



Direct Current Supply for Future Home

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- Existing AC Power Distribution
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Existing AC Power Distribution

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Advantages of AC Distribution

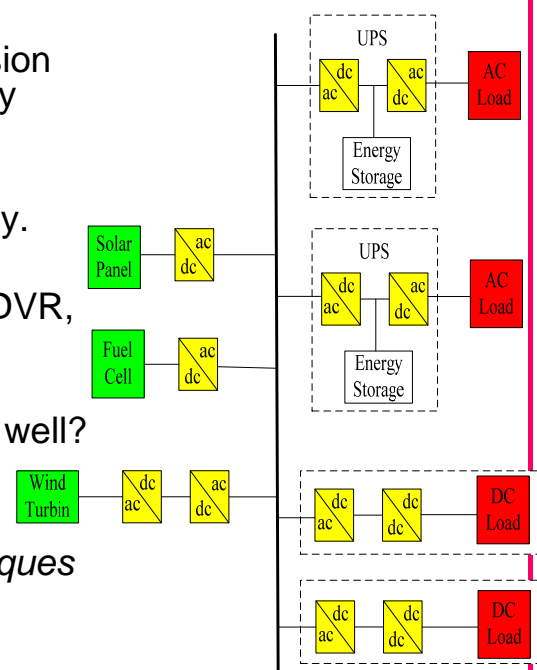
- Alternating current power transmission or distribution networks is commonly used.
- Well developed, matured technology.
- Supporting Devices such as UPS, DVR, APF are well developed

Why AC distribution system served us well?

A. Voltage Transformation

B. Circuit Breaker Protection

C. Established Voltage Stability techniques

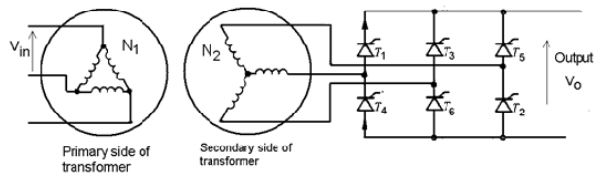
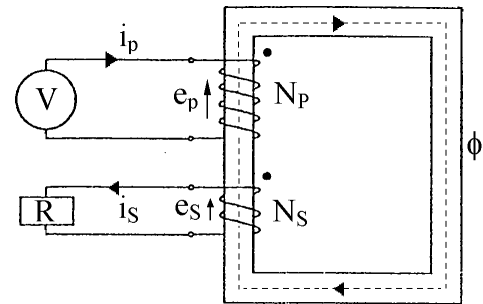


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- The greatest benefit to ac systems is the ease with ac voltage conversion
- Transformer techniques have been used for good voltage conversion under various load conditions.
- High efficiency
- Voltage control from AC-AC is well established such as Transformer rectifier unit (TRU)



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- Circuit protection is mature for ac distribution systems than for dc systems
- AC circuit protection schemes benefit from periodic zero voltage crossings,
- Extinguish a fault current arc.

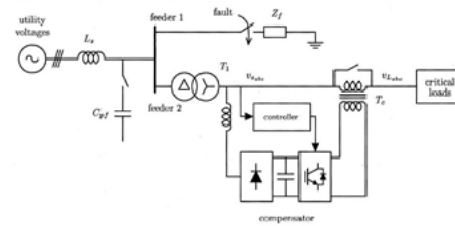


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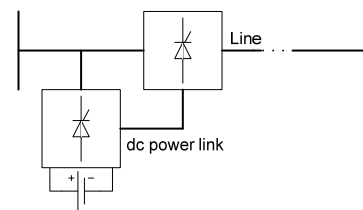
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Controlled Voltage Stability

- The advantage of an ac system is that the stable voltage can be controlled independently from real power through the management of reactive power.
- Voltage dip restorer can also be used for stability.
- Active power supply/filter could inject reactive power



