrow$  **to be controlled**

a) Assuming the phase angle  $\delta : const$  and varying the amplitude of the inverter output voltage

b) The amplitude of the inverter output voltage = cts and assuming the phase angle  $\delta : var$



a



b

Other

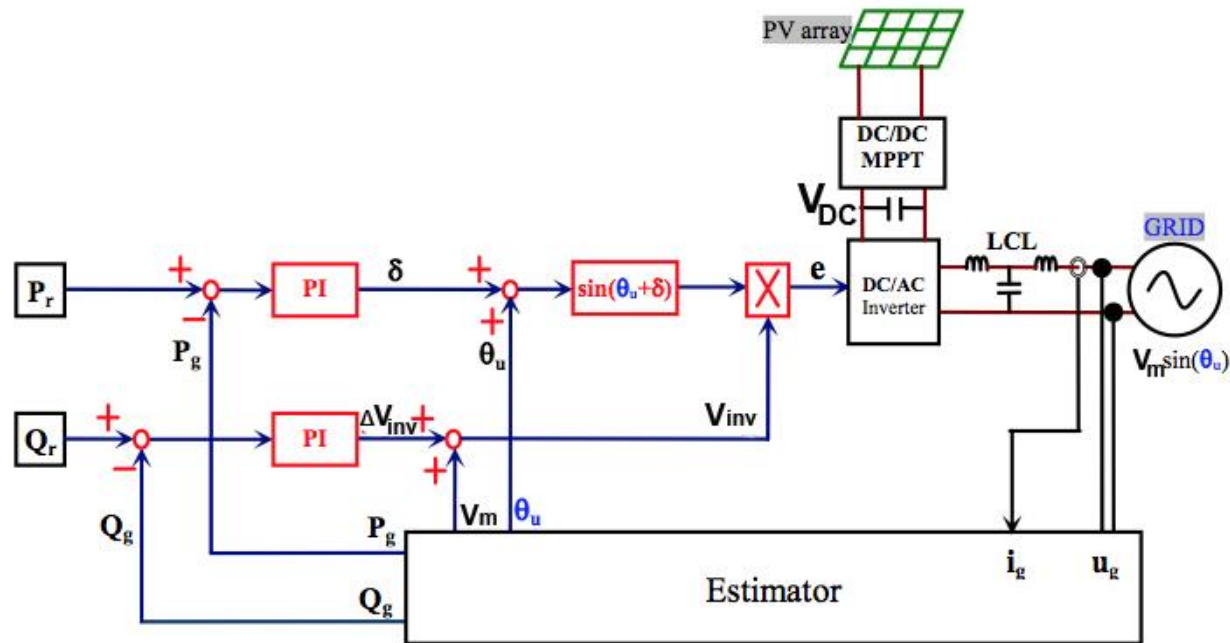
$$V_{inv} \sin \delta = V_L \cos \varphi = X_L I_{out} \cos \varphi$$

$$P = V_{grid} I_{out} \cos \varphi = \frac{V_{grid} \cdot V_{inv} \sin \delta}{X_L}$$

