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MPPT VS FPPT: Solar Photovoltaic System Perspective

Ts. Dr. Muhammad Ammirul Atiqi Mohd Zainuri
Senior Lecturer

Department of Electrical, Electronic and Systems Engineering
Faculty of Engineering and Built Environment
Universiti Kebangsaan Malaysia



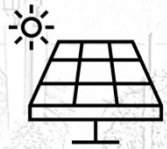
Lecture outline



Background and
Motivation



Maximum Power Point
Tracking (MPPT)

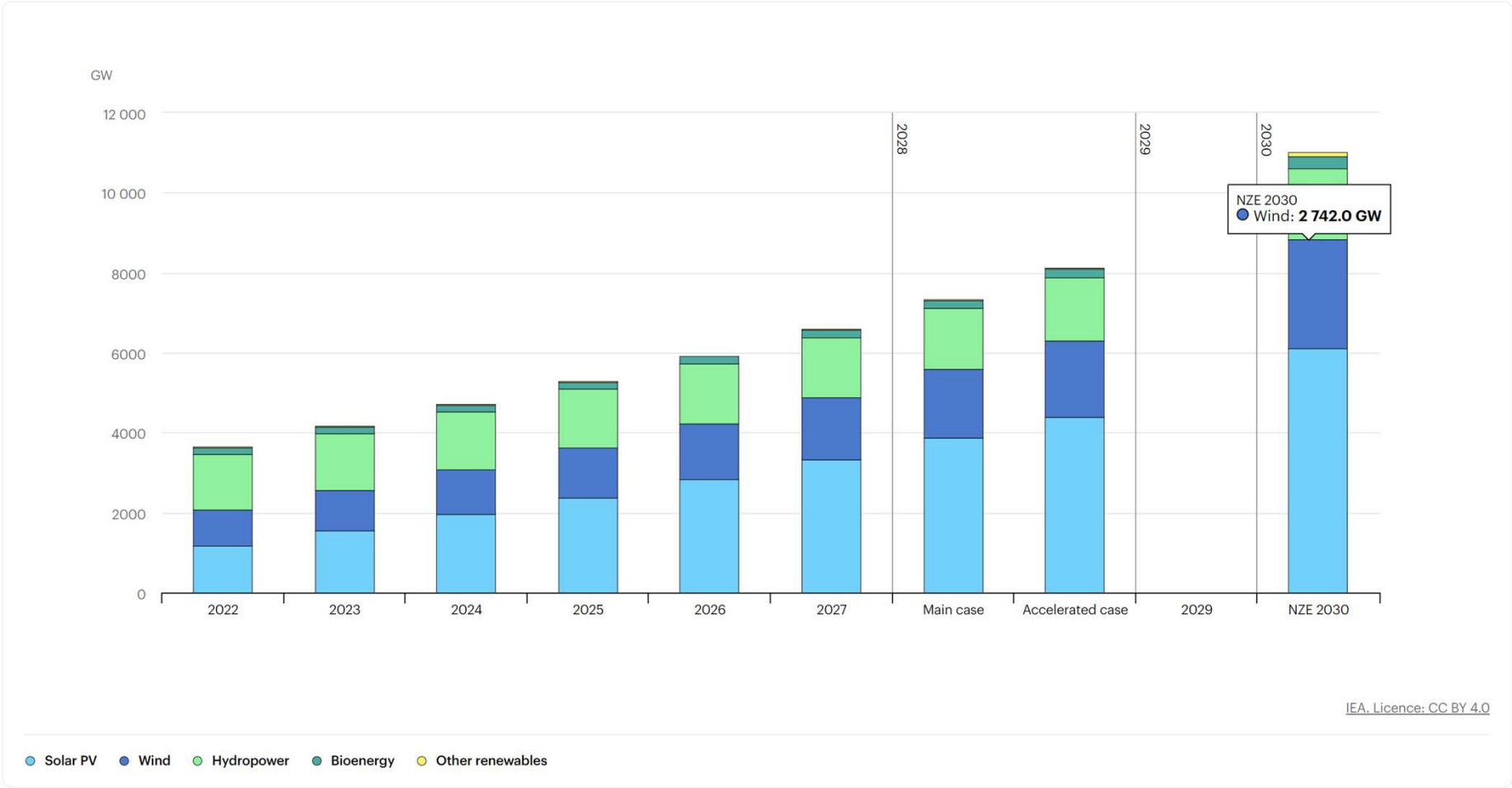


Flexible Power Point
Tracking (FPPT)



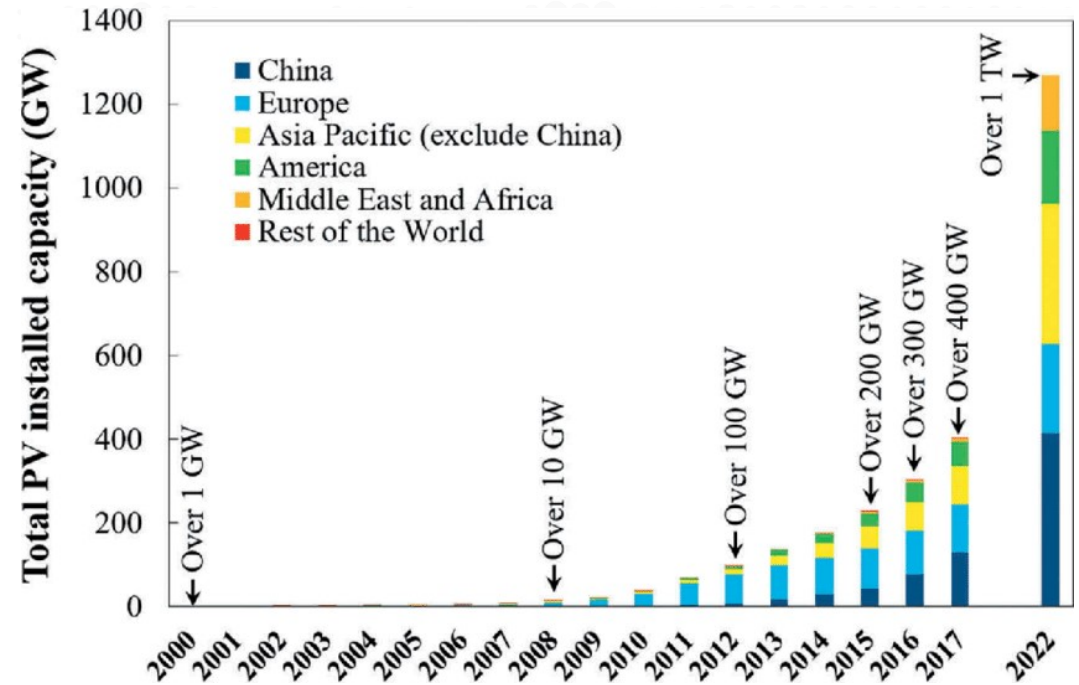
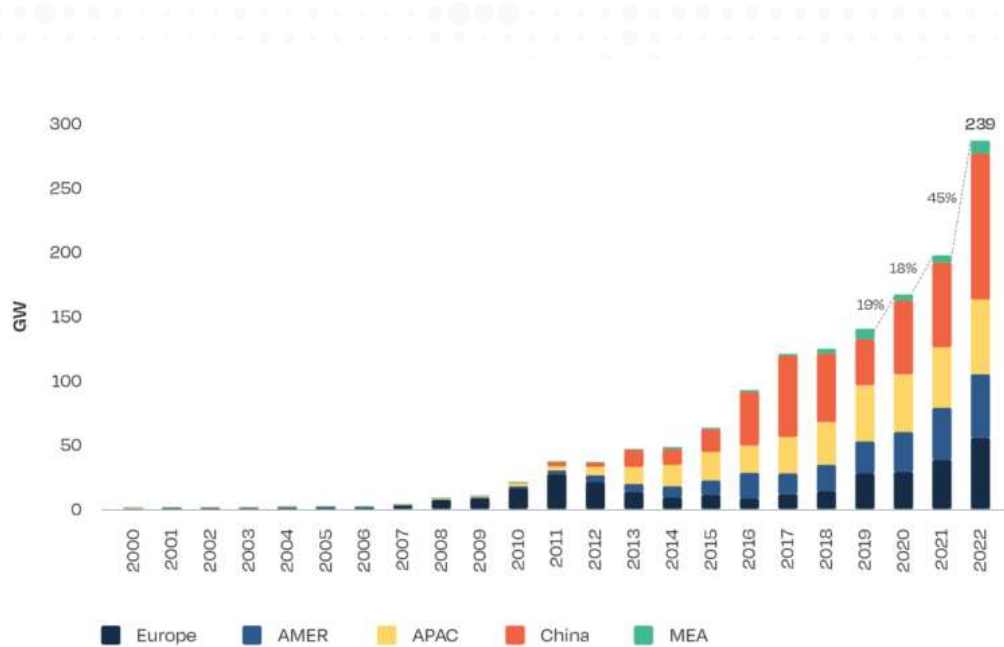
Summary and
Discussion

Renewable Energy Evaluation



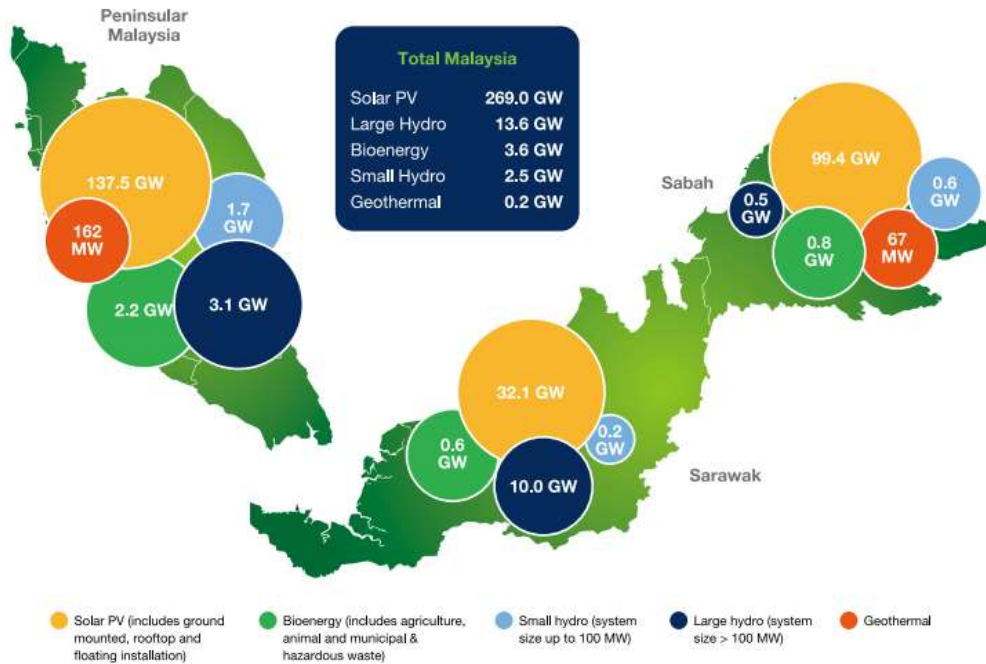
[Source from International Energy Agency]

Renewable Energy Evaluation

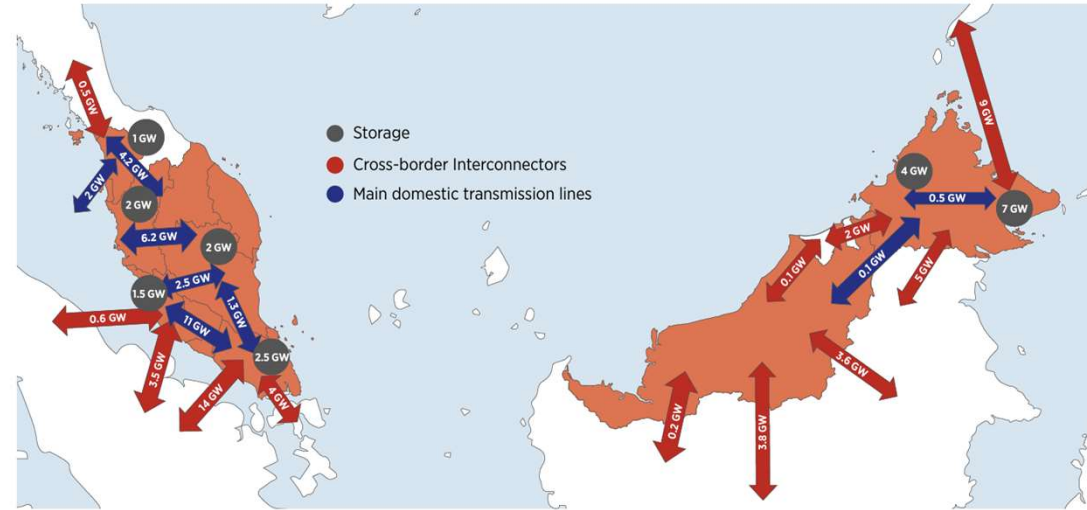


Global installed solar PV capacity (until 2023): **239 GW** of new installed solar capacity, 118 GW on roofs. By the end of 2022, the global cumulative installed PV capacity reached about **1,185 GW**.