DVR

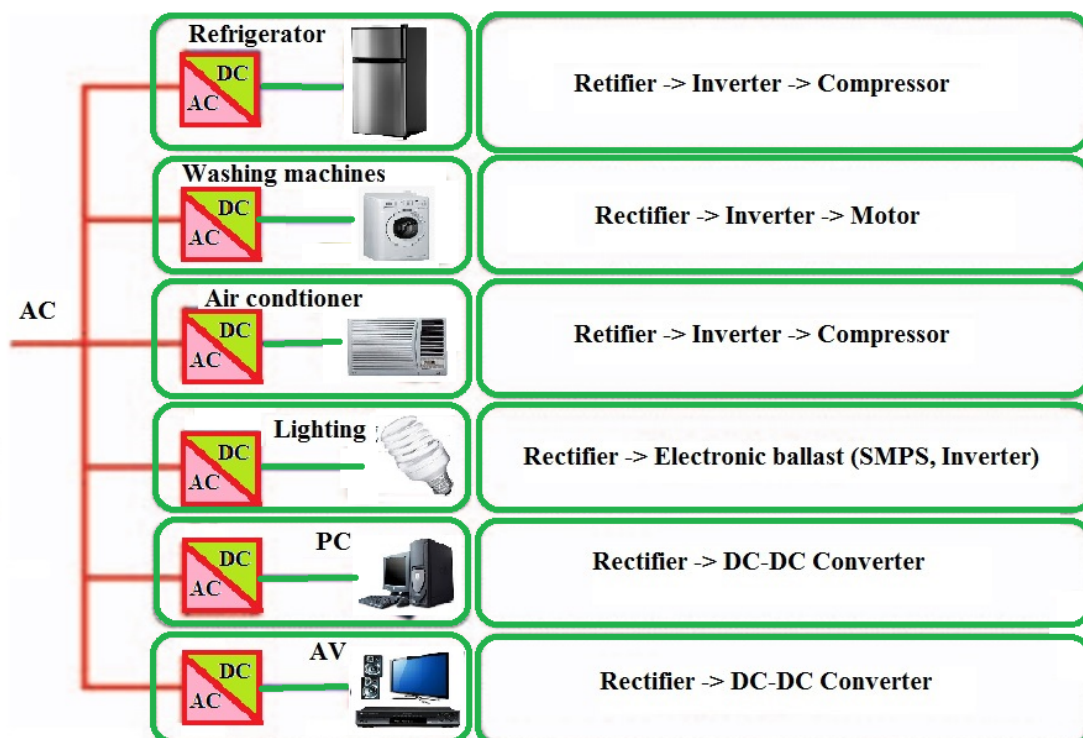


Reactive power compensation

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AC Home with 220V and 50Hz (Existing system)



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Why DC distribution

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The DC distribution

- The DC distribution system is an alternative method for delivering power.
- The method has been proved to have advantages over the conventional AC distribution/transmission in terms of energy saving, operation and cost.

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DC devices are Everywhere

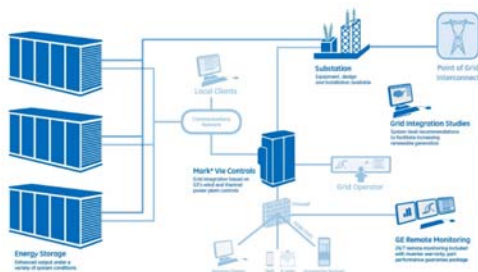
- Most of the electrical parts and systems are based on DC: lighting, heating, air-conditioning, elevator, escalator, entertainment appliances, industrial drives.
- They may accept or use AC but internally have embedded with an AC-DC converter to obtain the necessary DC.

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DC distribution suitable for Future

Battery Energy storage



Electric Vehicle



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For example

- The **computer** units are derived by low voltage DC such as 3-20V.
- The motor drive **inverter** also has a DC link supplied by AC-DC rectifier of around 600V.
- Most of the electronic lighting is now embedded with an **electronic ballast** which is also with a DC link of several hundred volts.
- The recent popular **LED** lighting is also a DC based system.
- **Battery** is also an DC System

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Why not DC before

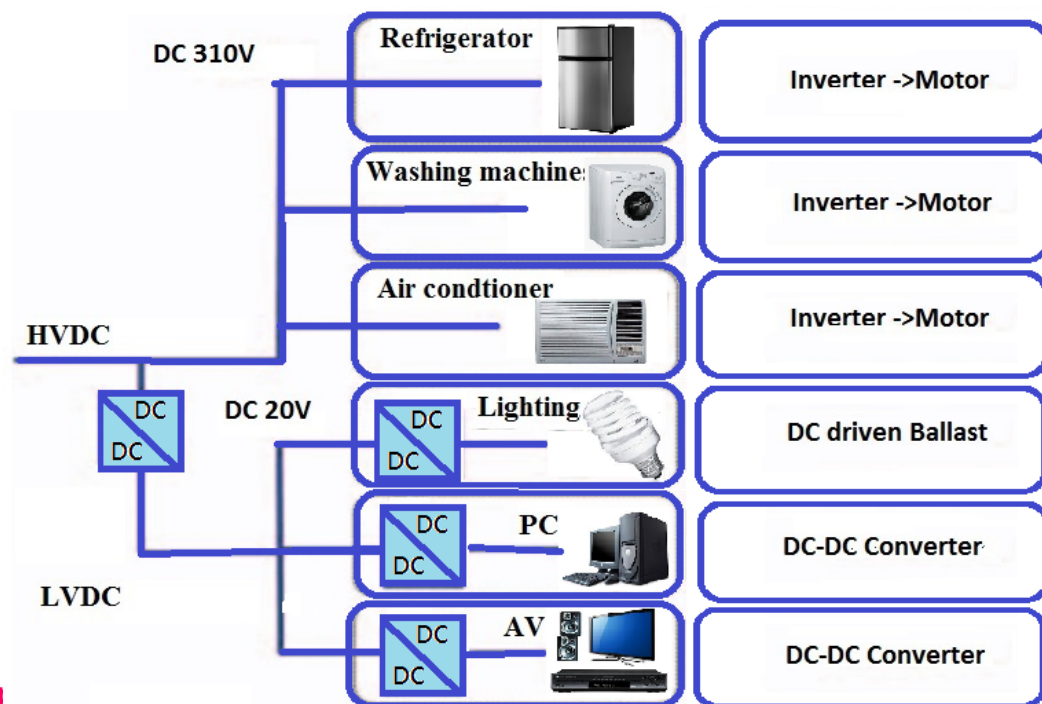
- **Power Electronics** has developed rapidly in last 2 decades for power conversion
- It allows the higher performance DC-DC power conversion
- Most of the equipment/appliances are embedded with **DC-DC power converters**
- **Renewable energy** and energy storage can be DC based.



