# To reduce impact of the variation of power from renewable energy by using super capacitor in Smart grid

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*Abstract:* - In the production of renewable energy, maximum power point tracking (MPPT) is always expected .The amount of regeneration energy sources in the network integration of infinite energy, mainly due to changes in the flow of energy. From these sources, in order to ensure the quality of power, in the case of cable resistance, and striking which can be applied mainly AC voltage from high-quality, energy storage, and a significant level to inject energy. On the other hand, this is not a useful resolution. In this article, the energy storage super capacitors have been proposed to be used as the main power source to obtain the time needed to support demand management to work properly (the energy, as the infrastructure, installation via ICT). As a result, it is possible sources.

*Key-Words:* - Connection and control of the production of renewable energy, converter DC-DC, integrated system, Super Capacitor

## 1 Introduction

To increase the power of the reliability and availability to the load, renewable energy sources have been suggested to be integrated into an existing power grid [1] [2]. MPPT often are implemented in order to increase the efficiency of the power converter [3] - [5]. However, large-scale integration of renewable energy, power quality problems to a connection point of the renewable energy sources (e.g. voltage flicker) can cause [6] [7]. (Due to the risk of over-voltage), in order to limit the power injection from renewable energy sources is equivalent to the power loss in the power system [8]. Such a problem, power injection of the coupling point, in response to the variation and the grid impedance angle of the short-circuit power levels, can be quantified [9]. Typically, in the case of the power fluctuation from renewable energy sources to the AC grid there are two possibilities to ensure the power quality. The first method is to control the flow of reactive power to control the AC voltage [10]. If there is a line impedance that is extremely resistant, results in reactive power control, to ensure that the quality is the AC voltage is not very effective [9]. The second method is to use energy storage to mitigate the variation in the power injected from renewable energy sources to the AC grid [11]. Until now, not always been granted part of the regulation of the power distribution network is by the first method (AC voltage control by reactive power control). In the second method, (electrical energy for storage) batteries, often, their advantages are applied to [11]. Such, I was used to easily and high energy capacity. However, rather than a drawback of the battery, there is a sufficiently high power capacity and not very long service life.

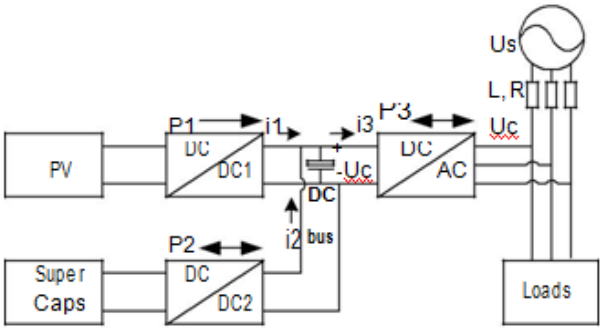


Fig. 1- Research platform generation and control of renewable energy in the smart grid.

As compared with the battery, super capacitor has the main advantage of long life and high power capacity (12). However, in general, the super capacitor has a tenth of the energy capacity of the battery. Super capacitor, to ensure the power quality, when applied to replace the battery as the electric energy storage section is able to secure the

MPPT, power inverter, smart grid (e.g. several can be implemented with superior properties by inertia). Therefore, research platform for generation and control of renewable energy have been developed as shown. Where 1, PV represents a photovoltaic energy source is coupled to the DC / DC converter 1 (DC / DC1). Function of the maximum power point tracking (MPPT) is implemented in DC / DC1. Figure. 1, and is connected to the super capacitor energy storage with (super cap) DC Converter2 of the DC / DC that runs as a peak power units on the bus (DC / DC2). The DC / AC inverter (DC / AC) is applied to dispatch power from the PV to the AC grid in variation range limited the power. Power flow of DC / DC1 (P1) is unidirectional. Power flow of DC / DC2 (P2) is bidirectional. And the DC / power flow of AC (P3) is also bidirectional. Here, it is a positive power flow from left to right. Figure.1 shows a main power query AC grid, L, and R respectively represents the line inductance and the wiring resistance. Load represents the total load that is connected to the same connection point between the DC / AC inverter.