Renewable Energy Evaluation (Malaysia Scenario)



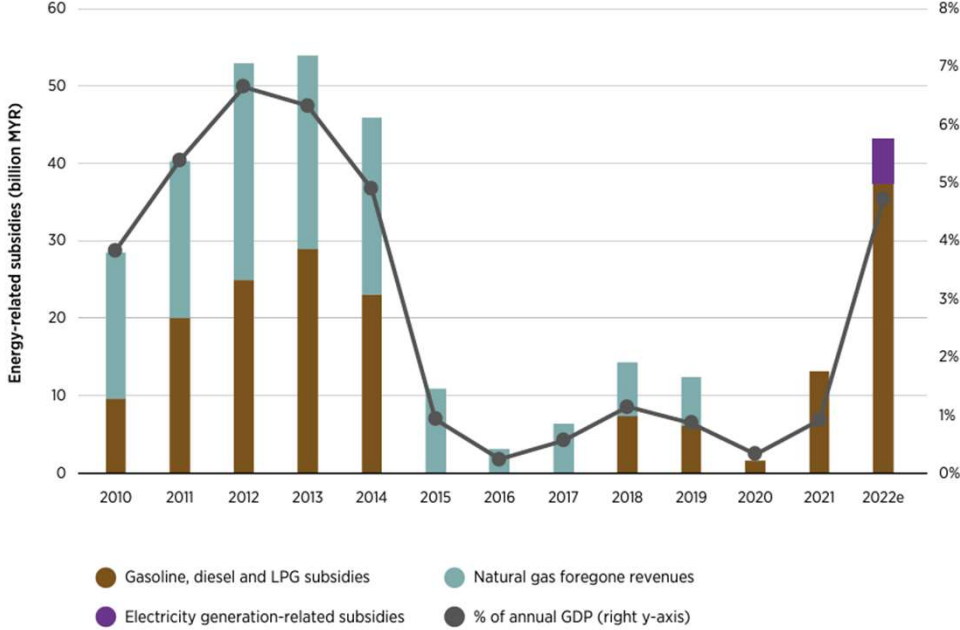
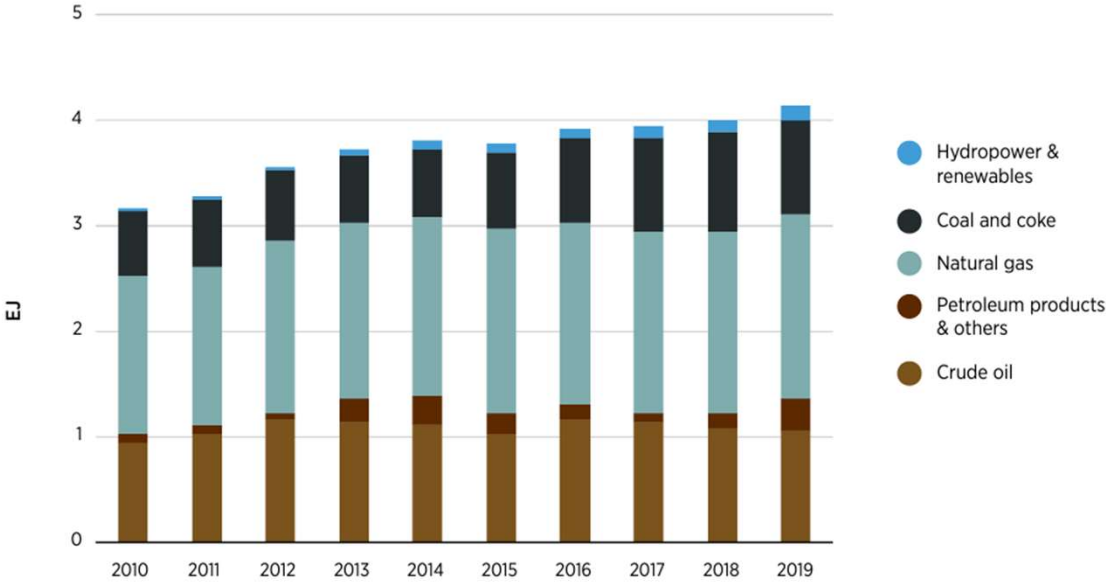
[Source from Energy Tracker Asia, 5 April 2024]



Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

[IRENA, Malaysia Energy Transition]

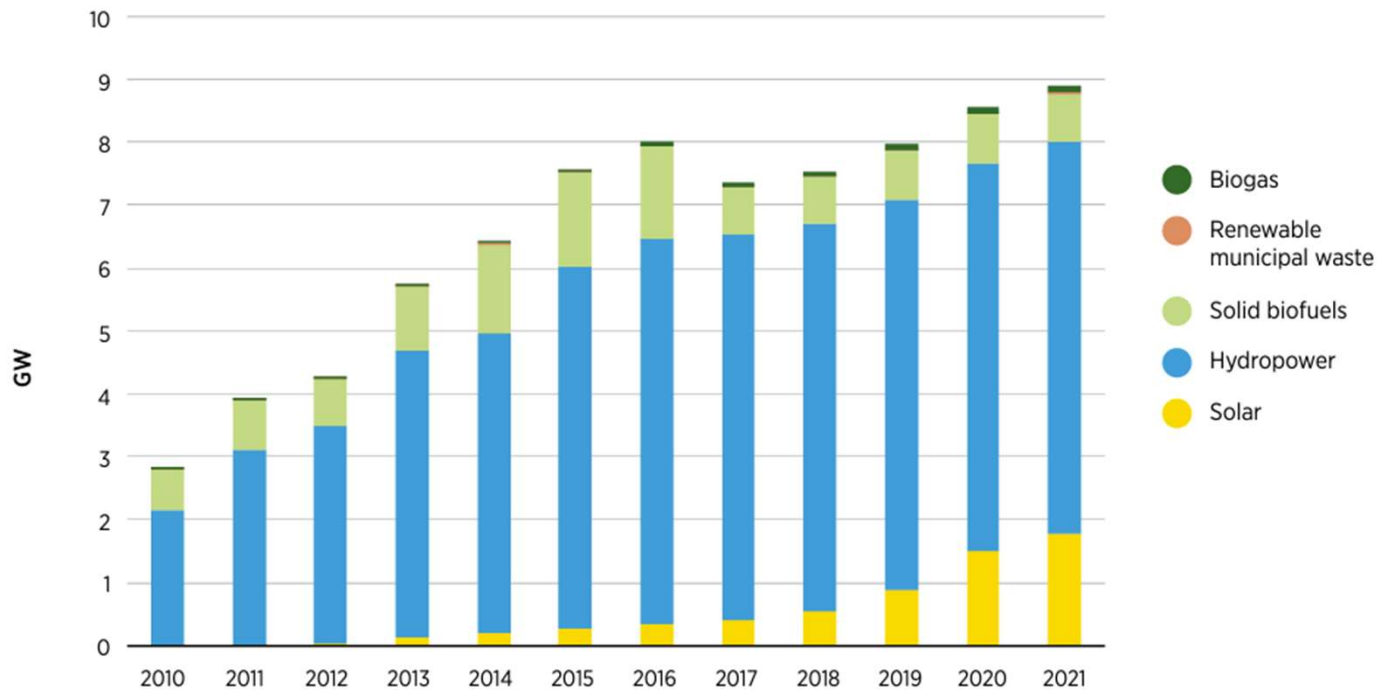
Renewable Energy Evaluation (Malaysia Scenario)



Source: IRENA analysis, estimated from MOF, 2020, 2022; PETRONAS, 2020a.

[Source from IRENA Analysis]

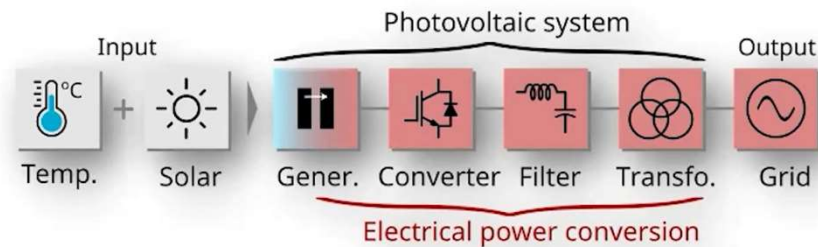
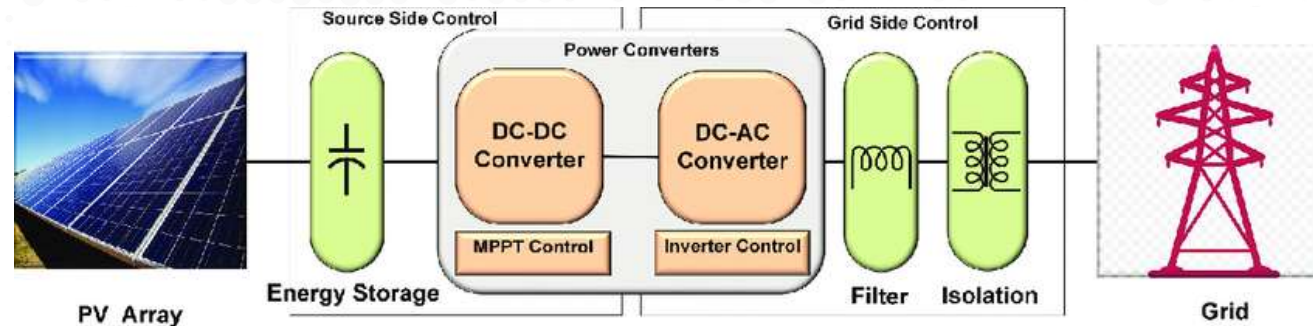
Renewable Energy Evaluation (Malaysia Scenario)



Source: IRENA, 2021a.

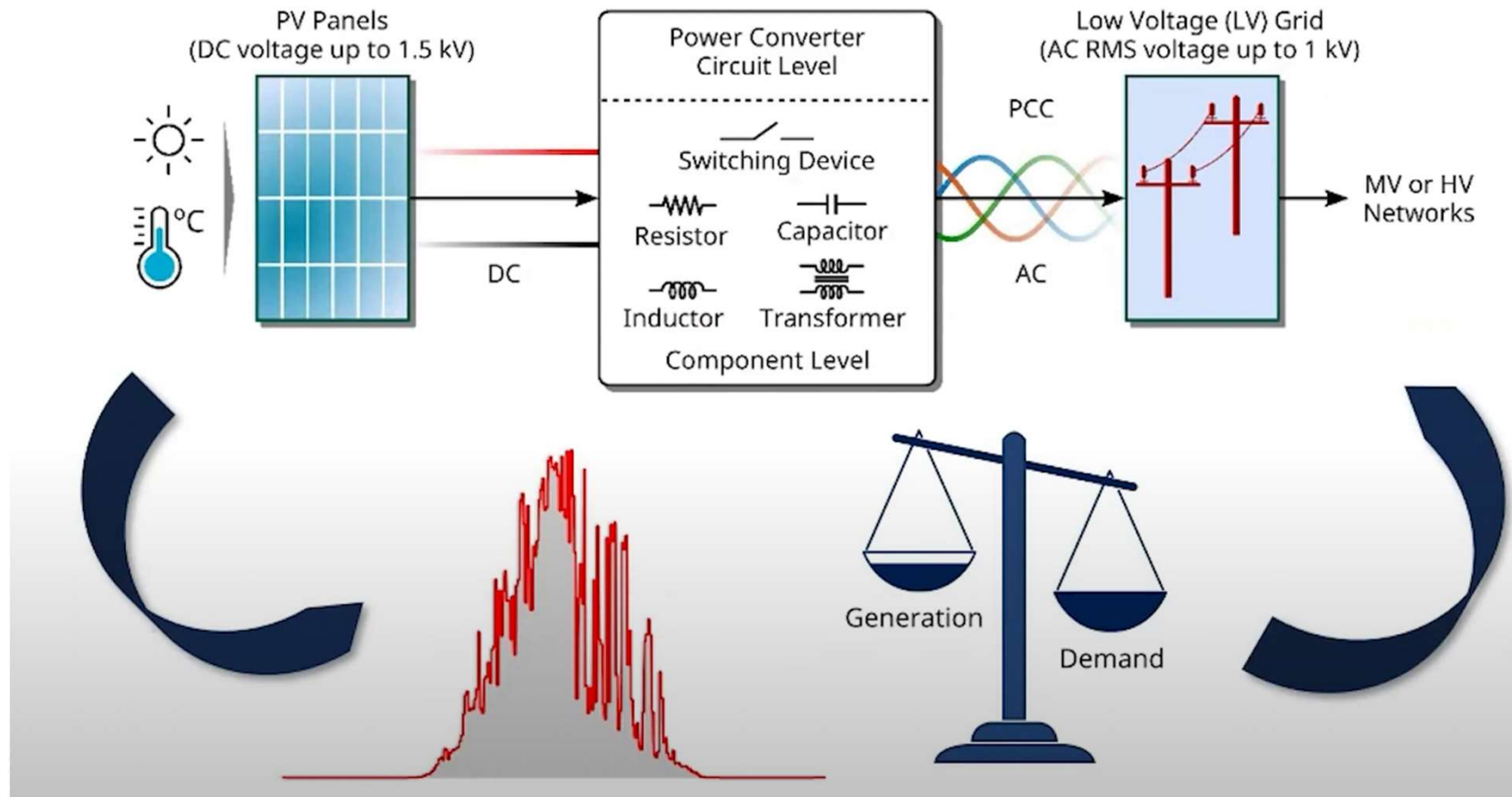
[Source from IRENA Analysis]