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DC Home with 310V + 20V



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Onboard DC Grid

- 1000V DC circuit
- A significant step forward in electric propulsion
- 20 percent fuel efficiency improvement



- Source : ABB Communications

This is the **ABB** Onboard DC Grid.
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<http://www.abb.com/cawp/seitp202/3415983275230248c1257b64005080ef.aspx>

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270V DC for Aircraft

DC Distribution has been in aircraft

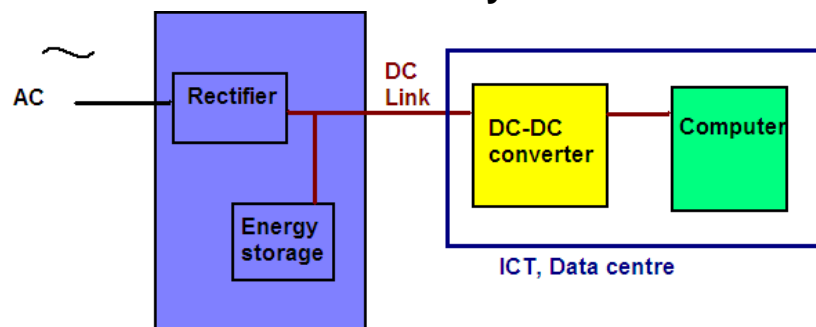
- F22 Raptor
- Lockheed-Martin JSF X-35A/B/C



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High-Voltage DC Distribution Improves Data Center System Efficiency



- DC used for server power supply
- 20-40% reduction in loss
- Increase reliability through DC link
- Reduce maintenance cost.
- **Example : Baldwin Technologies Inc**
- Why:
 - High efficiency for DC-DC power conversion
 - Improved reliability using DC battery energy storage
 - Less loss due to DC and eliminate AC loss
 - Work well with ICT even with long cable

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San Francisco's DC Grid

- 250V DC
- Coexist with AC
- A feeder head, rectifier, and output smoother atop a pole in San Francisco's South of Market neighborhood is visible evidence of the city's DC grid.



Source: <http://spectrum.ieee.org/energy/the-smarter-grid/san-franciscos-secret-dc-grid>
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DC in Various Cities



- NTT East Saitama Shin-toshin Building
48VDC



- DC 380V University Campus in Aichi,
Japan

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DC 380V, Chung Cheng
University, Taiwan



DC 380V, Chung Cheng
University, Taiwan

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General Concept of DC Distribution

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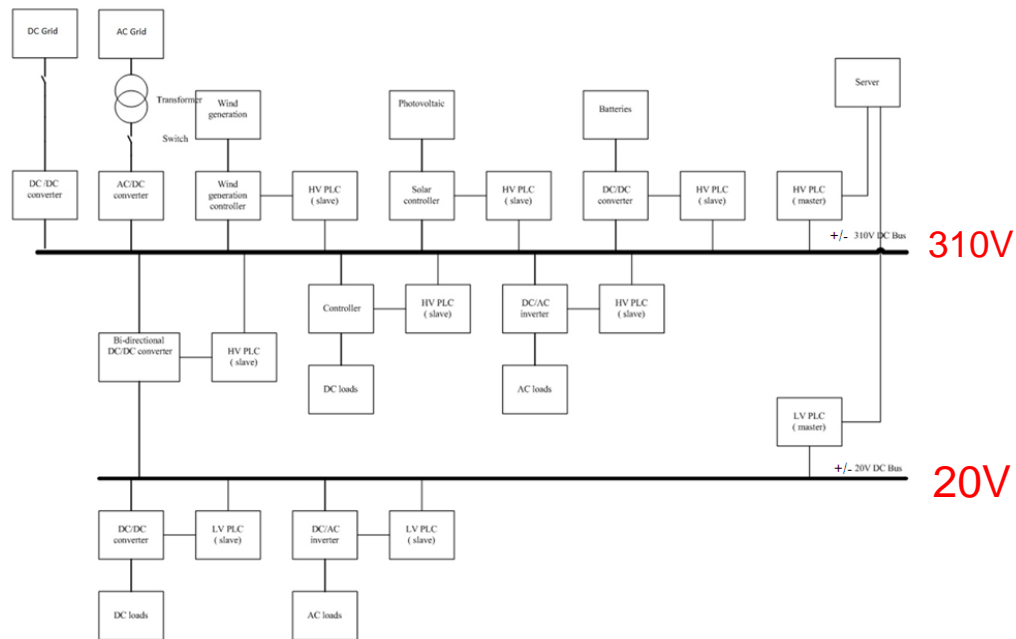
General concept of DC Distribution

- The DC distribution system is an alternative method for delivering power.
- The method has been proved to have **advantages** over the conventional AC distribution in terms of energy saving, operation and cost.
- In the past, AC is used for most of the transmission and distribution system. Now DC can be made using power electronics
- The distributed **renewable energy source**: It is possible to **skip** one stage conversion and to use DC-DC conversion only by using DC for distribution systems .