In this paper, strategies of control in the first renewable energy power generation and smart grid, is presented include the state of the bus voltage control and charge control of the super capacitor. Then in principle (As a unit of peak power) in order to ensure a reasonable voltage is variation of a super capacitor explaining how to configure a super capacitor energy storage. Then, I will describe the results of evaluation of the control strategy for voltage fluctuations in the DC bus voltage and super capacitor. Evaluation was performed in the case of the actual (recording) power profile of PV as a test platform type. The result, the super capacitor storage and PV system, to ensure efficient power conversion, have shown that it can be controlled to mitigate the impact of rapid fluctuations in the power demand in the power generation and smart grid.

## 2 Generation and Control Strategy of Renewable Energy in Smart Grid

Generating a control strategy of renewable energy in the smart grid, consist DC bus voltage control and status three parts of the control for maximum power point tracking (MPPT), charge (SOC) energy storage. As shown in Figure in our research platform. As shown in Figure 1, the maximum power point tracking function is implemented in DC / DC1. DC bus voltage is controlled by the DC / DC2. Voltage of the super capacitor is controlled by the DC / AC inverter (or AC / DC converter). A control system diagram is as shown in Fig. The first part 2, the maximum power point tracking (MPPT) is a renewable energy source to the DC bus (for example, PV) to ensure the power conversion efficiency from. In the second part, high-speed control of the DC bus voltage, the constant DC bus voltage for the (identical and are connected to the DC bus) the proper operation of each converter or inverter (or within a specified range) hold to. In the third part, the energy storage in different circumstances a slow control of the charging status of the energy storage (SOC) intelligently (e.g. super capacitors) maintaining the appropriate voltage level. Detailed implementation of these strategies, I will be described in the following subsections.

### *A. The maximum power point tracking in renewable energy production*

In order to accomplish the purpose of renewable energy generation of maximum power point tracking, DC / DC converter PV (DC / DC1 in FIG. 1), ignoring the voltage fluctuation of the DC bus, slowly added continuously as shown in Figure that produces a small sinusoidal current, DC current I 0. 3.

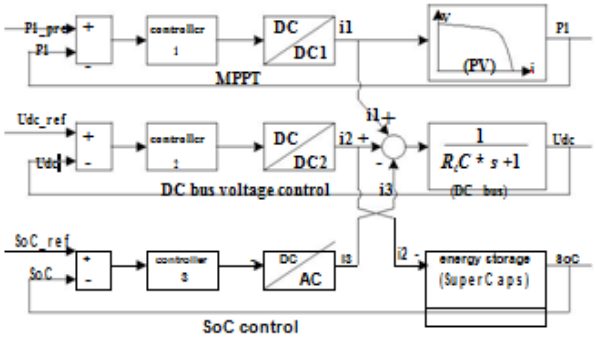


Fig.2-Research platform of control in the conversion and the smart grid of renewable energy.

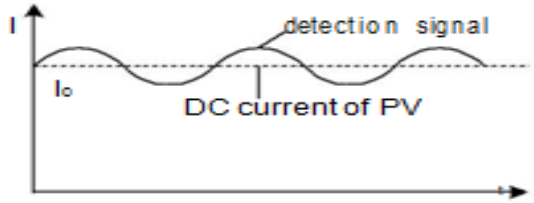


Fig.3-Maximum power point tracking (set of initial current of PV).

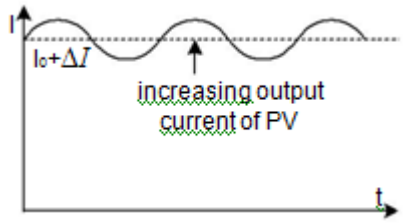


Fig.4- The maximum power point tracking (PV to increase the output current).

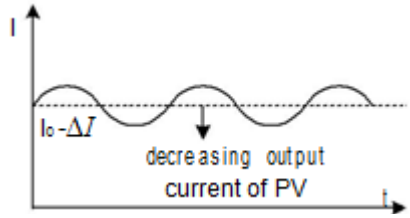


Fig.5- The maximum power point tracking (to reduce the output current of the PV).