Integration of Solar PV System

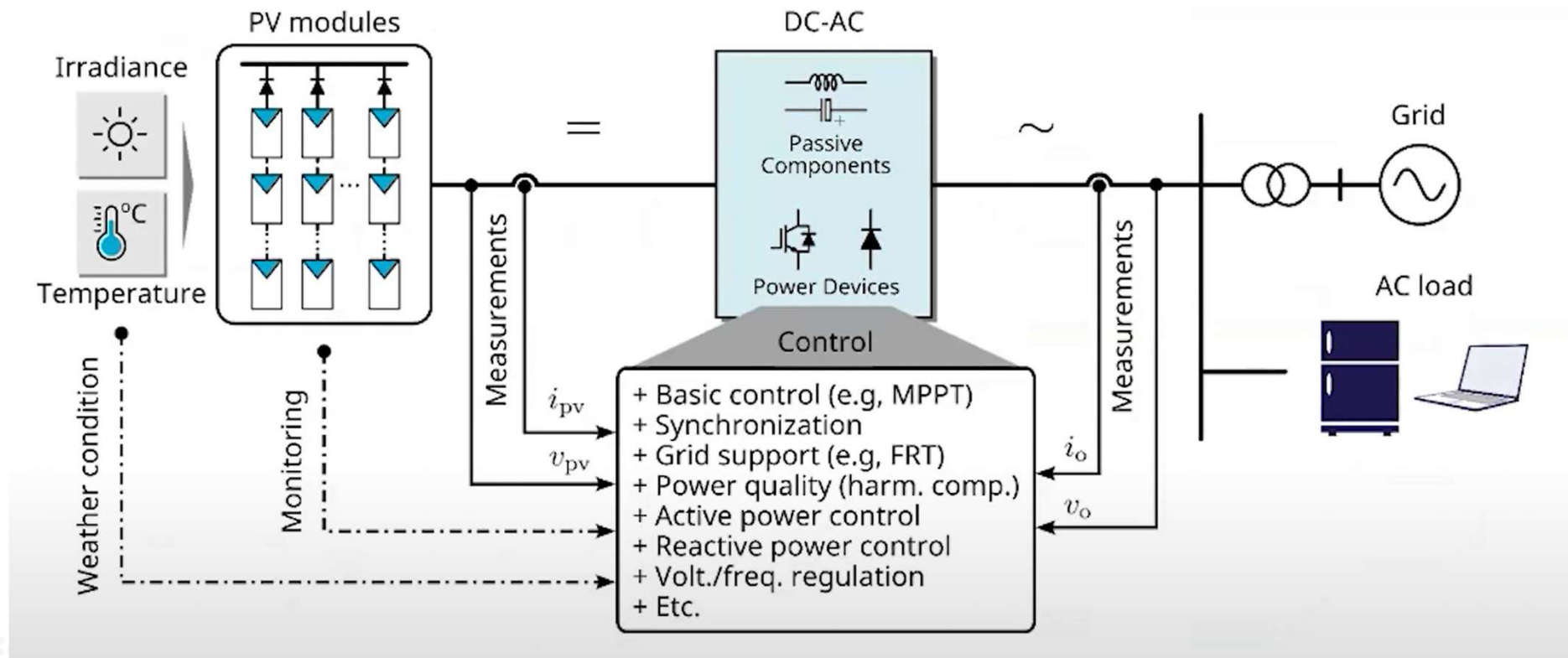


- **Photovoltaic Effect**
Power generation is dependent on the ambient conditions
- **Power Electronics**
Power converters are essential to realise the power transfer
- **Power Grid**
The synchronous generator-governed system with fixed frequency and voltage

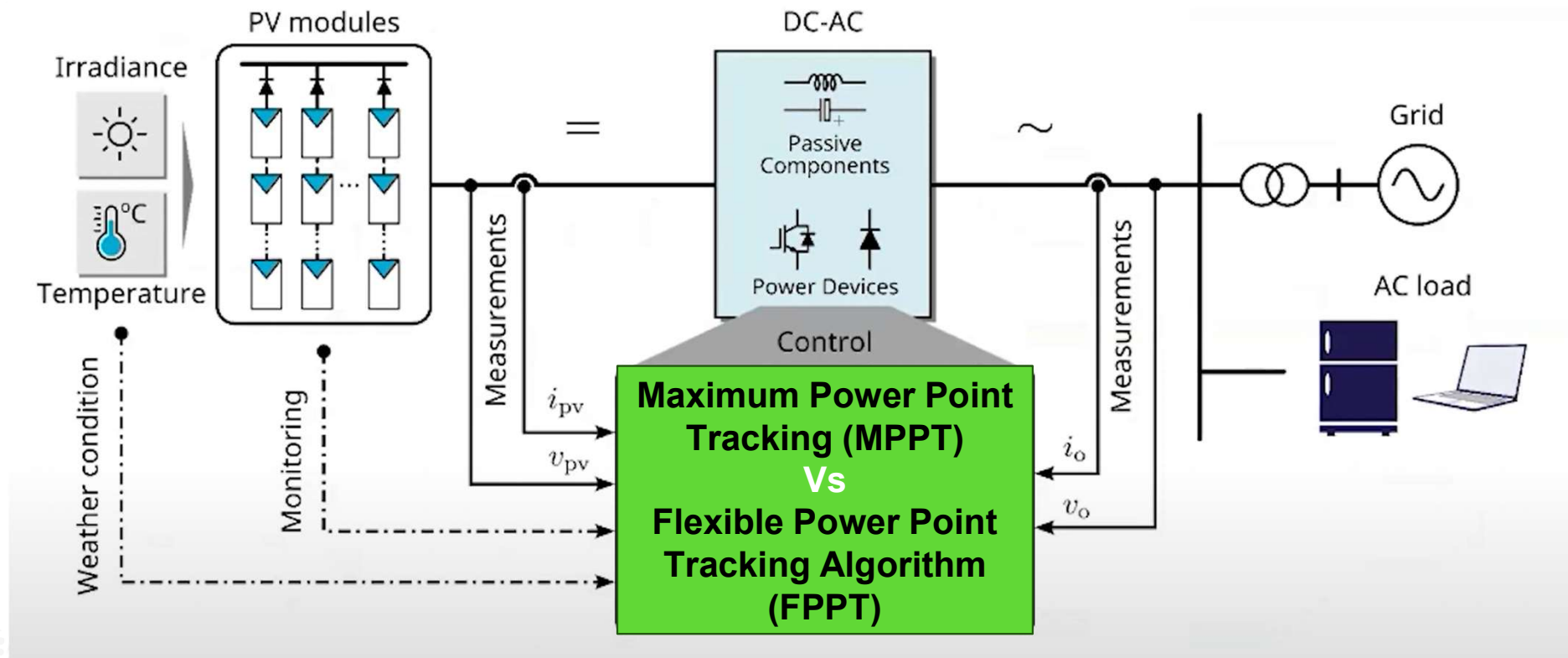
Drawback of Solar PV System



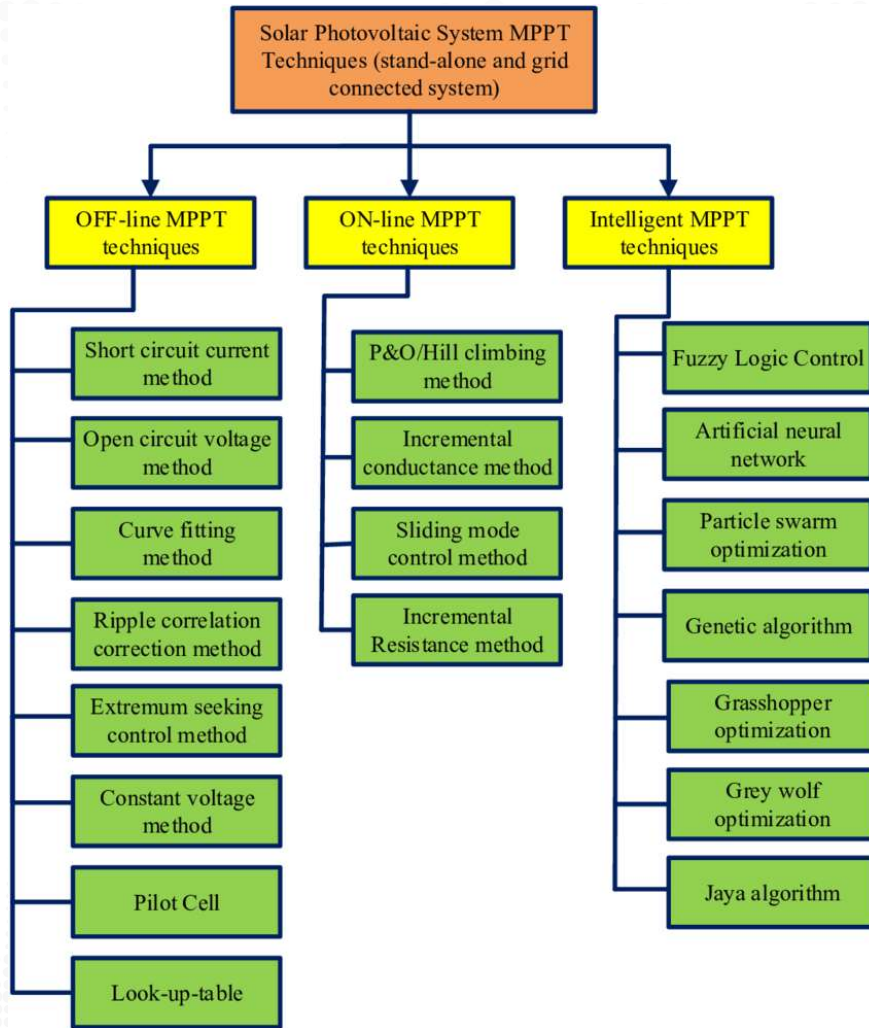
Controllers in PV System



Controllers in PV System

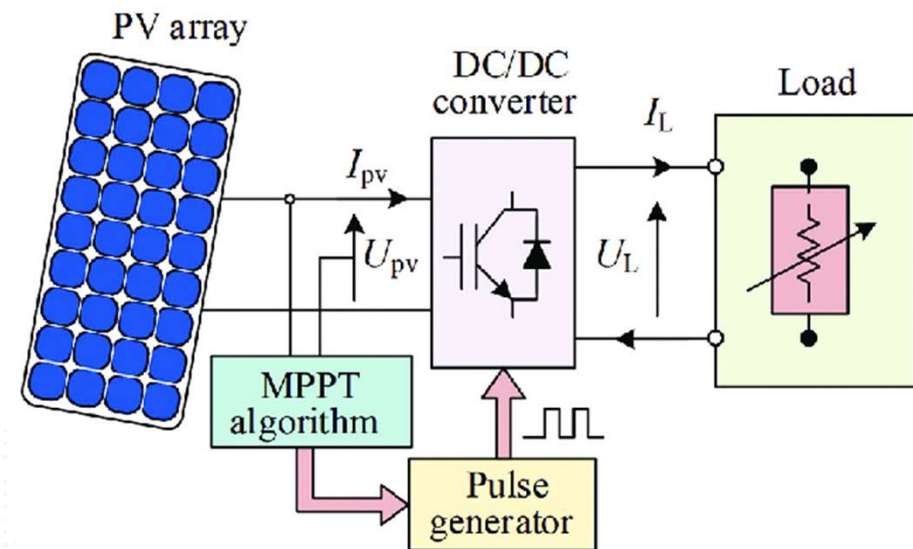


Maximum Power Point Tracking (MPPT)