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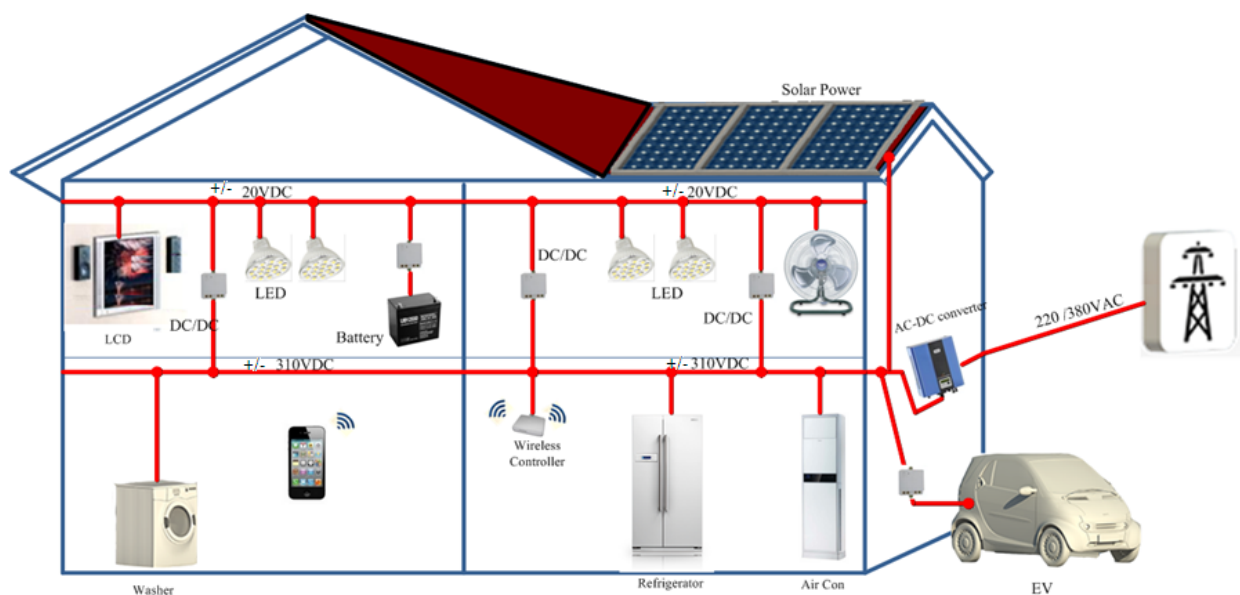
DC distribution system with double-layer structure



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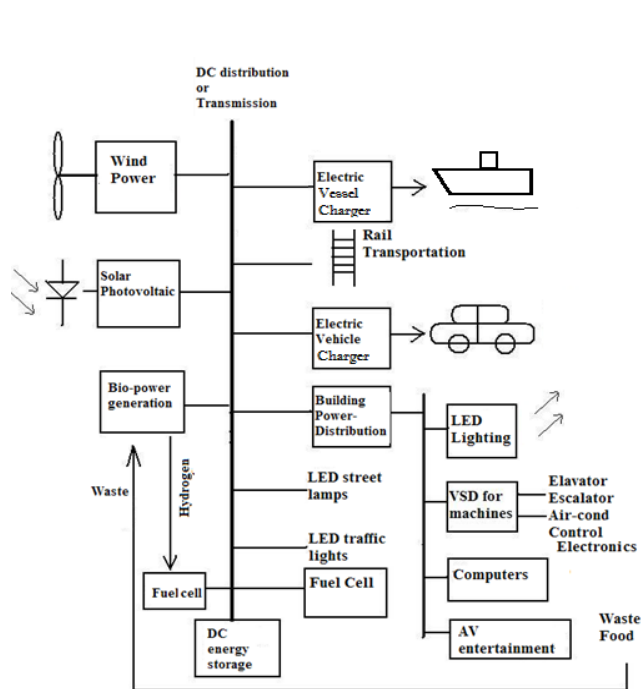
The DC Smart Home



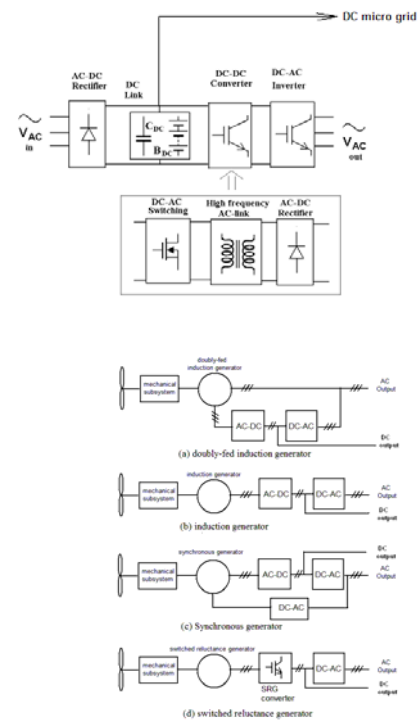
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Smart DC City