The output power of the PV is, i> I0 than in the <output current i is the I0, then DC / DC1 is a direct current component of the output current of the PV increases as shown in the figure, when the output current If in is higher. Output power of the PV if low when the output current i 4.> I the I0 than in the <output current I0, then DC / DC1 is a DC component of the output current of the PV as shown in Fig. decrease. 5. According to the output power of the PV function slow sinusoidal current, it is possible to adjust the output current from the PV (DC component). As a result, the purpose of MPPT for PV is accomplished.

***B .Fast be in charge of DC bus voltage***

In accordance in Figure 1, the DC bus voltage can be represented by a function of the output current of the DC / DC1 i1, DC / AC inverter i3 as the output current of the DC / DC2 i2 is the input current (1).

$Udc=1/c£(i_{1+}i_2-i_3Udc/Rc)$ .....(1)

Here, C is the total capacitance on the DC bus. And Rc is an equivalent parallel resistance of the DC bus. As described above, the DC / DC converter 1 (DC / DC1) ignores the change in DC bus voltage, MPPT no. In this case, the best solution for controlling a DC bus voltage is to control the output current of the DC / DC converter and super capacitor i2. Capacitance of a super capacitor, as much higher than the capacitance of the DC bus, in order to control the DC bus voltage so that the required value during a short time interval (for example, several seconds), sufficient energy from the super capacitor I have. DC bus voltage control loop, as shown in the figure are shown in the control system diagram. Obviously, the output current of the DC / DC1 i1 is the disturbance in the control loop of the DC bus voltage. Another failure in the control loop of the DC bus voltage is the input current of the DC / AC inverter i3. However, the input current i3, in order to limit the variation in the power injected from the DC / AC inverter to the AC grid is kept slowly changing.

***C. The dawdling control of the state of charge of the super capacitor***

Energy storage (for example, super capacitors) energy capacity, as is very limited in the actual case, the state of charge of the energy storage is detected, should be maintained. Some goals If it is needed on the DC

1) Securing the energy storage (super capacitors) with sufficient energy capacity Bus. I so as to accumulate enough energy

2) Energy storage (super capacitors) when there is a high power injection From PV.

State of a change of super capacitor is dependent on the capacity of the voltage with different voltage level of the super capacitor. In order to maintain the charge state of the super capacitor, voltage of the super capacitor has to be controlled within an appropriate range at any time. SoC control loop of the super capacitor is shown in Fig. 2 (bottom). In this control loop, SoC super capacitors are controlled by the input current of the DC / AC inverter i3. To (slowly), I want to change the input current of the DC / AC inverter i3 to change the first DC bus voltage. DC bus voltage control is to be in the high speed control loop, the output current of the DC / DC2 i2 is changed immediately. As a result, the voltage of the super capacitor is maintained after a sufficient time. The super capacitor of SoC control loop, the output current of the DC / DC1 i1 is disturbed. Capacitance of the super capacitor is so high compared to the equivalent capacitance on the DC bus, but, SoC super capacitor is not so much changed in a short time.

## 3 The configuration of the super capacitor energy storage

Super capacitor energy storage was constructed using a series 150 Maxwell K2 series ultra capacitor cell (2.7V / cell and 650F / cell). In this case, the maximum value of the operating voltage is 405V, the maximum value of the equivalent capacity. The super capacitor energy storage is, / DC2 performed via the DC, as shown in Figure, is connected to the DC bus. 1. The purpose of this configuration is that it allows the voltage variation of a super capacitor during By limiting the variation of the injected power of the DC / AC inverter to the smart grid (or current) and 400V at a constant 1 minute minimum time the 200V in the case of maximum variation of the jet force from one PV.

## 4 Evaluation of control approaches

This approach of renewable energy production and control are evaluated during power injection procedure, in particular, as in the two triangles in Figure 1, as a platform for the study, to acquire the true power of the PV. The energy used as the reference in P1_ref power control system as the power output of the DC / DC1 as a research platform for C P1 in Fig. Is controlled to follow the reference P1_ref in (as in Fig. 1) both cases, the output of the DC / DC2 P2 abrupt changes in P1 is the resistance in the power supply of the inverter DC. / AC P3 will smooth a time constant of about 60 seconds in the evaluation is based on the DC bus voltage is fixed. (650V) 50% and the rated voltage (400V) super capacitors are expected to exceed 100% of the range.