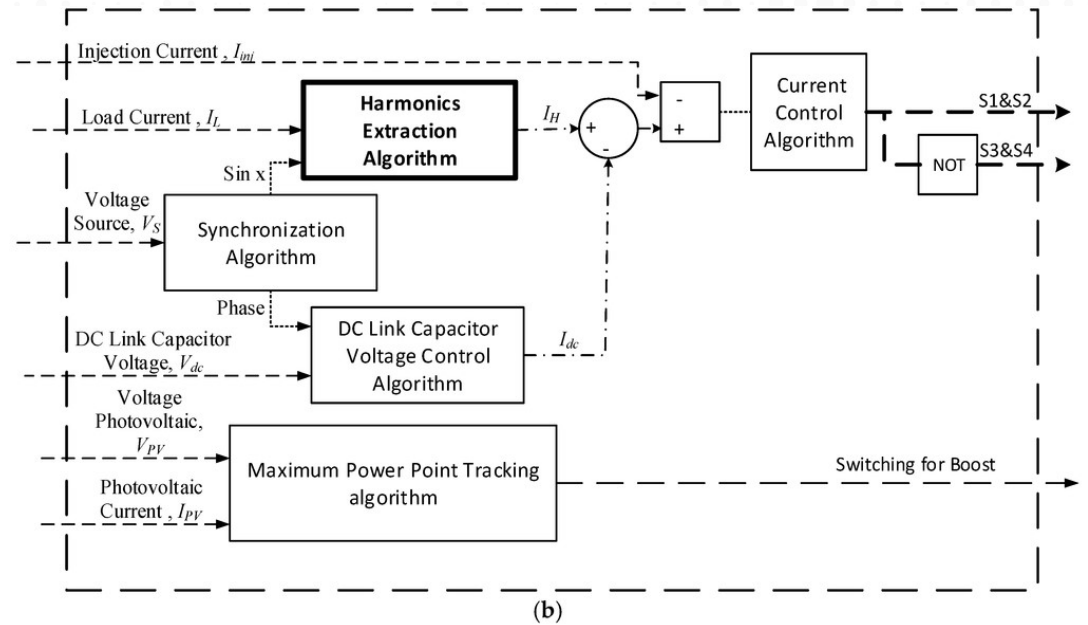
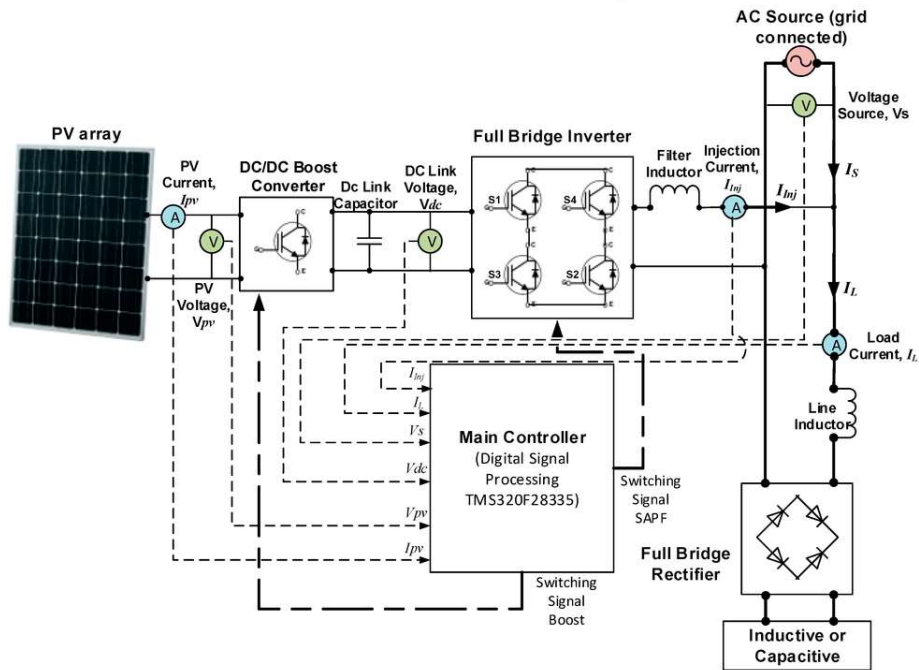


Principles:

- MPPT optimizes the power output by continuously adjusting the electrical operating point of the modules or array.
- It finds the maximum power point (MPP) on the power-voltage (P-V) curve of the solar panel, where the product of current and voltage is highest.

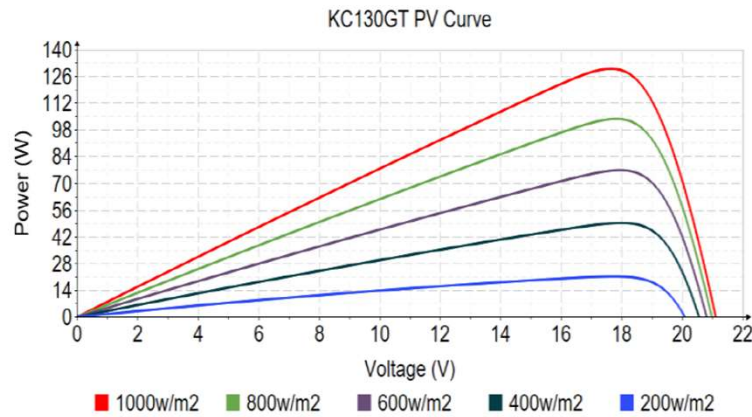
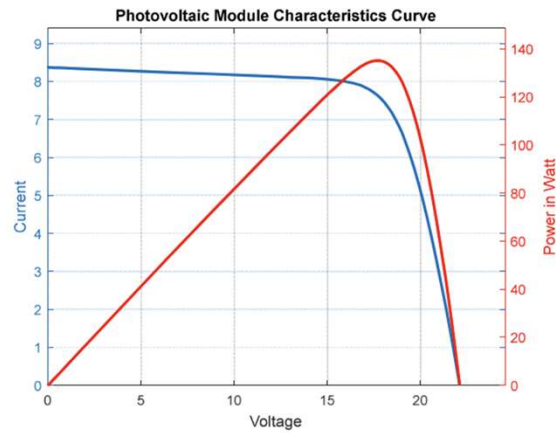


Maximum Power Point Tracking (MPPT)

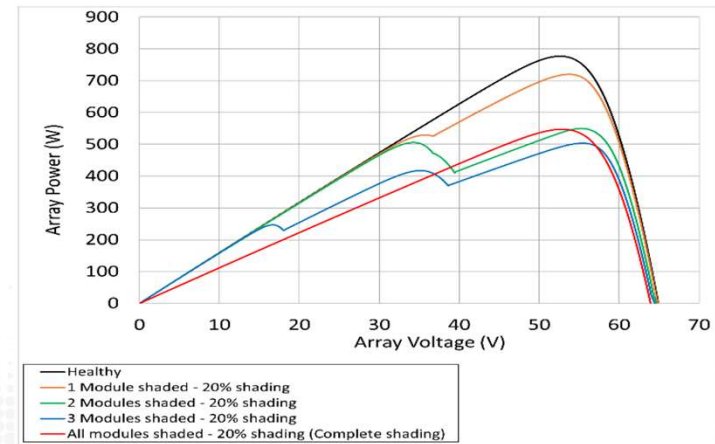
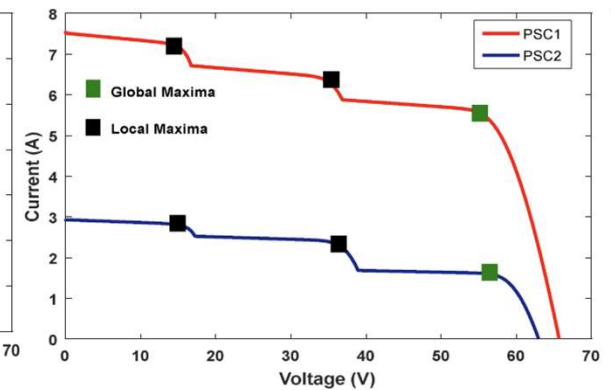
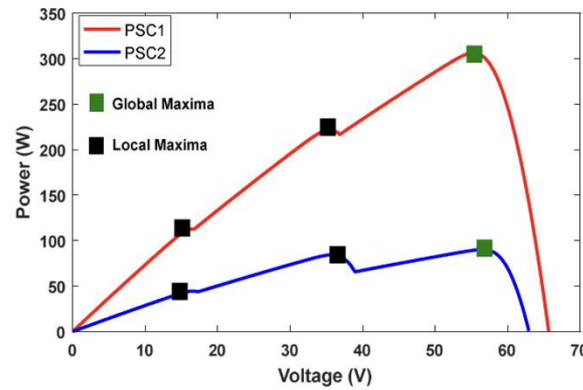


Maximum Power Point – Global vs Local

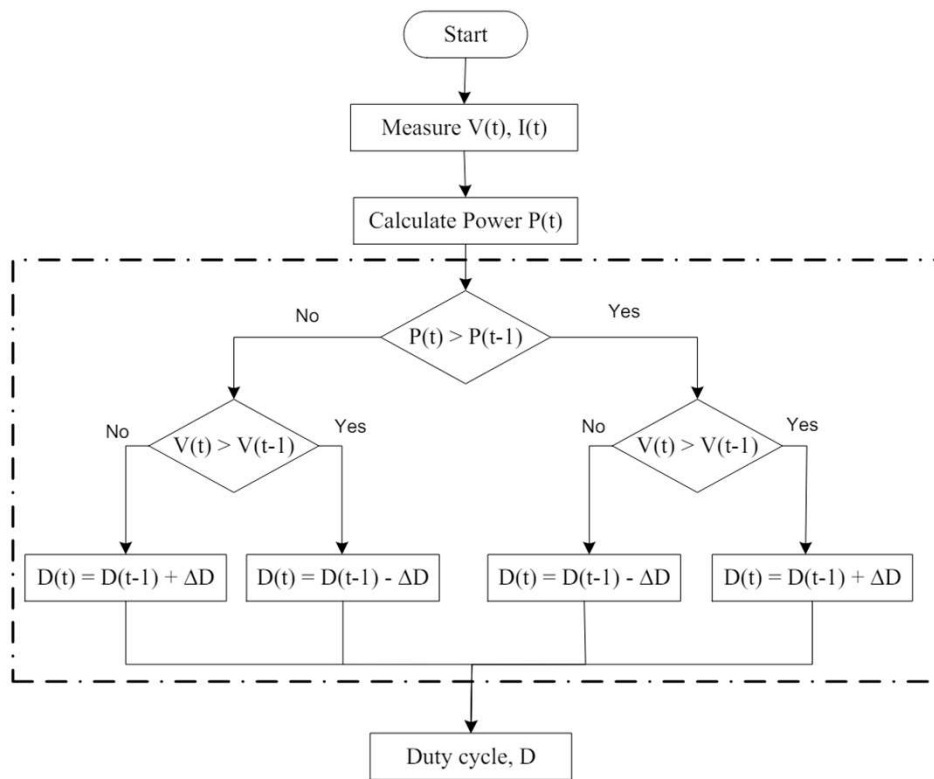
Global



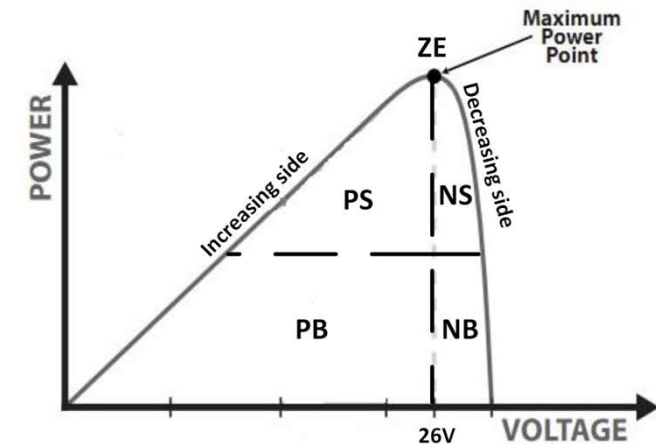
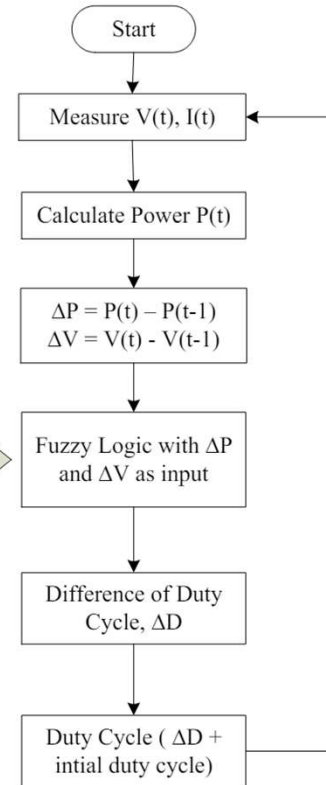
Local