$$Q = V_{grid} \cdot I_{out} \sin \varphi$$

$$X_L \cdot I_{out} \cdot \sin \varphi = V_{inv} \cos \varphi - V_{grid}$$

$$Q = \frac{V_{grid} (V_{inv} \cos \varphi - V_{grid})}{X_L}$$

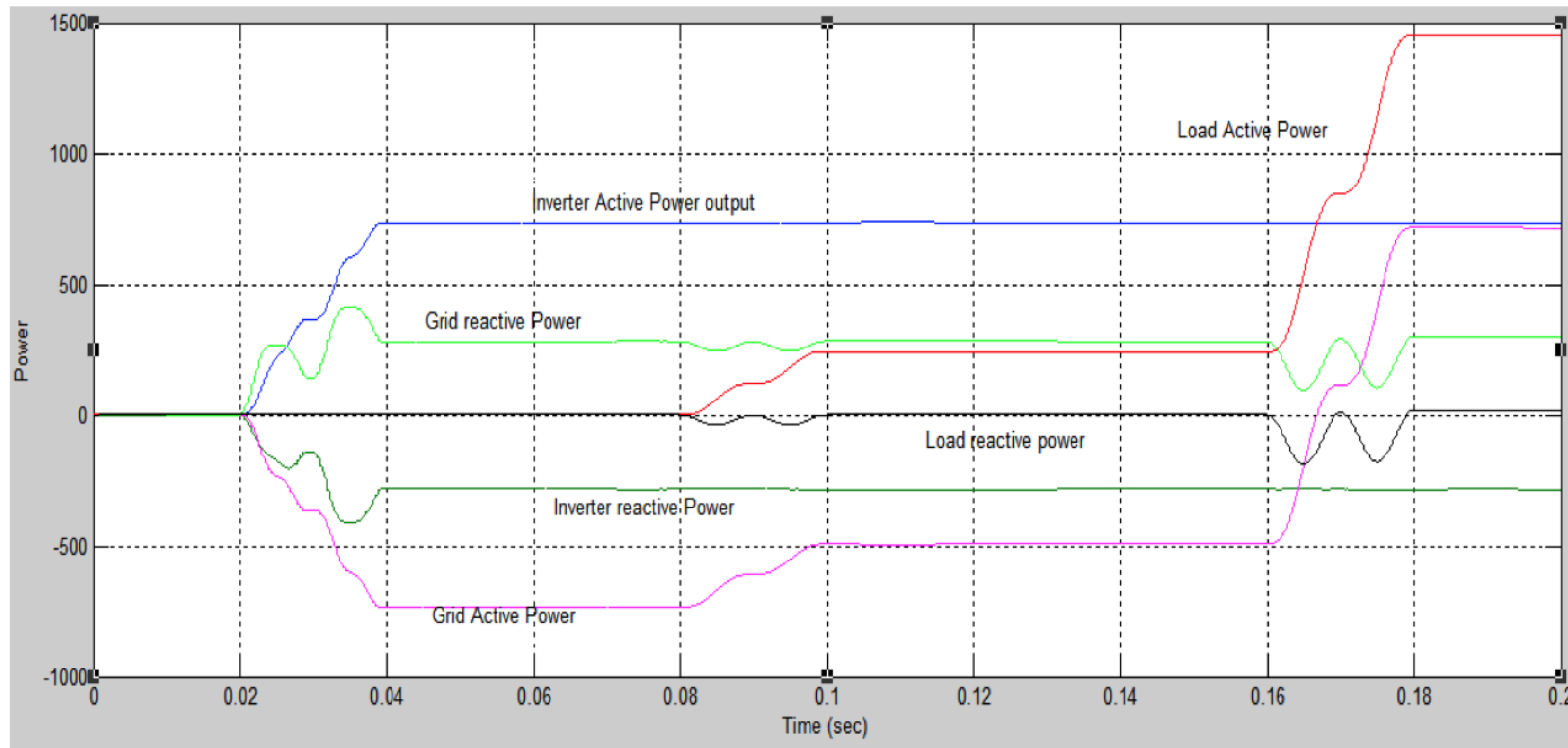
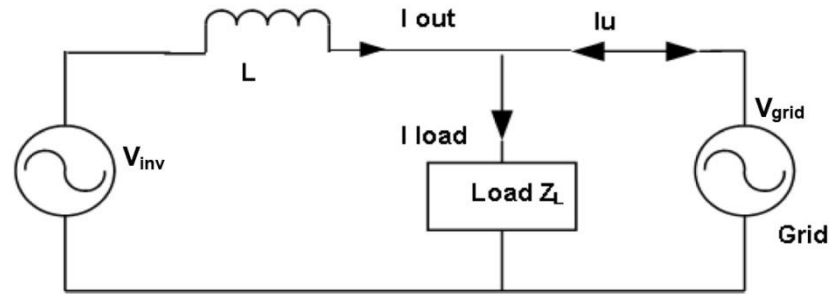