### *A. Evaluation in the case of step-by-step power injection*

PV purpose of evaluation in the case of phased power injection from DC / DC converter (DC / DC1) is that the appropriate time constant of the DC / AC inverter it is checked whether it is set. Super capacitor DC / DC converter (DC / DC2) is, whether to respond to the disturbance from or DC / DC1properly.This evaluation is then Back 0 kilowatts, have been performed in a state of gradual power injection start of 15kW at T = 5S T = 100S, after the set to -15kW at T = 200S, and finally, returns 0 kilowatts at T = 300S. Corresponding output current of the DC / DC1 i1 is shown in FIG. 6, DC bus voltage is because is controlled to be about 650V. DC / AC inverter i3, the input current is shown in Fig. 6. One, i3 can see the smoothly varying; it will be have a time constant of approximately 60 seconds expected. This proves that the super capacitor DC / DC converter (DC / DC2) is working properly. Output current of the DC / DC2 i2 is shown in FIG. 7. This corresponds to the peak power injection. During stepwise injection of power from the DC / DC1 to the DC bus voltage of the DC bus, as shown, is controlled almost constant. Super capacitor of the DC / DC converter is (DC / DC2) 8. On the other hand, is adjusted within the expected range between as slowly Fig change of using the voltage of the super capacitor (corresponding to 50% to 100% of the rated voltage of the super cap) and 200V and 400V that. 9. This, DC / AC inverter, which means that it works appropriately as well

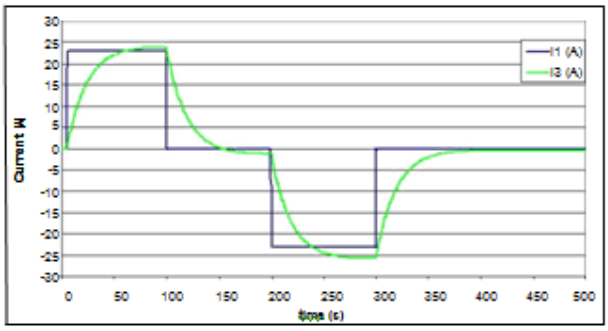


Fig.6- DC / DC1i1 and DC / AC i3 in the case of phased power injection, the output current of the input current

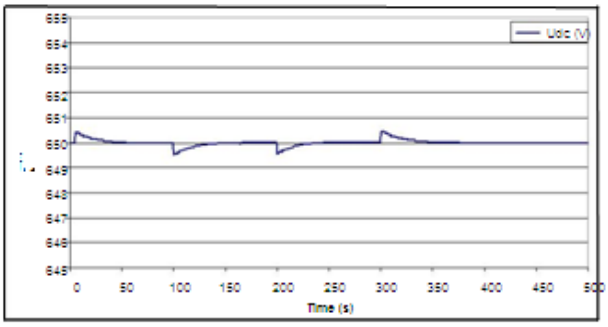


Fig.7- For phased power injection, the voltage of the DC bus

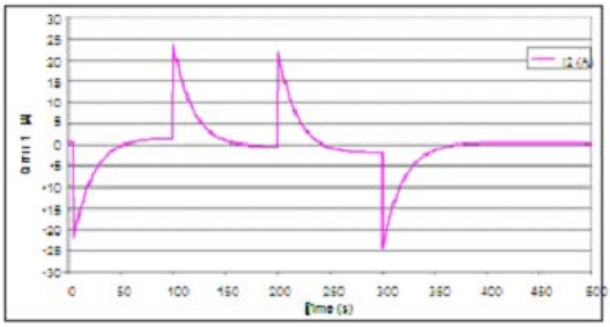

Fig.8- Output current of the DC / DC2 I2 in the case of phased power injection

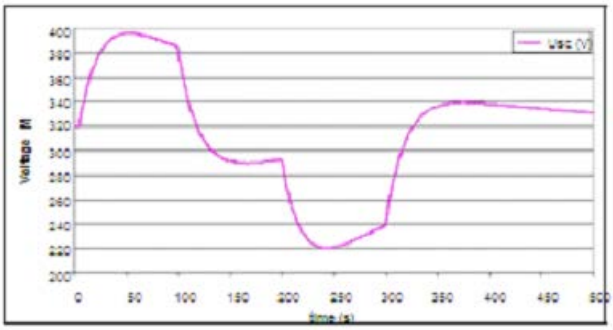

Fig.9-. the voltage variation of the super capacitor in the case of phased power injection

Check the evaluation results in the case of phased power injection from DC / DC converter PV (DC / DC1) to the DC bus, DC / DC converter of the super capacitor (DC / DC2) and the DC / AC inverter (as the DC / Figure 1, AC in research platform) is ready for further evaluation.