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Research Area

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Research Area

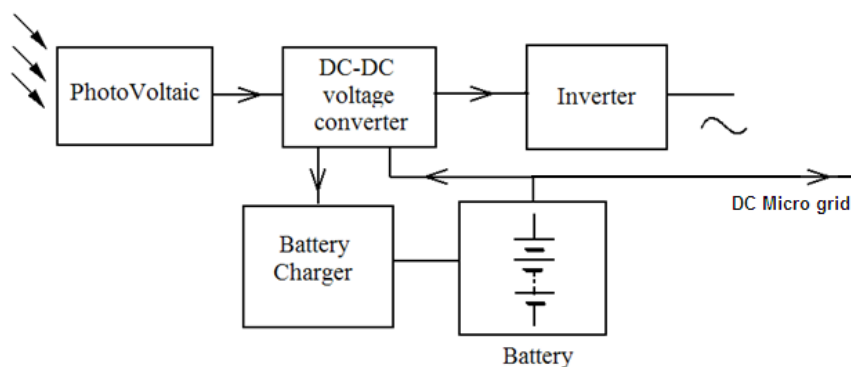
- High frequency DC/DC power conversion
- DC safety
- DC energy storage
- DC standard
- DC to AC actuation
- DC actuation
- Distributed DC power generation
- DC load

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Alternative energy sources

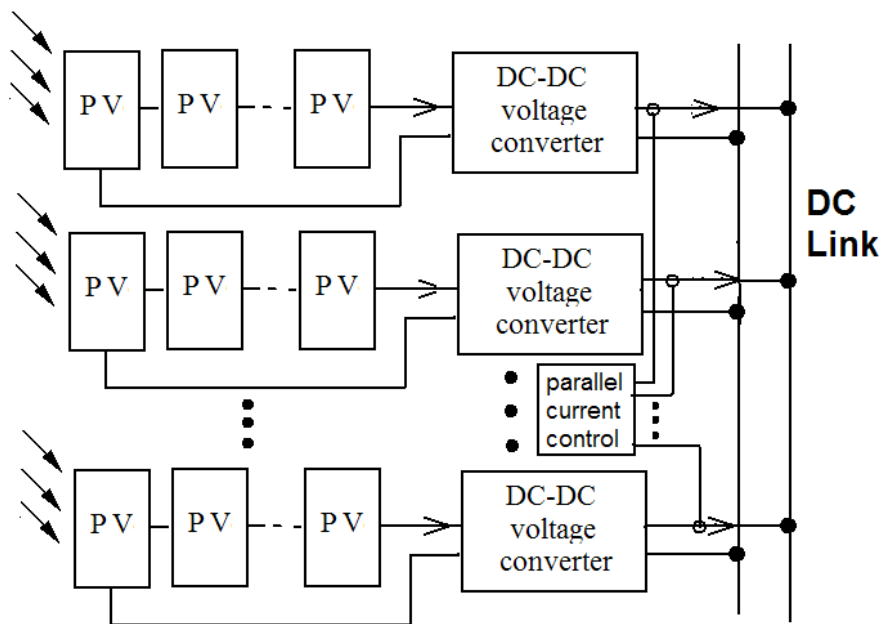
- The alternative energy source such as Photovoltaic is also DC source. Battery and capacitor for energy storage is also DC.



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Parallel sharing of PV systems

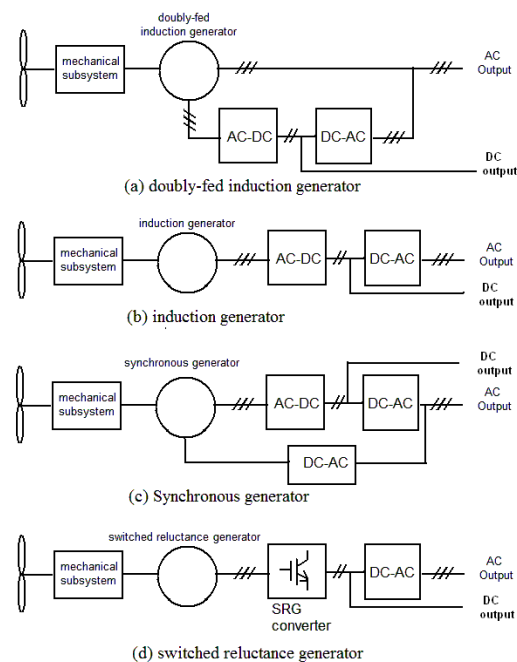


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Wind power sources

- All the sources can output DC
- They usually use inverter to change from DC to AC.
- Can tap power using DC