Maximum Power Point Tracking (Uniform Condition)

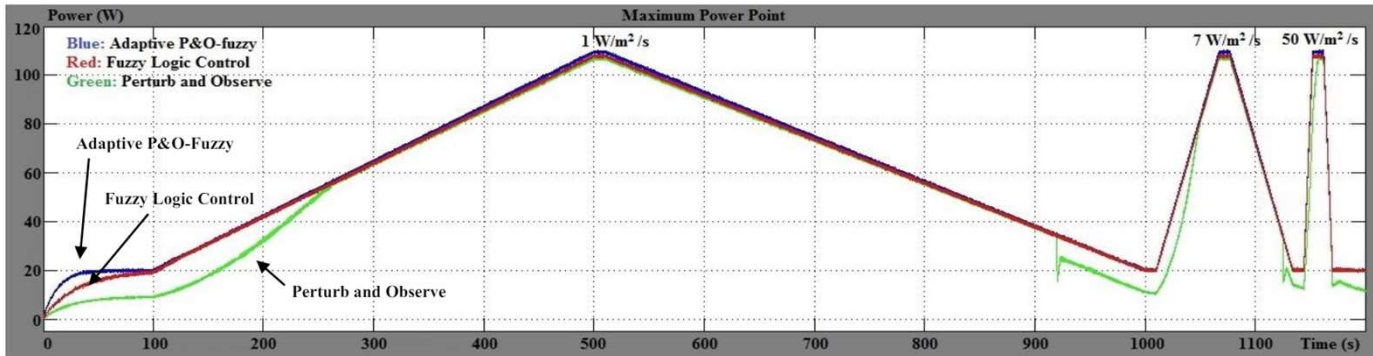


Convert

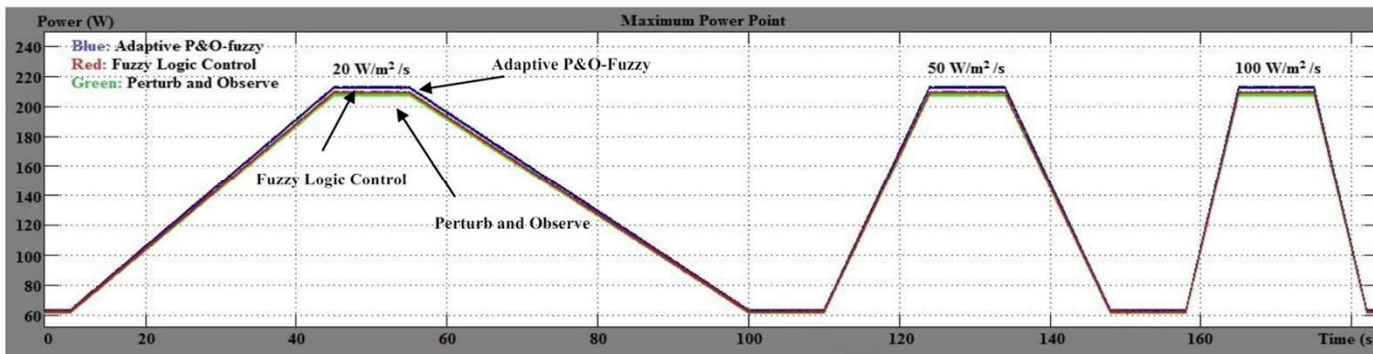


Perturb and Observe (P&O) algorithm Adaptive P&O-Fuzzy algorithm (2012)

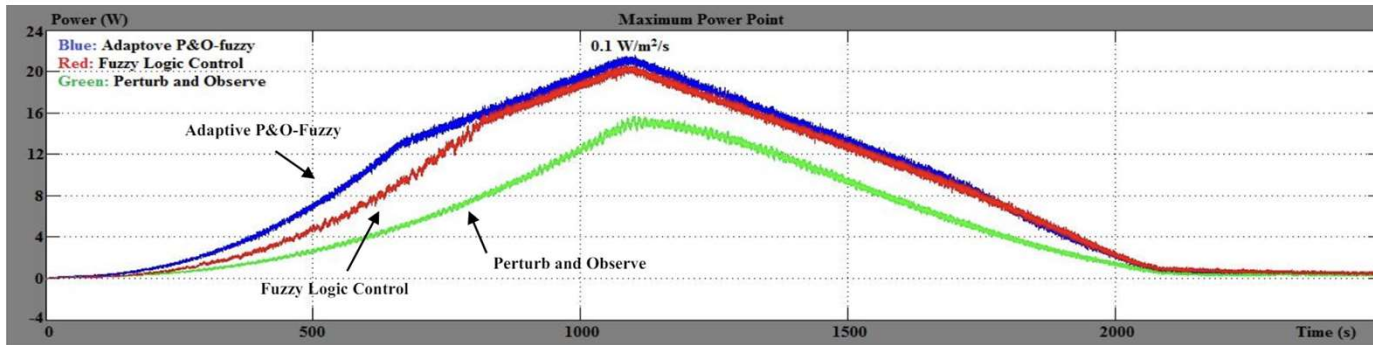
Maximum Power Point Tracking (EN 50530;2010)



low-medium irradiance

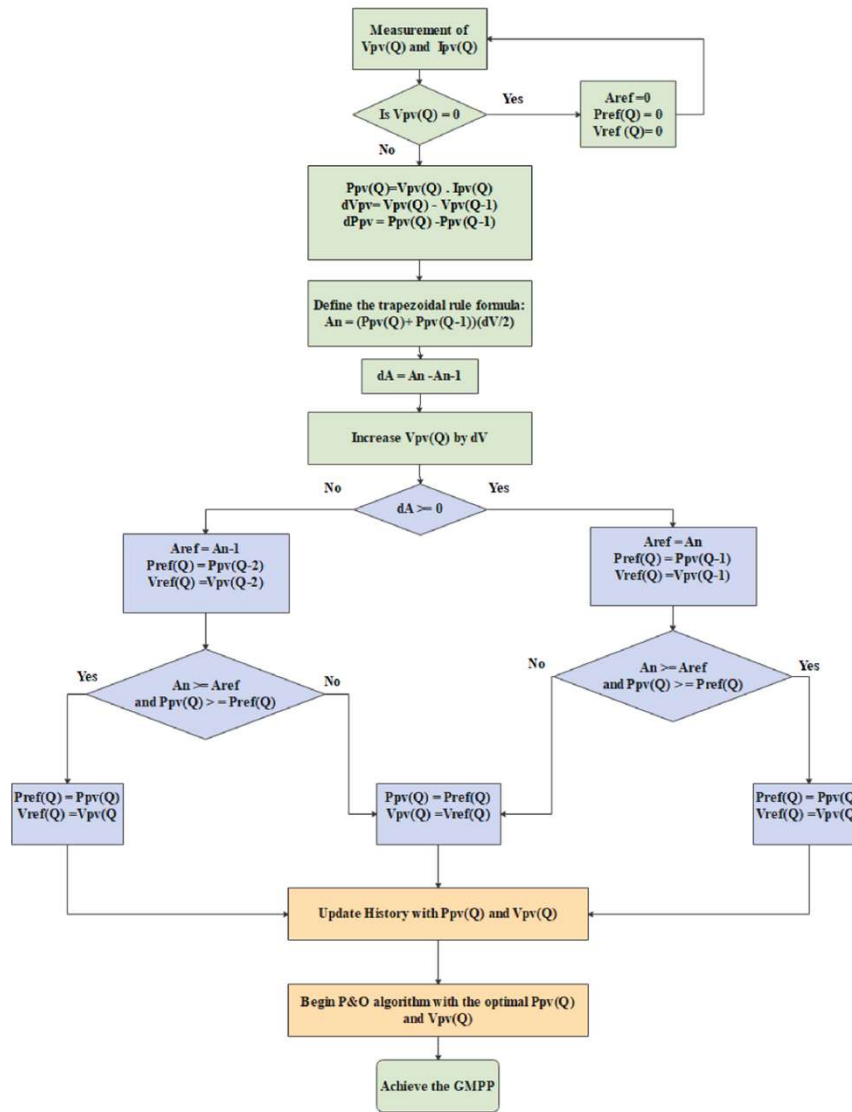


Medium-high irradiance

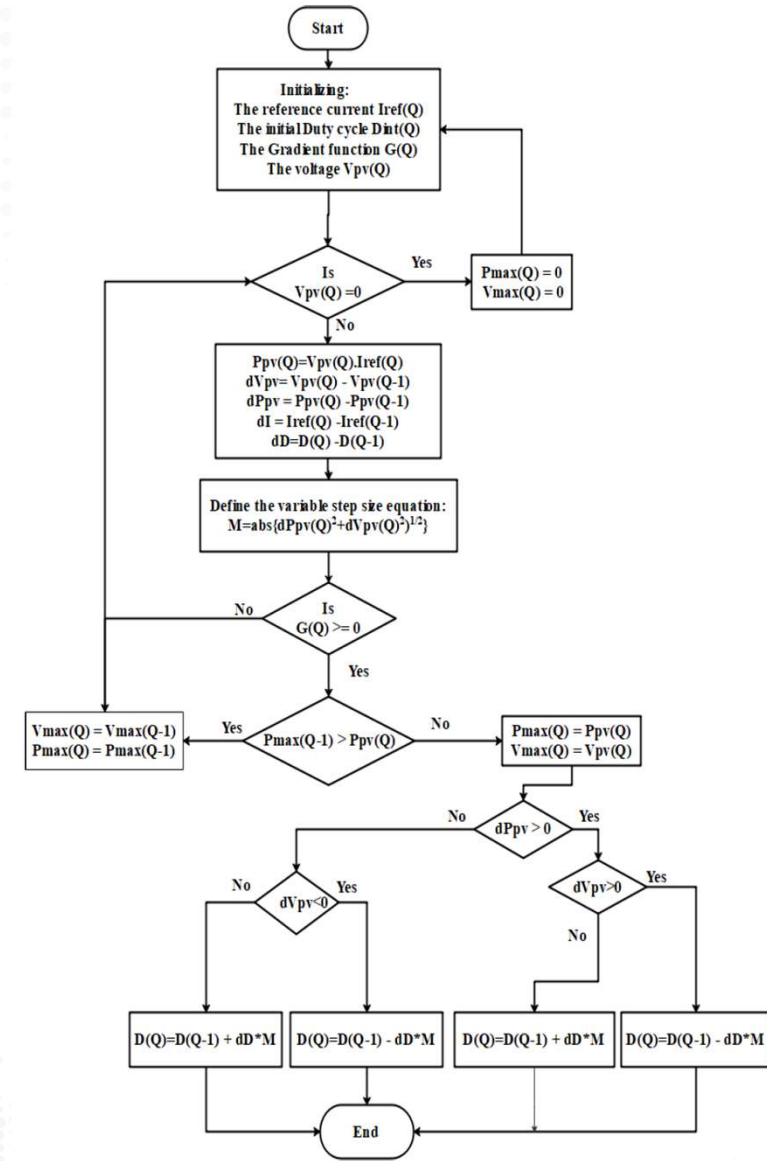


Start up and shut down test

Maximum Power Point Tracking (Partial Shading Condition)