### *B. Evaluation in the case of actual recorded PV power shape*

The purpose of the evaluation of the actual saved. Details of the use of solar energy is as shown in Figure 10 to determine whether it may be a DC / AC inverter to AC power to the table that changes smoothly. Whether Superconvert DC / DC (DC / DC2) of the capacitor voltage is still whether it is possible to control. Whether the fluctuations are the voltage at the capacitor is allowed. Details of the real power of the PV as shown in Figure 10, DC / DC1 i1 in this evaluation, mapping the output current is shown in Figure 11, the output current of i2's / DC2 are shown in Figure 12

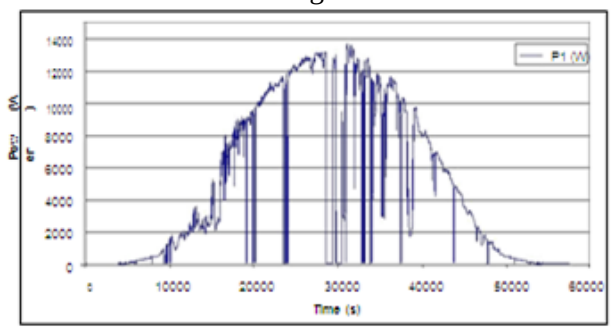

Fig.10- PV detailed real power saved.

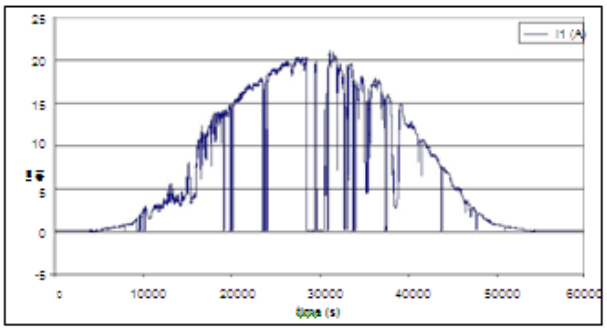

Fig.11- Actual PV detailed in the case of a record current output DC / DC1i1.

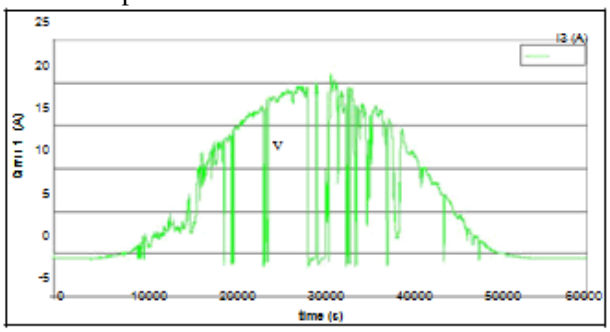

Fig. 12- In fact in the breakdown model of PV of the current input DC / AC I3

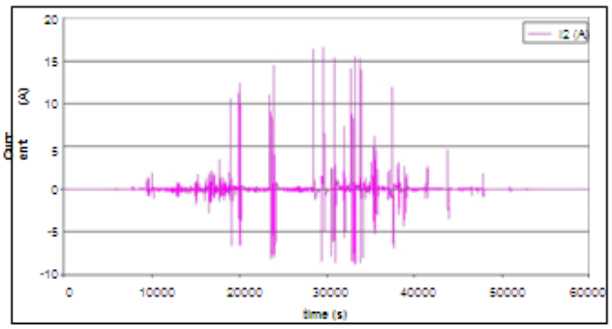

Fig.13-The actual recorded in the case of PV profiles the input current of DC / AC i3 of the PV