$$e = \sqrt{2}V_{inv} \sin(\delta + \theta_u)$$

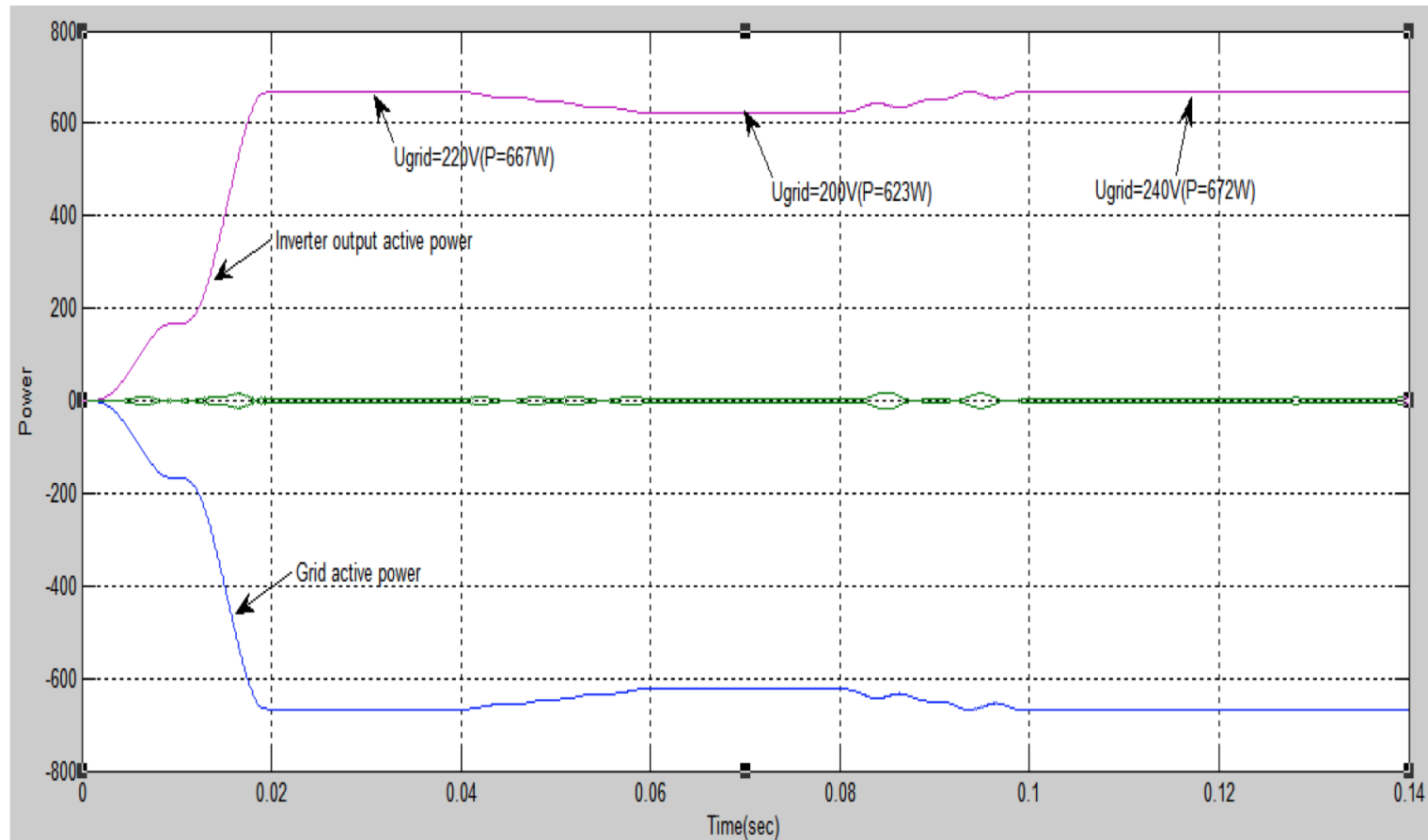
$$t = T - \frac{\delta T}{360^\circ} = T \left(1 - \frac{\delta}{360}\right)$$

