

Direct Current technology In the building industry

1

WHY DC INSTEAD OF AC ?

2

INITIATIVES:

CHINA, CANADA, HOLLAND, USA, FRANCE

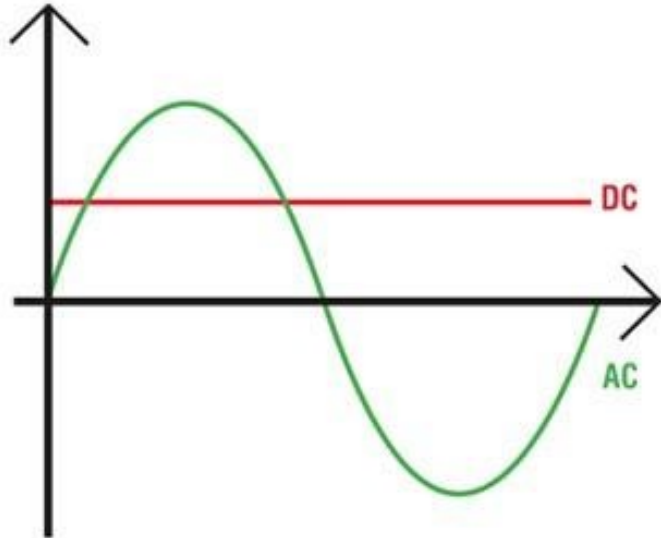
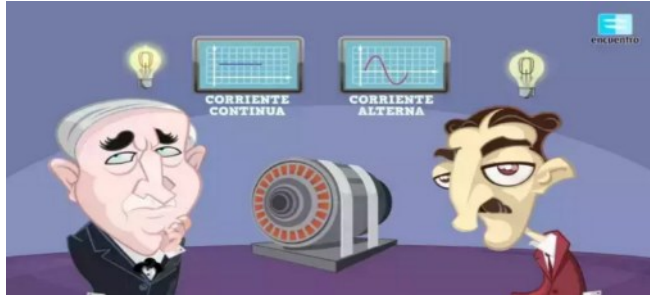
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HOW TO MOVE FORWARD ?

WHY DC INSTEAD OF AC ?

1

Why DC instead of AC ?



Three basic characteristics of DC

1. **Simple:** No frequency, No phase, No amplitude
2. **Stability:** No periodic changes, No zero crossings
3. **Efficiency:** No reactive efficiency, High transmission efficiency

Three scenarios of DC application

1. **Long distance transmission:** Submarine Cable, Urban Underground Cable;
2. **High reliability power supply:** Data center, Electronic production line;
3. **High-precision control:** High-speed train, Electronic equipment control.

Why DC instead of AC ?

Driving force:

From the both sides of **supply** and **demand**, distributed power supply and DC load promote the development of DC power distribution technology.

2050 Non-water
renewable energy

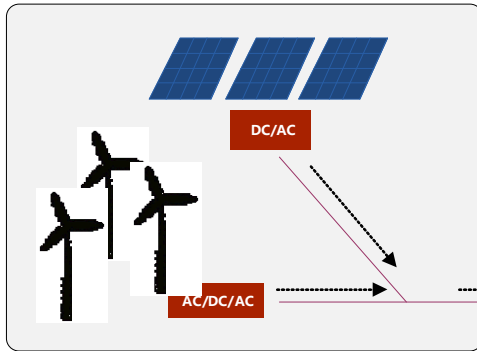
43.4%

Distribution Network
loss

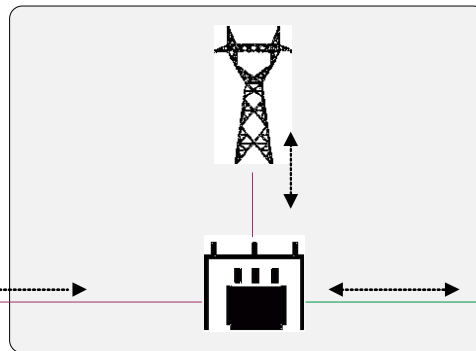
15%

Generalized DC load

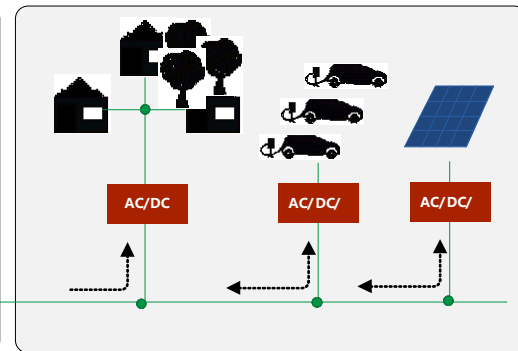
50%



Cleanliness



Homogenization

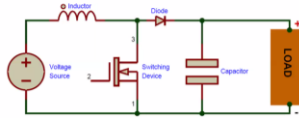


Electronic

Why DC instead of AC ?