As shown in the figure, is a DC / DC converter output current of the super capacitor i2. 12, as shown in FIG, DC / AC inverter i3 on the DC bus is controlled input current to counteract the disturbance of power injection. I3,smoothly changes. 23400s This, (PV i1 during the super capacitor i2 Note DC / AC inverter i3 is, it was evident in the zoom of the curve of the output current of the DC / DC converter of the DC / DC converter output current of the input current and 24400s as shown in Figure 1). 14. One, i3 can be changed very smoothly (with a time constant of about 60 seconds) by referring to the (DC / AC inverter input current). In this case, it is possible to assume a corresponding output power of the DC / AC inverter to the AC grid having a (60 seconds) the same time

constant. Due to the technical progress of ICT applications, demand management (for example power matching) already, you can handle on top of the power injection of slow variations in the smart grid. As mentioned above, the evaluation of our strategy of generation and control of renewable energy in the smart grid should be against the DC bus voltage and super capacitor voltage. Power injection at the time as shown in the figure as shown in Figure 10, DC bus voltage is controlled to be substantially constant. 15; as can be seen, the voltage of the super capacitor is adjusted to within the expected range as shown fig 16.

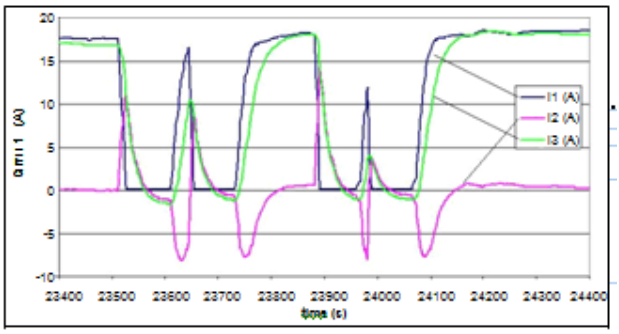


Fig. 14- The zoomed-in curves of i1, i2 and i3 (between 23400s and 24400s)

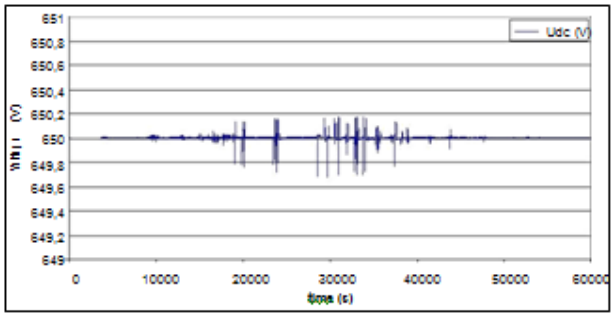


Fig. 15- The voltage of DC bus in case of a real recorded power profile of PV

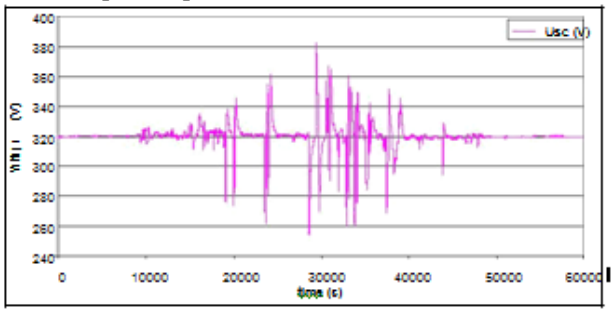


Fig. 16.-The super Cap voltage in case of a real recorded power profile of PV

Study platforms like our Figure 1 to verify the results of evaluation of the two cases. Achieved as can be independently doing MPPT can be a one piece target minimum energy storage with the appropriate (Super and improve power quality capacitors). In the storage is always healthy in order to ensure the energy of the super capacitor, the nonlinearity of the capacitance in our implementation also super capacitors the state of charge (SoC) is estimated considering. USC by voltage measurement of the super capacitor, as in the capacitor Csc super capacitors can (2), expressed as a function of voltage.

$$C_{sc} = C_{re}\left(1 - \frac{U_{re} - U_{sc}}{U_{re}} * n\,\%\right) \quad \ldots\ldots \quad (2)$$

Here, Cre indicates the rated capacity of the super capacitor at rated voltage Midge; USC voltage of super, Capacitor. N% lies in nonlinearity of super capacitors and (According to the modeling, it usually should be identified about 30%). If real SoC of the estimated SoC and super capacitors do not correspond to each other, it means the alteration equivalent capacity or series resistance. It is necessary to consider the appropriate measures. This critical parameter value when far away it is their initial value, a super capacitor, is bad SoH subsequent national health. There is a need to replace the energy storage. Thus, it is possible to ensure the safety and reliability of the super capacitor applications for the generation and control of renewable energy.