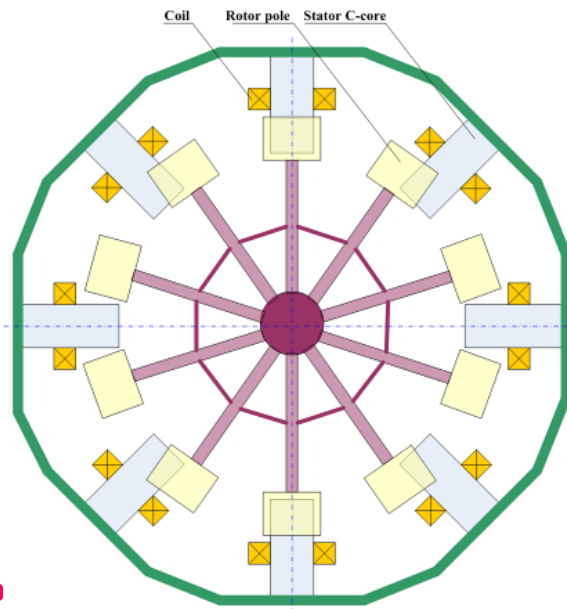
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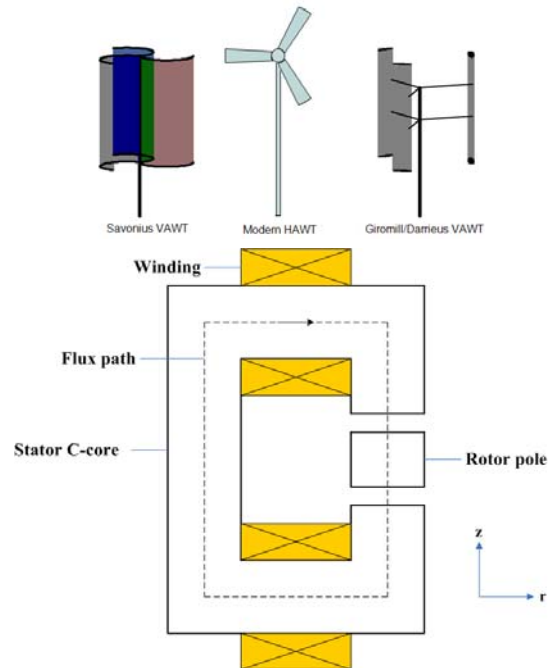
Design and Fabrication of Generator for Wind power



New wind power generator such as SR generator are DC based

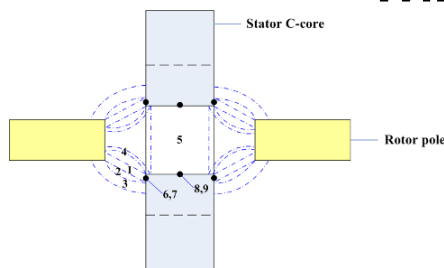


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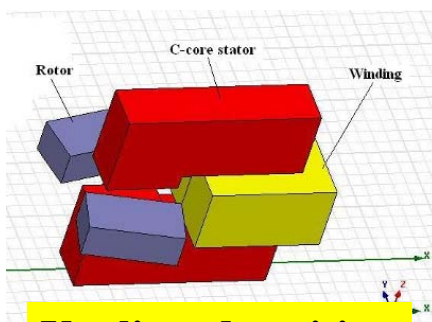


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Design and Fabrication of Vertical Axis Wind Power Generator

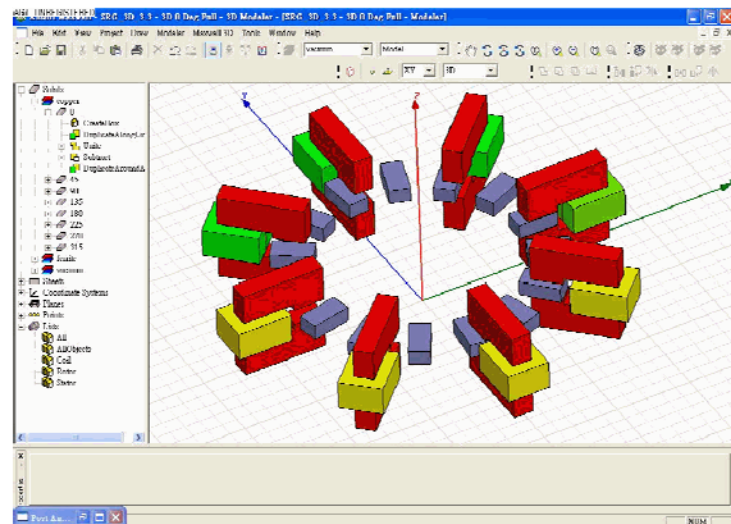


Equivalent flux paths



Unaligned position

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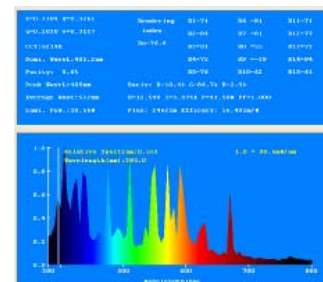
LED lighting system

- DC based
- DC-DC power driver
- Thermal design
- Low loss
- Spectrum control



Source: <https://leotutoriales123.wordpress.com/author/leotutoriales123/>

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Energy Storage

- The energy storage devices are DC
 - DC battery
 - Fuel cell
 - Super-capacitor
 - Battery from Electric Vehicle of Hybrid vehicle