What changed that makes DC useful again?

Major Reason #1: The DC Transistor



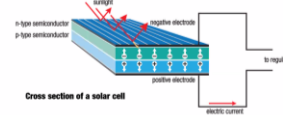
The basic **DC-DC voltage converter** will take the **current** and pass it through a "switching element". This turns the signal into a square wave, which is actually AC. The wave then passes through another filter, which turns it back into a **DC** signal of the appropriate **Voltage** necessary.



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What changed that makes DC useful again?

Major Reason #2: Renewable DC Power Generation



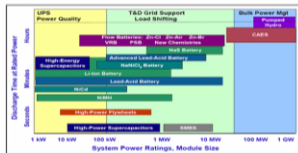
Solar PV cells generate electricity by absorbing sunlight and using that light energy to create an electrical current. There are many **photovoltaic** cells within a single **solar** panel, and the current created by all of the cells together adds up to enough electricity to be useful.



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What changed that makes DC useful again?

Major Reason #3: DC Energy Storage



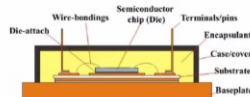
Rechargeable **batteries**, where energy is stored electrochemically, are one of the most cost-effective energy **storage technologies**. For large-scale energy **storage**, there are a number of advanced **battery technologies** to consider such as super capacitor, nickel, lithium, lead-acid, flow, metal-air **batteries**, and so on.



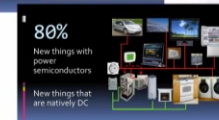
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What changed that makes DC useful again?

Major Reason #4: DC Power Electronics



Power electronics is the application of solid-state **electronics** to the control and conversion of electric **power**. ... The **power** range is typically from tens of watts to several hundred watts. In industry a common application is the variable speed drive (VSD) that is used to control an induction motor.

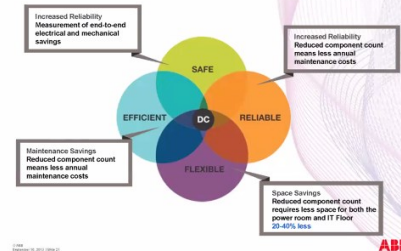


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Can you summarize the benefits of DC?

- Single voltage (380VDC) global standards – fewer OEM equipment variations – potential equipment cost reduction
- Simplicity , scalability , ease of deployment
- High reliability – elimination of series conversion steps
- Power quality maintained (vs AC eco-mode)
- No need for phase balancing
- Elimination of harmonics impact
- Lower Total Cost of Ownership
- Migration path to true electric power network: Enernet

DC solutions



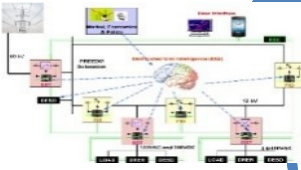
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Why DC instead of AC ?

Advances in DC research: simultaneous research at home and abroad, supply-side leading demand, equipment leading applications, and industry leading civilian use.

North Carolina State University, USA:
FREEDM
Flexible distribution system(DC400V)



Virginia Tech University:
AC/DC hybrid distribution network(DC380V/48V)

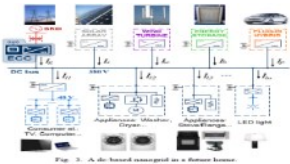
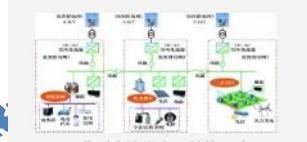
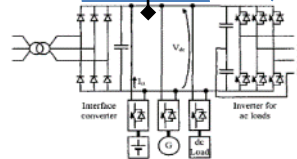


Fig. 3. A dc based microgrid on a battery bus.