## 5 Management needs of the smart grid

In order to maintain the balance of power supply of the required power of the load on the electricity distribution network is a simple diagram, the needs for the development of ICT infrastructure. The basic principles of managing the demand side 17 is to achieve a balance between demand and supply of dual price and volume in microeconomics road [15] In general, the required energy is accompanied by an increase in the cost of electricity rose while. Reduced or vice versa in most generators and load control of power networks are becoming smart grid.

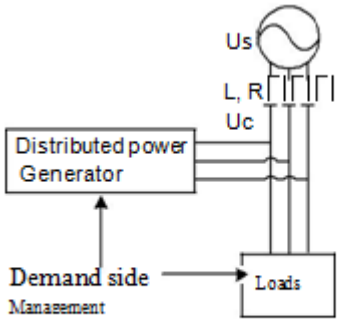


Fig17- Management needs of the smart grid.

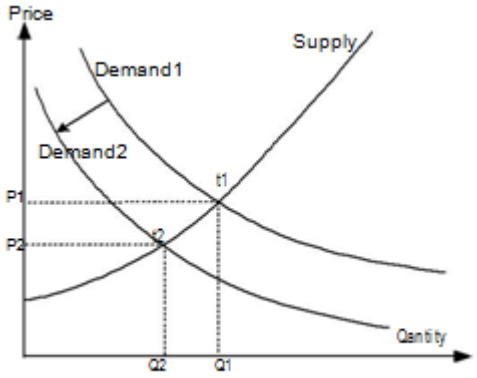


Fig.18- Demand curve.

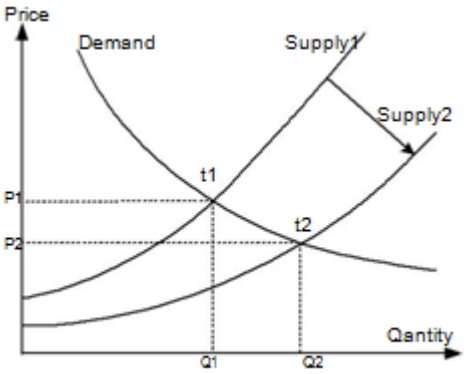


Fig. 19- Supply curve

Actually, to drop by changes in the actual situation in the bend of the smart grid tie power supplied by the curve and the price of the work function of the tariff is necessary. It is possible that they occur at the same time, there is reason to be divided in the event of a change in the supply line on the demand curve. Assuming that the power supplied to the price of the function does not change the nature of the work load is changing the energy needed to move. For example, I can load the grid smart is small, as shown in Figure times t1, 18 (P1, Q1) of prices and money supply process to (P2, Q2) prices and quantities. time t2 does not change the energy necessary to assume that the value of the function if the total capacity of the generator with the power to change as a function of the price to drop. For example, the total capacity of power generation in the smart grid may be increased as shown in Figure (P2, Q2) and (P1, Q1) 19. According to the need for balance is the demand management, energy storage systems. (Such as super capacitors, converters and inverters) must work together with the appropriate action. (Power Delivery mode) power distribution only if the time constant of the fluctuation of power, it is possible to ensure the quality of its energy needs.

# 6 CONCLUSIONS

Renewable energy sources to the power grid (e.g. PV) effect of fluctuations in power may be limited by the use of super. And if the paper (For example, MPPT control voltage DC bus capacitors and super-control) is presented, which is subject to the terms of use of appropriate strategies to create and control of energy. Assessment of the true details of the injection energy process and injection power, PV, it is confirmed that it is possible to change power injected into the grid AC to control at a certain time (. 60) is the demand side. (E.g. power matching) will be able to deal with the slow change in the injection power smart grid correctly. As a result, it is possible to achieve the highest and lowest energy storage, and (super) and the goal of high-quality power transmission, renewable energy.

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