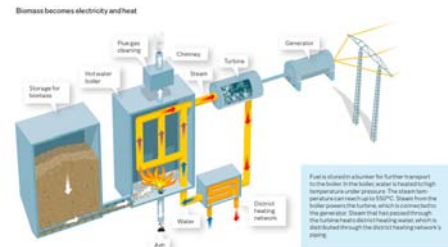


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Bio-mass power generation

- The bio-mass can be used to generate electricity through different voltage potentials
- It can also be used as to generate methane gas and then to generate for fuel cell for other generators
- All outputs can be DC



Source:

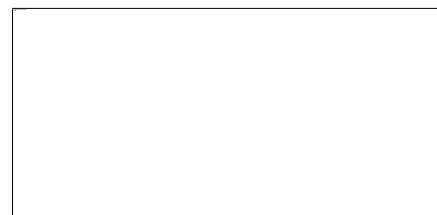
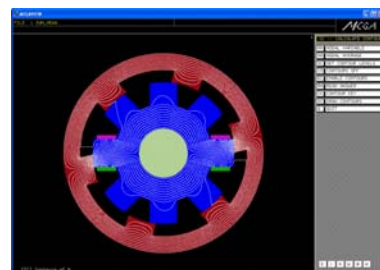
https://corporate.vattenfall.com/globalassets/corporate/about_energy/illustrations/biomass_becomes_electricity_and_heat3.jpg

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Motor are DC driven

- Most motors such as DC, switched-reluctance, Induction, are driven with an inverter.
- Using DC will reduce the AC-DC sub-circuit

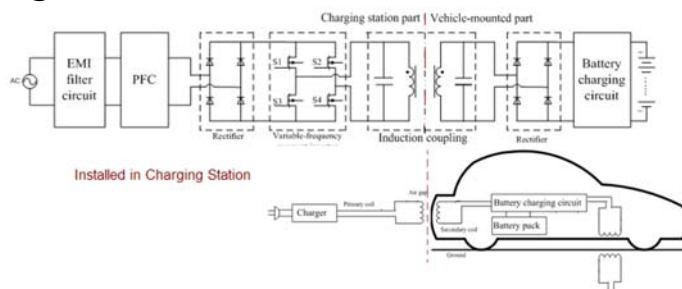


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Wireless Power Transfer

- Allow DC power conversion to transfer through partition, glass or wall.
- Use the same technology for wireless charger
- High frequency resonant switching, magnetic resonant, near field analysis



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Advantage of DC distribution

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The saving in DC distribution

	Size reduction	Power input reduction
Electronic ballast	30%	5%
Motor inverter	30%	4%
Renewable energy system	40%	5%
Distribution	50%	2%
Low power Charger	20%	10%
Video/Audio Entertainment	10%	10%
Computer	15%	8%
Average	25%	4.5%

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DC Distribution Versus AC Distribution

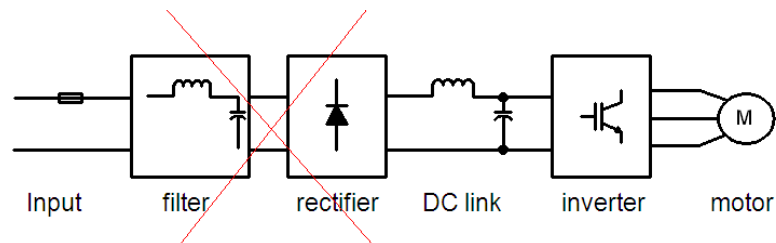
- Higher efficiency
- Suitable for **today and future** technologies
- Easy to connect to renewable energy storage
- Work with **electric vehicle** for additional energy storage
- Higher **efficiency** for distribution
- Easy for different **DC sources connected together**.

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Saving

- All power components can be reduced by around 1/3
- The rectifier can be eliminated
- Some inverter circuit can be eliminated
- Reduce materials cost by up to 1/3
- Power station to users saves 5% electricity.



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Safety

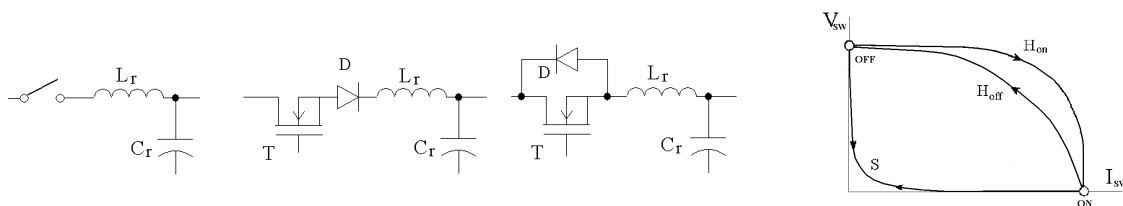
- Proposed DC 20V
 - Lower than extraneous safety voltage in different standards
 - SELV BS EN 60335
 - ELV IEC (60V)
 - Lower than Zone 0 SELLV of Code of Practice Electrical Wiring of EMSD(30V)

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Switching

- Install power breaker with zero-current switching:
 - Develop zero-current switching such as quasi-resonant, extended resonance and resonant transition.
- Residual current device (RCD): For unbalance current.
- MCCB/MCB for DC