State Grid Zhejiang:
863 Project "High
Density Distributed
Energy Access AC/DC
Hybrid Microgrid"
(DC560V)

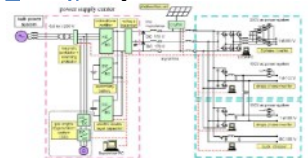
Milan Polytechnic University, Italy:
Low voltage DC power distribution
system
(DC400V)



CSG Shenzhen:
863 Project "Intelligent
distribution network based on
flexible DC"(DC400V)



Osaka University, Japan:
AC/DC hybrid microgrid
(DC±170V)



EXAMPLE OF A CHINESE INITIATIVE

A Chinese initiative by Institute Of Building Research (IBR), Shenzhen

More than 20 Chinese and foreign units jointly initiated the establishment

Combined "Source, Grid, Load, Storage"

Combined "Production, learning, research, use"

Options	Total	Proportion
Technical standard research	25	60.98%
Power grid planning and design	6	14.63%
DC equipment development	8	19.51%
DC electrical development	5	12.2%
Switch and socket development	6	14.63%
Automatic control system development	18	43.9%
Power storage technology research and development	10	24.39%
Other	8	19.51%
Effective number of people	41	





Mobile Lab



DC Open Lab



Full DC building
demonstration

DC Open Lab:

Experimental verification:

1. DC power distribution efficiency under distributed energy access conditions;
2. Safety and stability of building DC power distribution;
3. Application of different DC end product combinations.



DC power load



DC Open Lab



Converter and active protection equipment

2 What we have done

DC Building Demonstration Exploration: Future Center

Project Location: Pingdi Street, Longgang

District, Shenzhen

Land area: 11037.76m²

Building area: 62 523m²

Building height: 99.8m

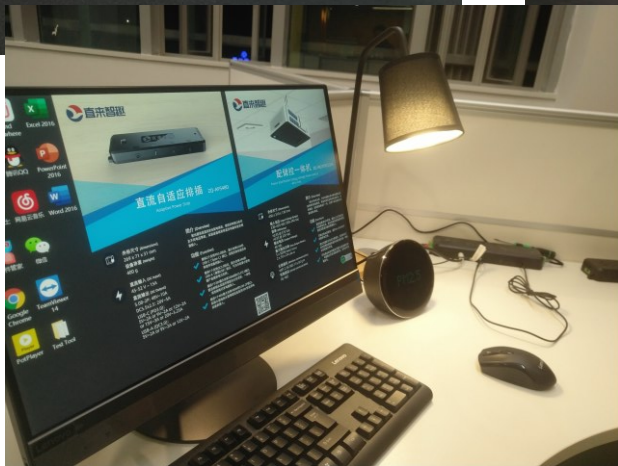
Main functions: R&D, office, experiment, pilot plant test, display, education, residence, Cultural exchanges and other functions, Explore the future of low carbon life work mode.

Building DC system design range: 5000m² office + 50 residential



Solve the problem of demonstration and promotion of net zero-energy building technology in summer hot winter and warm regions and even the world's same climate zone

A Chinese initiative: International Low Carbon City



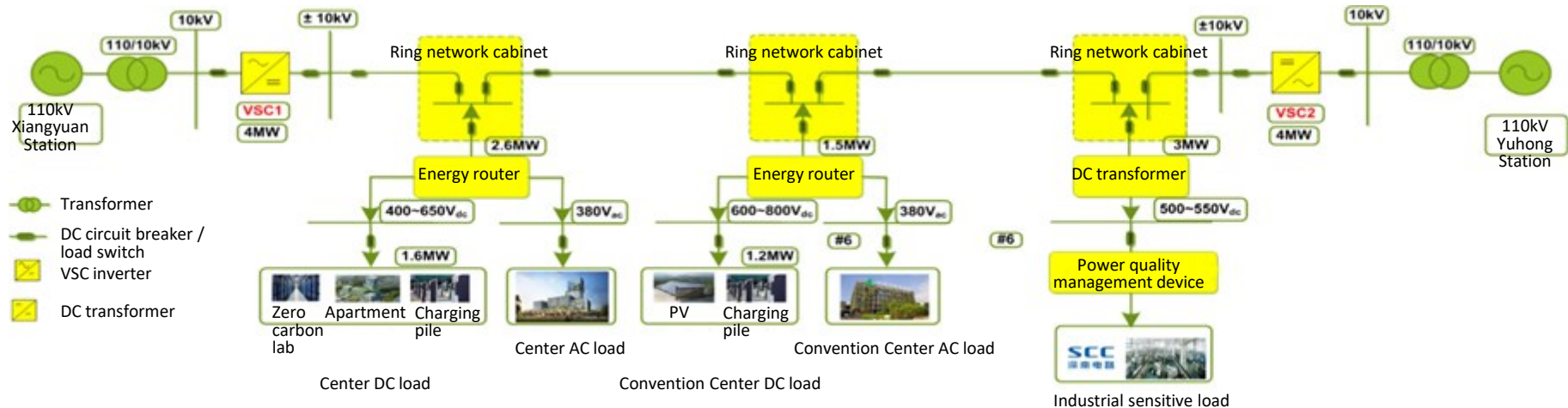
A Chinese initiative: International Low Carbon City

DC Building Demonstration Exploration:

External power supply condition

Each 4MVA voltage source converter (VSC) is arranged at 110kV Xiangyuan Station and Yuhong Station. It provides DC power supply interface to Low Carbon City Future Center, Low Carbon City Convention Center and Shennan Circuit Company in a “hand in hand” manner.