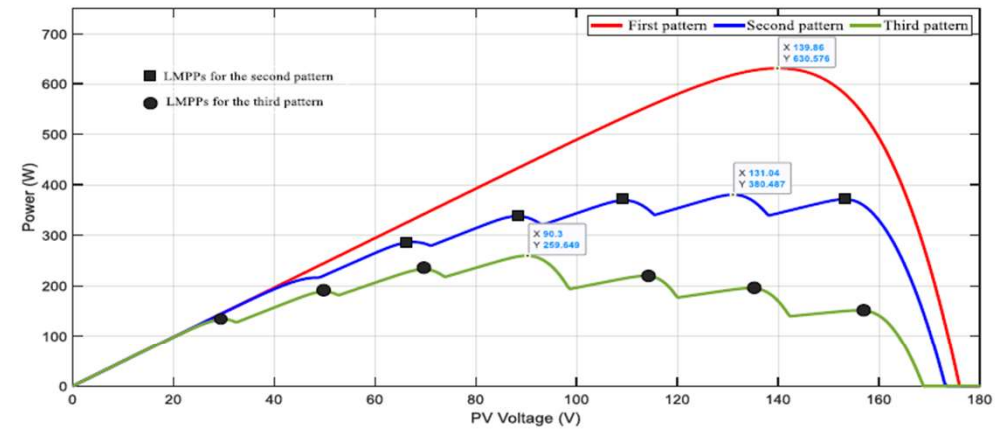
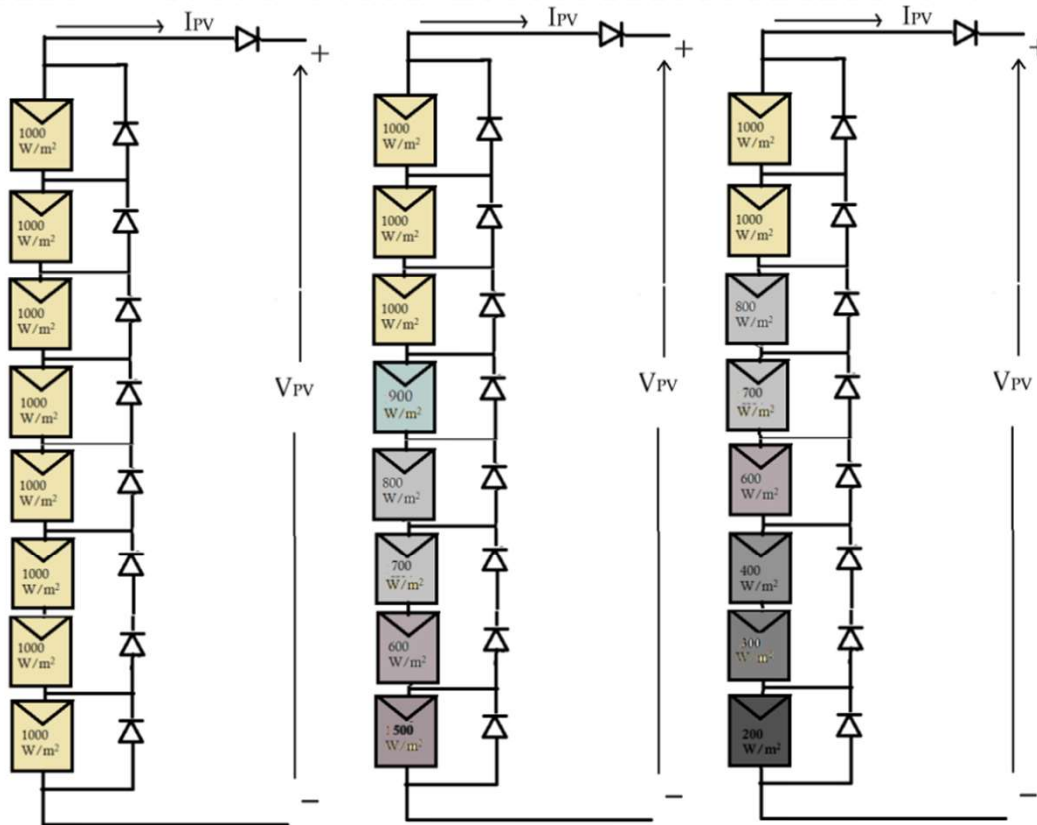


Trapezoidal rule (2022)

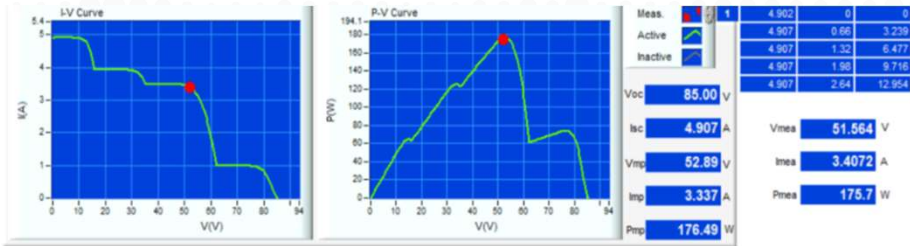


Adaptable step size P&O strategy (2020)

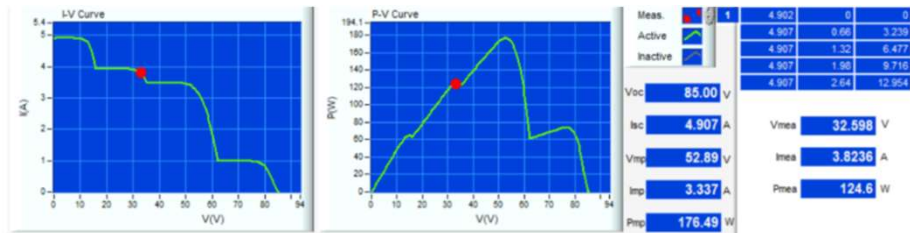
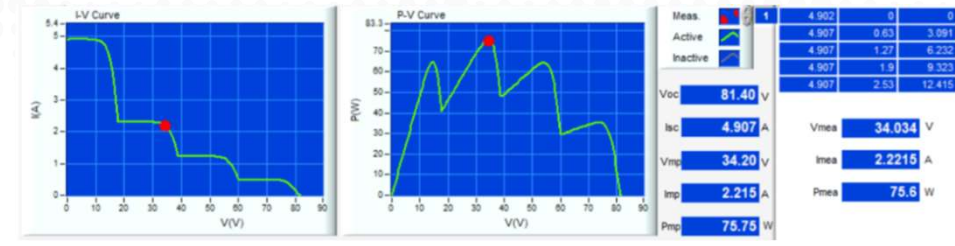
Maximum Power Point Tracking (Partial Shading Condition)



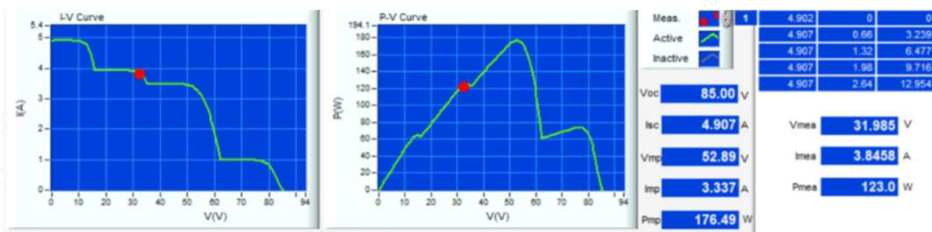
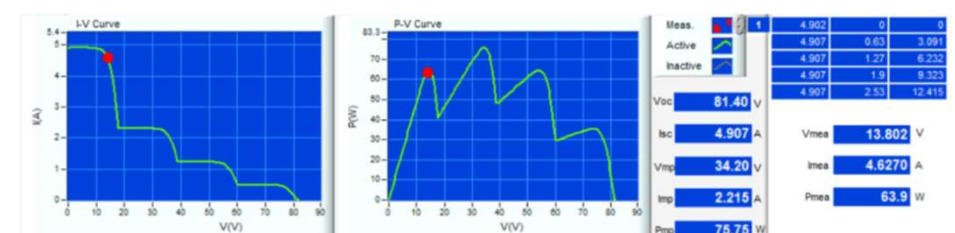
Maximum Power Point Tracking (Partial Shading Condition)



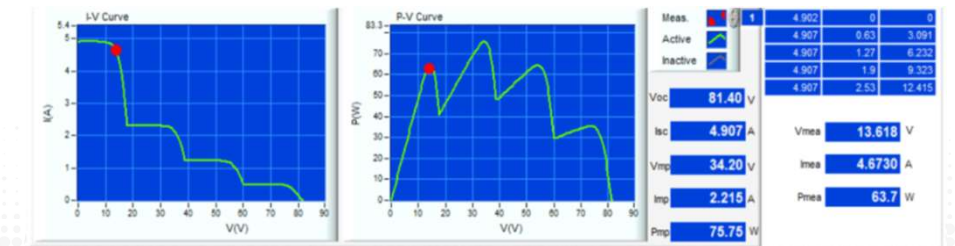
Trapezoidal rule



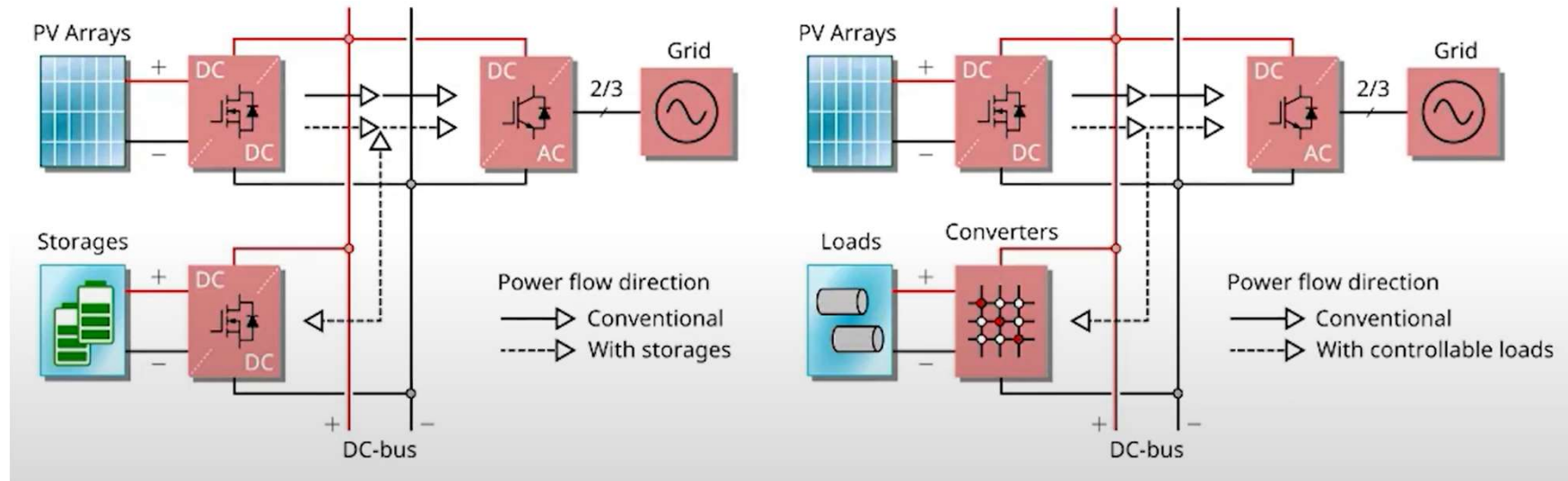
Incremental Conductance



P&O



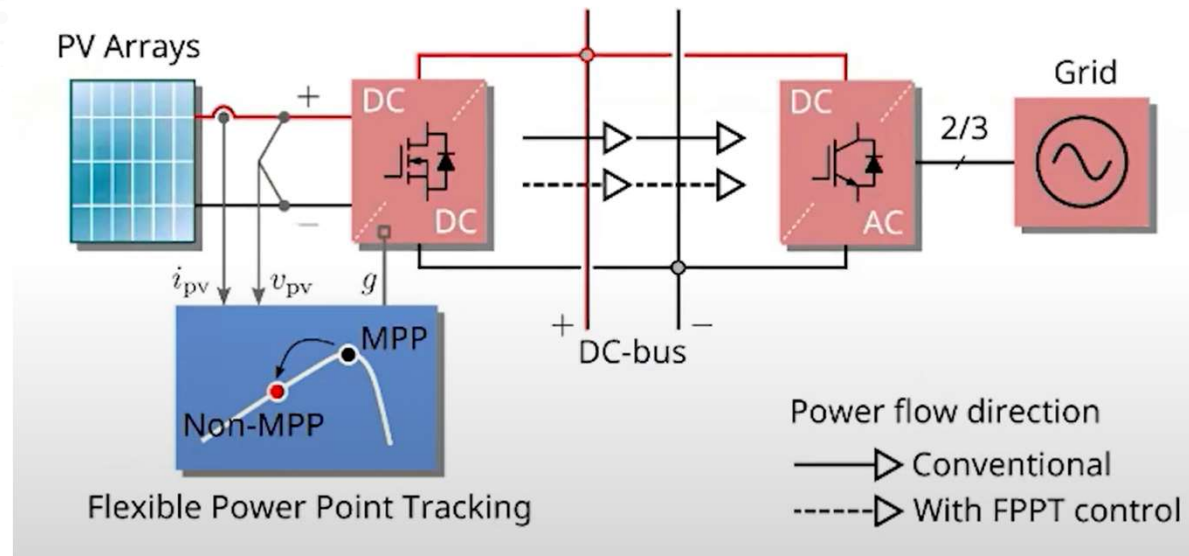
How to meet Power Demands?