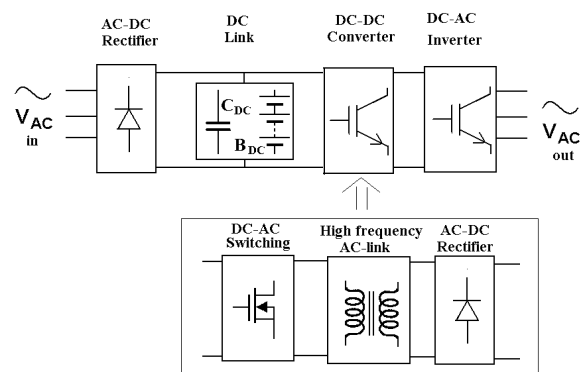


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The technology

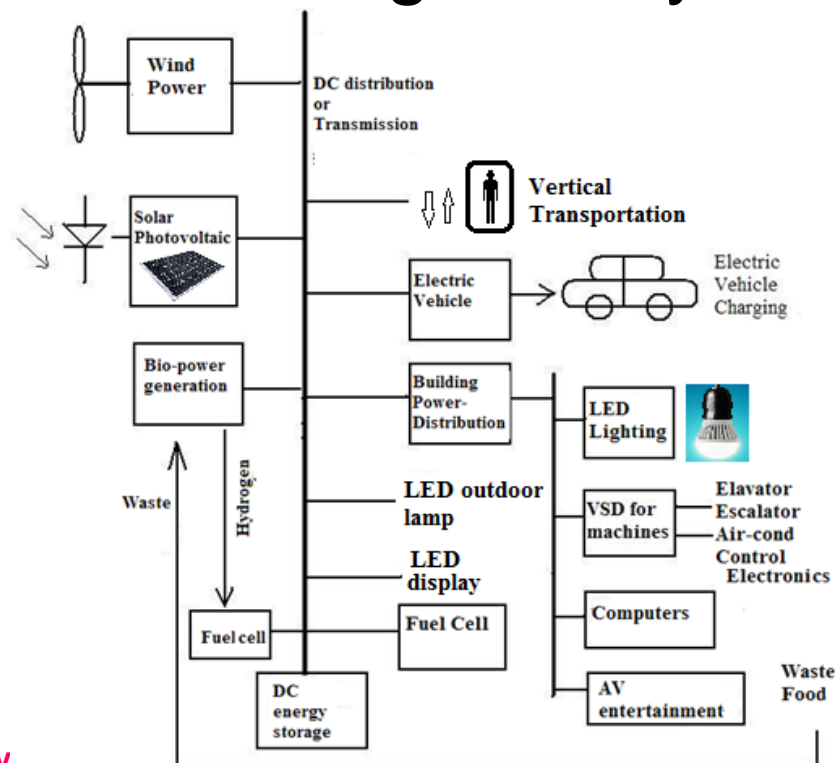
- We use high frequency **DC-DC power conversion** for all types of voltage conversion to replace the conventional AC-AC transformer
- Smaller size, lower cost
- The DC Link can be **connected to many energy storage devices.**



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The DC building and Systems



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The work

- Develop **model DC home** to prove the concept
- Develop the related electronics for the **retrofitting** the new system
- Provide the design for **new DC system** for electronics
- Develop the **standards** for new DC systems



DC Distribution Design in LWL Campus, The HK Polytechnic University

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Why the project is important

- DC system to enhance new energy development in the world.
- A set of new standards for DC system will be made, that is equivalent to its AC counter parts.
- The standards and the patent developed for the project is a wealth for the R&D. All the other parties have to follow our standards and patent for DC systems.
- More importantly, the system will provide good saving in materials and energy.
- It will make the system stable and more reliable and increase life time.
- The system is compatible with other renewable energy source and energy storage (All DC based).

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Problem Encountered in DC Distribution

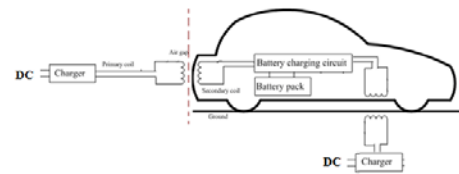
- **Change all AC** equipment/ appliance to DC
- Easy installed for new building, **not existing building**
- **Difficulty in Acceptance** by existing AC devices' manufacturers and suppliers
- **DC safety**: Electrostatic, electrolysis, electromigration

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Smart equipment

- All LED lightings can be **connected** in a **smart manner** without using adaptor or using a small adaptor
- DC power source, enhance safety
- DC **contactless** switch
- Wireless power transfer
- DC smart charging platform
- Wireless or PLC control



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Conclusion

- The DC distribution method enables the new concept in **energy saving and materials** saving.
- **All equipment** such as lighting, vehicle, transportation, electronic appliances, power generators are all DC.
- Can be used in office, home, building or a city
- Match with **future renewable energy source**
- **Saving** will be increased with the increasing renewable energy being used.

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Conclusion 结论

Power Electronics Research Centre (PERC)

Fully supported from the industry and government.

Research in fundamental study as well as applied research

Aims - to help local industry and the region

电力电子研究中心 (PERC)

得到了工业界和政府支持

基础研究和应用研究同时进行

目标 - 提升本地区及其工业界的竞争力

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