$$\sqrt{2}V_{inv} = \sqrt{2}V_{grid} + \Delta V_{inv}$$

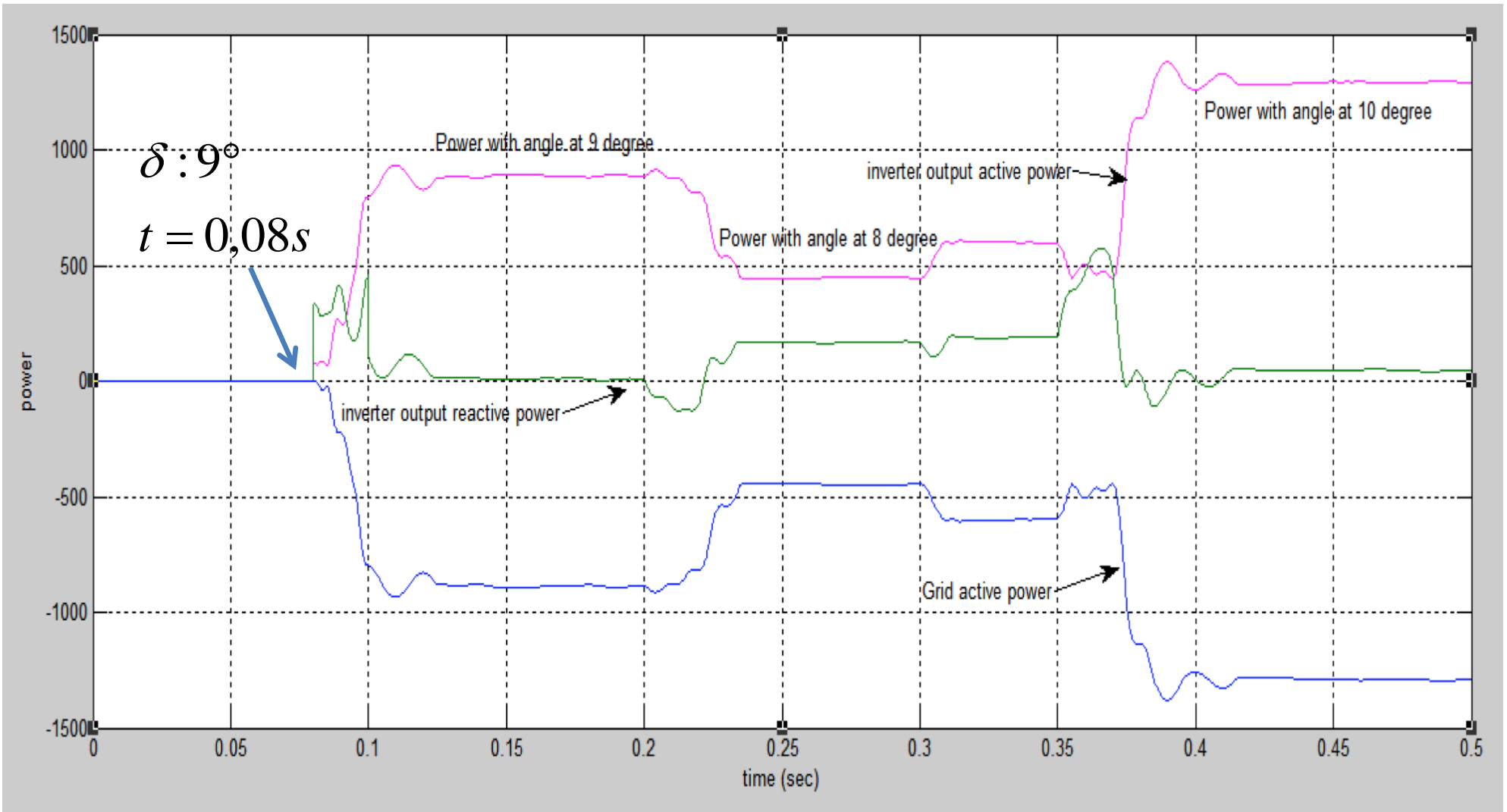
**Local load variation**



**Variation of grid voltage**