Meet the **POWER DEMANDS** by?

- Integrating energy storage: Most Flexible but **COSTLY** (Battery price still high)
- Adopting dummy loads: Not universal, limited applications
- Switching in/out PV modules units: Stability challenges (Dynamic drawbacks)

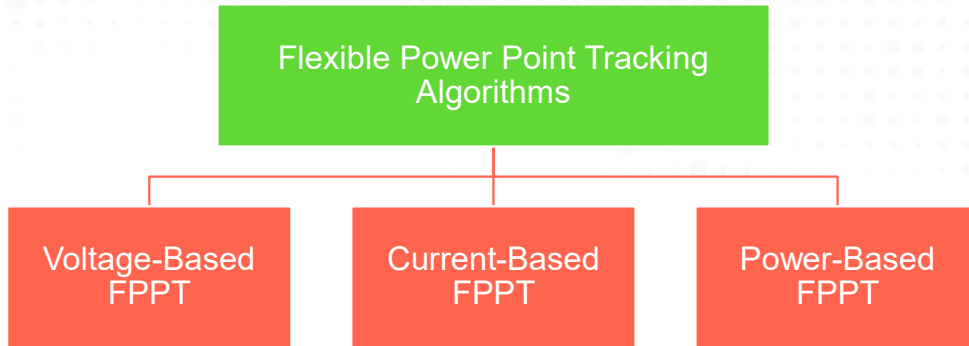
Power Demand Solution?



Flexible Power Point Tracking Algorithm.

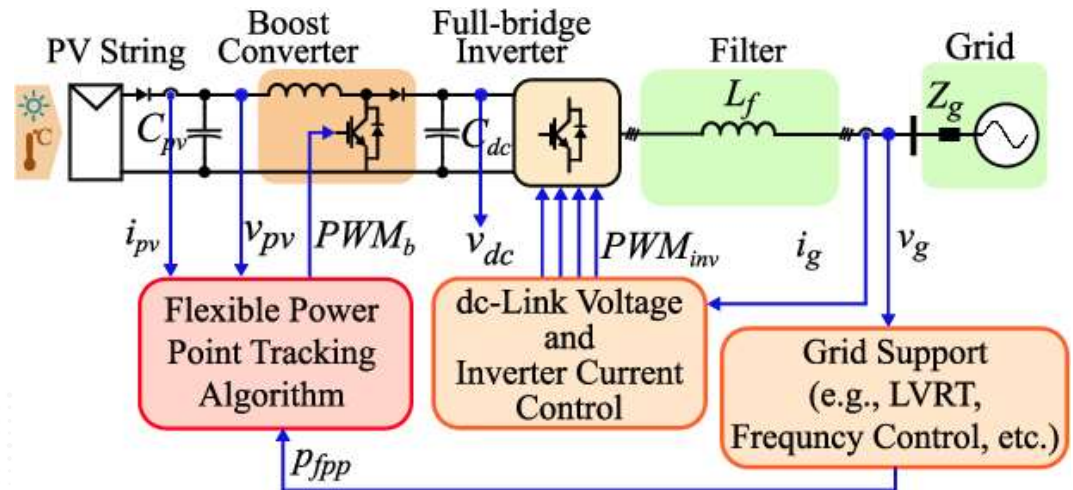
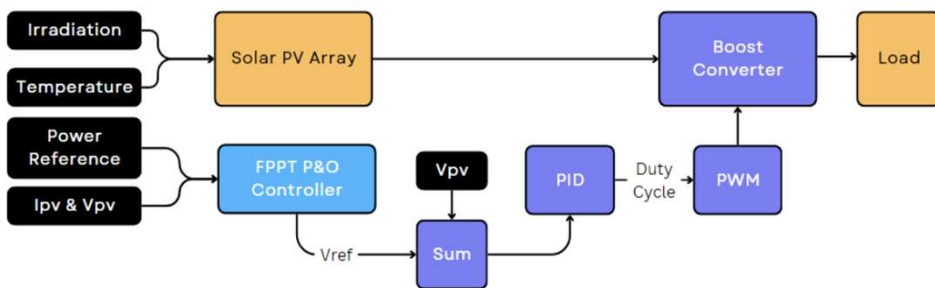
- No hardware modification needed and easy to implement.
- Universal solution to all PV Systems

Flexible Power Point Tracking (FPPT)

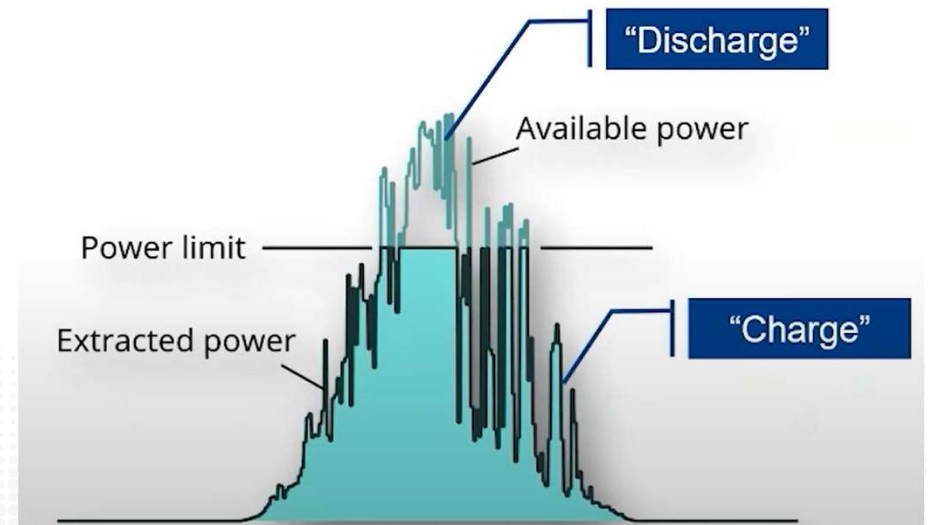
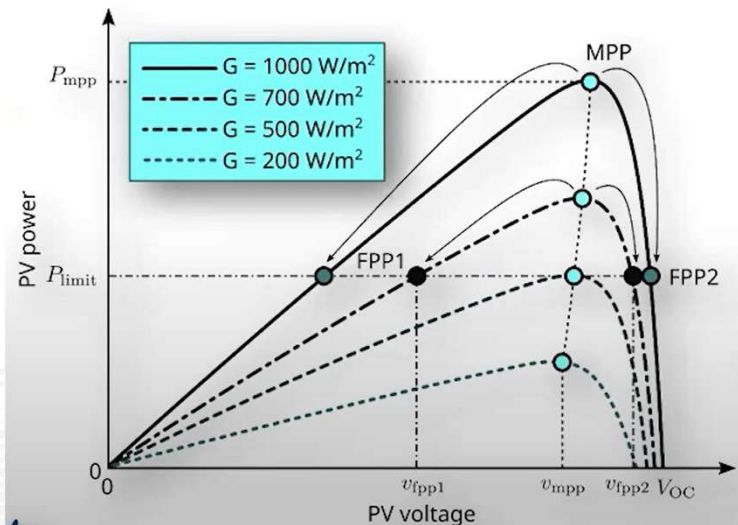
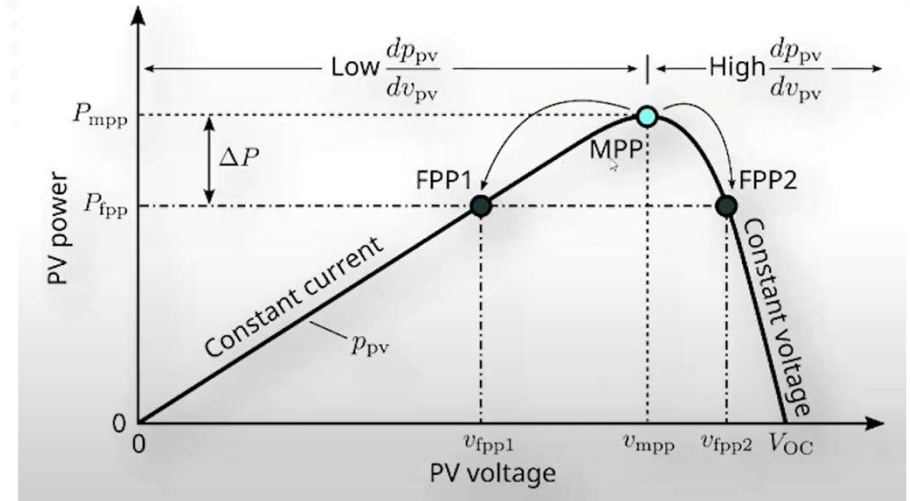
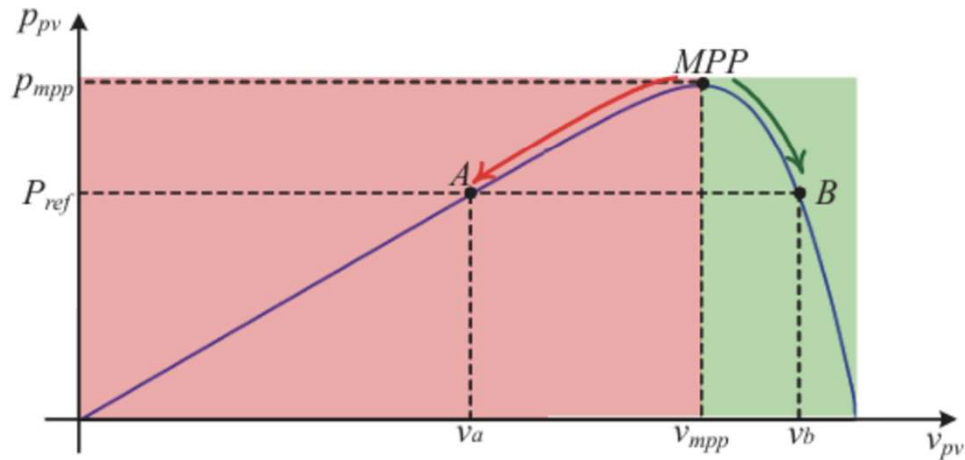


Principles:

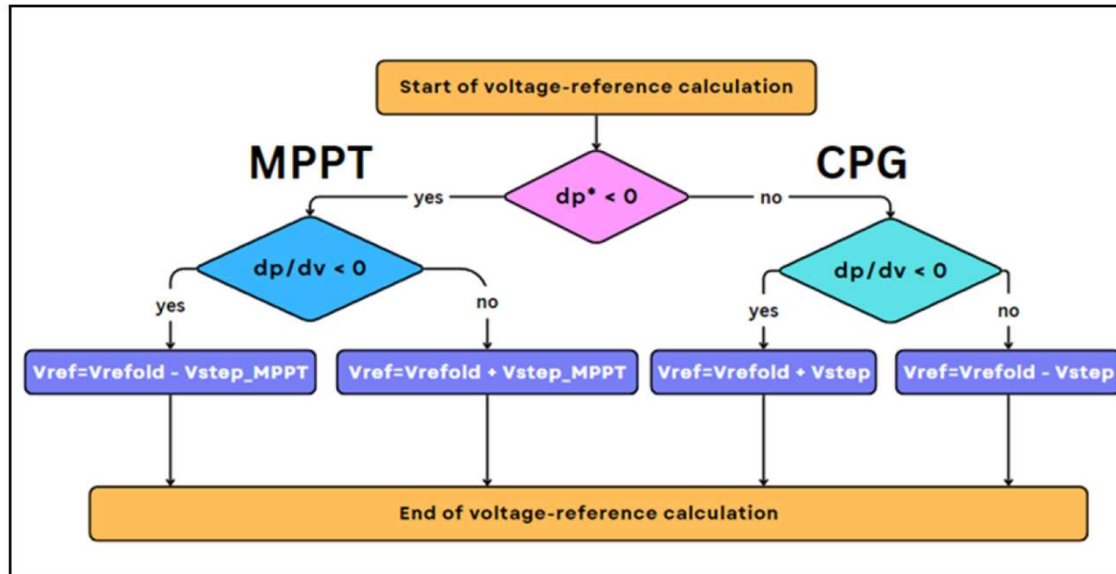
- FPPT sets the operating point of the solar panels to a predetermined fixed point.
- This fixed point is usually chosen based on an average or expected optimal operating condition.



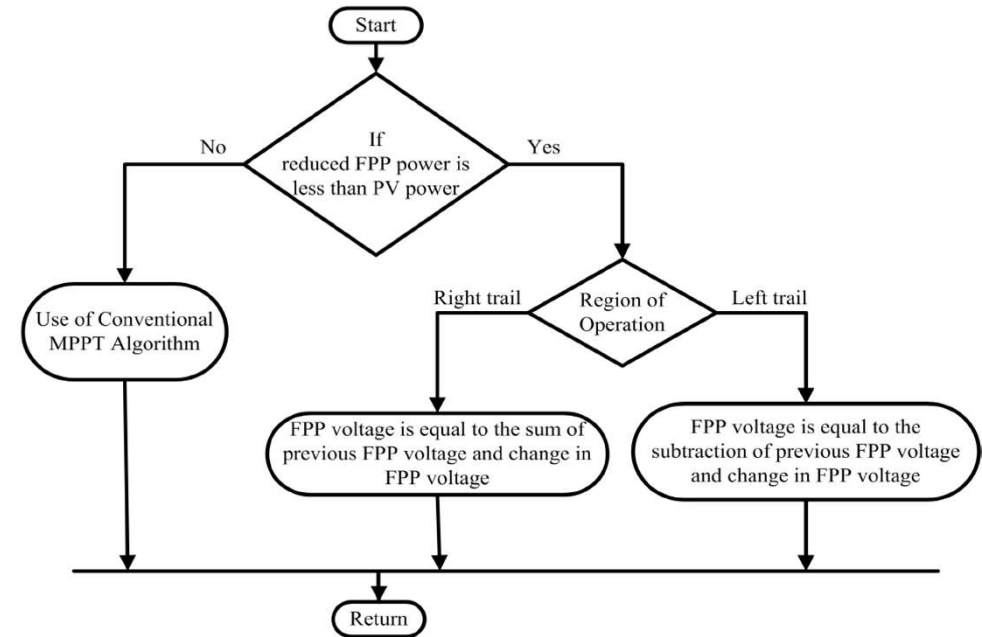
Flexible Power Point Tracking (FPPT)



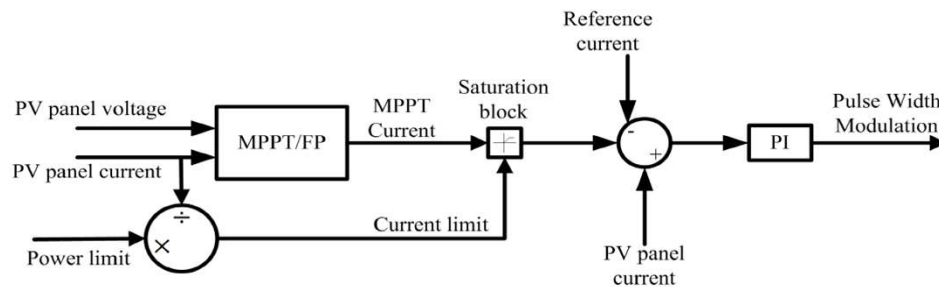
Flexible Power Point Tracking (FPPT)



Voltage reference FPPT algorithm

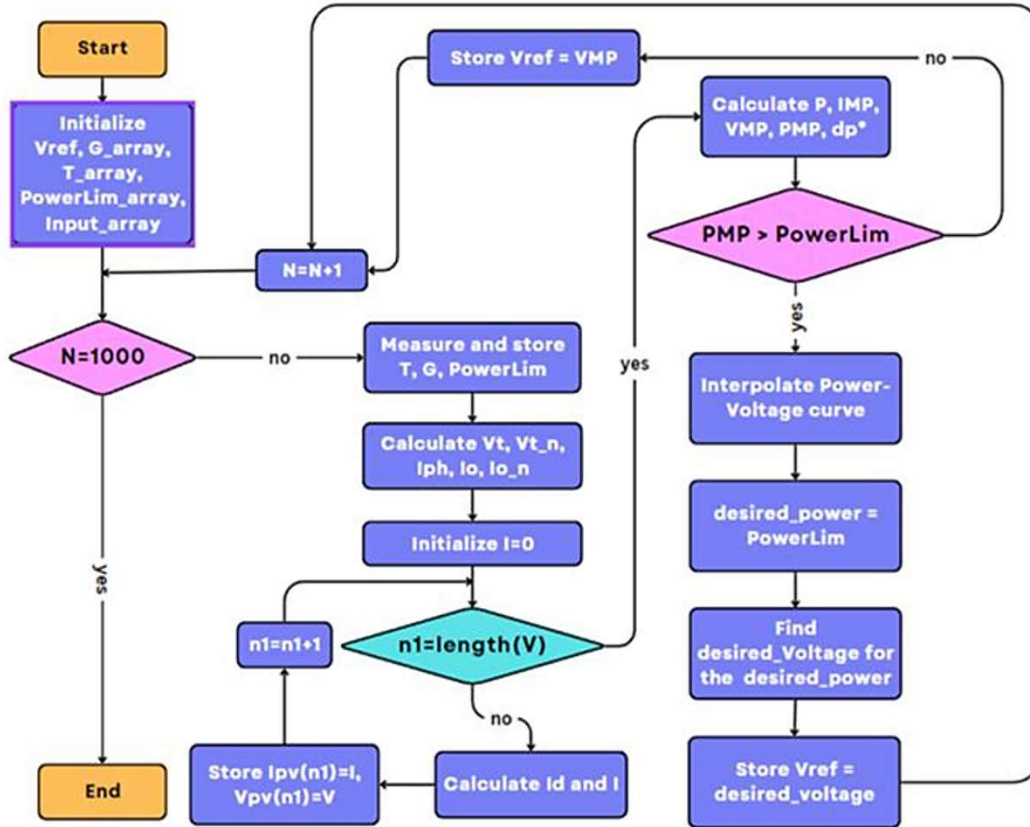


Multi-Mode Power-Based FPPT algorithm

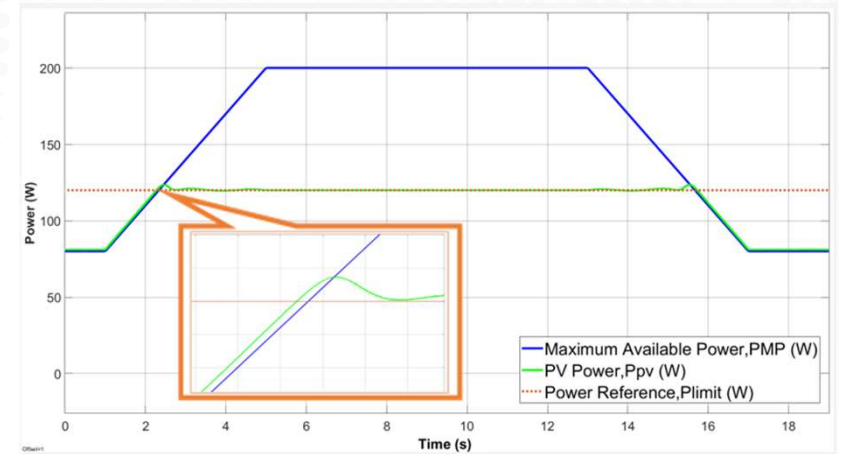


Current-Based P&O FPPT algorithm

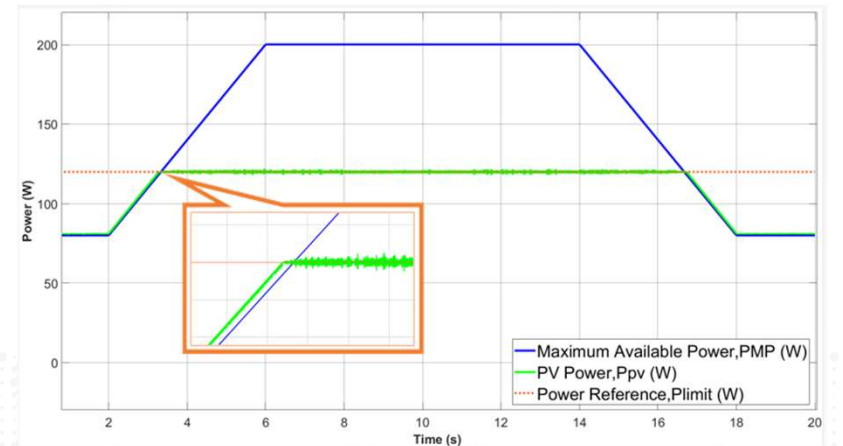
Flexible Power Point Tracking (FPPT)



Voltage reference ANN FPPT algorithm



Voltage reference P&O FPPT algorithm



Voltage reference ANN FPPT algorithm

MPPT Vs FPPT

Maximum Power Point Tracking (MPPT)	Flexible Power Point Tracking (FPPT)
<p>Advantage:</p> <ul style="list-style-type: none">• Efficiency: MPPT systems can increase the efficiency of a solar power system by up to 30% compared to systems without it.• Adaptability: It works well under varying weather conditions, including changes in sunlight and temperature.• Flexibility: MPPT controllers can handle a variety of panel configurations and are suitable for both small and large-scale systems.	<p>Advantage:</p> <ul style="list-style-type: none">• Simplicity: FPPT systems are simpler to design and implement.• Cost: They are generally cheaper than MPPT systems because they require less sophisticated technology.• Reliability: Fewer moving parts and simpler electronics can lead to higher reliability in some cases.
<p>Disadvantage:</p> <ul style="list-style-type: none">• Cost: MPPT controllers are generally more expensive than FPPT controllers.• Complexity: The system is more complex and requires more sophisticated components and control algorithms.	<p>Disadvantage:</p> <ul style="list-style-type: none">• Efficiency: FPPT systems are generally less efficient than MPPT systems because they do not adapt to changing environmental conditions.• Inflexibility: They are less adaptable to varying weather conditions and changes in sunlight intensity, leading to potential power losses.
<p>Applications:</p> <ul style="list-style-type: none">• Ideal for large-scale solar power installations where maximizing efficiency is critical.• Suitable for locations with highly variable weather conditions.	<p>Applications:</p> <ul style="list-style-type: none">• More suitable for smaller, cost-sensitive applications where the simplicity and lower cost are more important than maximum efficiency.• Can be used in stable weather conditions where solar irradiance and temperature do not vary significantly.

Conclusion

- MPPT (Maximum Power Point Tracking) and FPPT (Fixed Power Point Tracking) serve distinct purposes in optimizing solar power systems.
- MPPT is the preferred choice for most modern installations due to its higher efficiency and adaptability to varying weather conditions, making it ideal for large-scale and variable environments.
- FPPT remains a viable option for smaller, cost-sensitive applications where simplicity, lower cost, and reliability are more critical, particularly in stable weather conditions.
- Ultimately, the choice between MPPT and FPPT should be guided by the specific requirements and constraints of the solar power system in question.



MAJLIS KEMENTERIAN ABU BAZAL
مجلس كمنستر ابو بزال

Thank You/ Terima Kasih

Contact me at ammirulatiqi@ukm.edu.my



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THE END
Q&A