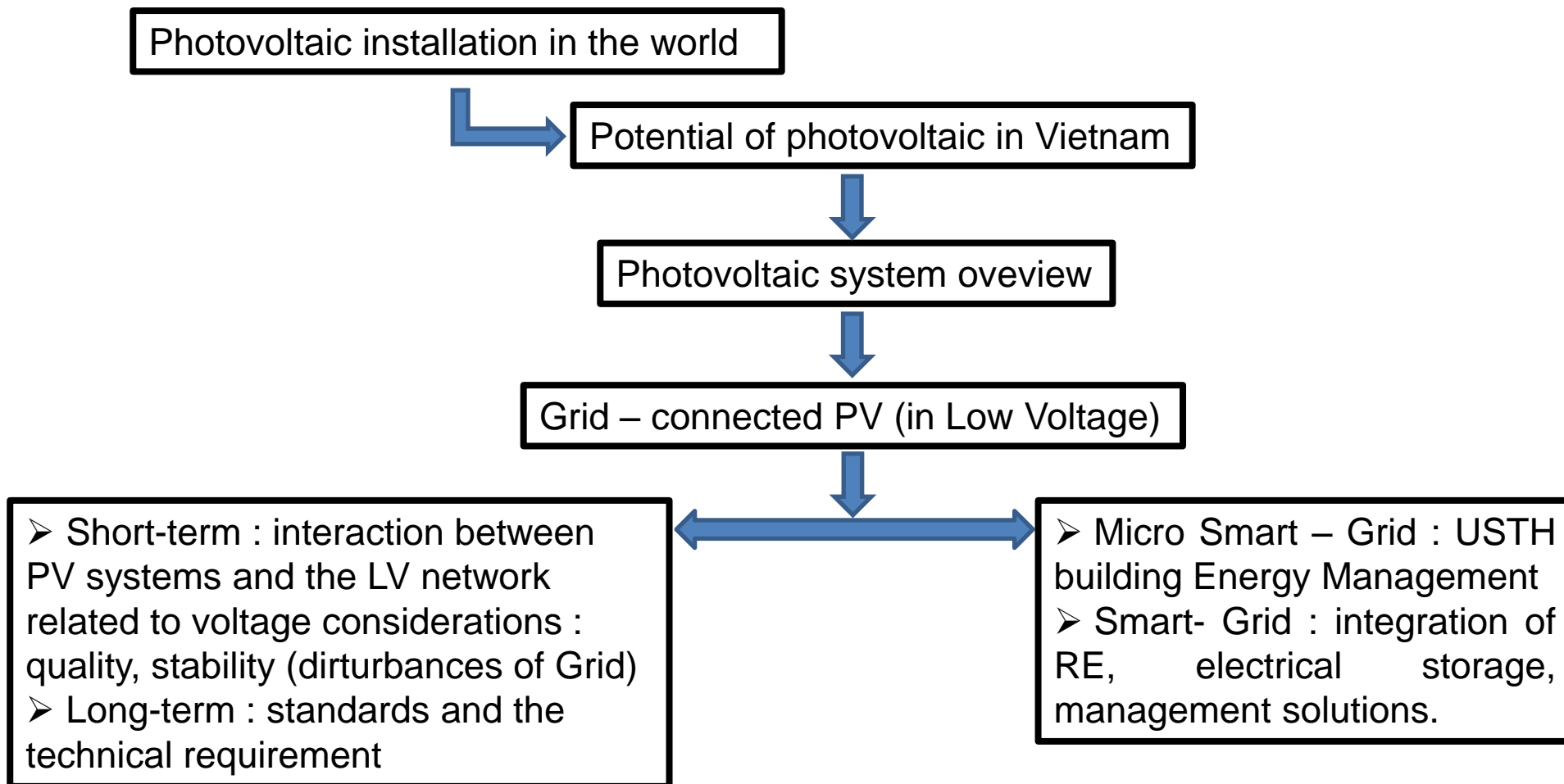


Variation of shift angle





## ■ Scenario of the project :



# Thank You

## Principe de fonctionnement des panneaux photovoltaïques