- System rated power supply capacity 8MW, rated voltage class $\pm 10\text{kV}$
- Future central energy router 2.6MW, including DC load 1.6MW, AC standby power supply 1MW



External DC power supply plan

EXAMPLE OF A DUTCH INITIATIVE

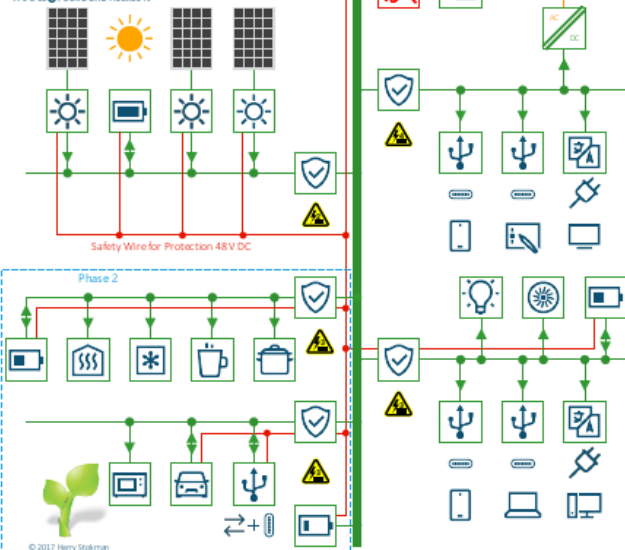
DC in Office Buildings



Direct Current BV has realized the design, engineering and realization of DC nets in utility building.
Example: 150kW 350V DC installation ABN AMRO Cir building in Amsterdam, installed by the BAM.

Advantages of DC

- DC gives reduction of raw materials.
- DC moving the world to the sand age. We are coming from the golden and of ages.
- DC is improving lifetime.
- DC is the direction of the EU without realizing.
- DC is fun and all sustainable energy create DC.
- DC is used by all modern devices, we already live in a DC world.

We Design Build and Realize it

DC is NOW!

AC is an option

Operating system of -Current-

PROTECTION

- ⚡ Protection against electrical shock. New DC zones implemented.
- 🛡️ Full protection against overloads, shorts earth faults etc.
- 🚗 In island the system can be switched OFF including the PV generation.

PLUGS

- 🔌 350V DC plugs for large users. Flash free.
- 🔌 Interface between standard devices that can handle DC.

PV

- ☀️ DC Micro converter + MPP tracking. No high voltage. The system can be ON/OFF in case of danger situations or work in progress.

LED

- 💡 Current/OS emergency mode in case of power issues. High dimming ratio possible without power factor is suits.

EV

- 🚗 Automatic charging when possible.
- ⚠️ Automatic priority set by user. Load shifting.

USB-C

- 🔌 Standard driven by the EU. Most used plug ever.
- 🔌 All new devices are using USB C up to 100W power.
- 🔌 USB C replaces Ethernet, HDMI one cable power and data.

BATTERIES

- 🔋 Power balance optimized and managing Current/OS. Batteries can lower TCO because of a lower connection capacity.
- 🔋 Batteries add a full UPS function. And in case of power failure unnecessary users are disconnected.

HVAC

- ❄️ Cooling, ventilation and heating is automatic optimized. Rilling in the caps in the power flow.
- 🌡️ Based on the Current/OS so there is no need for direct control. Only setup the systems. Systems stays working in case of communication failure.

EXAMPLE OF A US INITIATIVE

The background of the hero section is a photograph of a wind farm at dusk or dawn, with several wind turbines silhouetted against a colorful sky. A white network of dots and lines is overlaid on the image, connecting various circular icons that represent different aspects of energy and technology, such as a laptop, a cloud, a robotic arm, a Wi-Fi symbol, a solar panel, and a power tower.

Open industry association

Leading the rapid adoption of safe, resilient, economical and sustainable DC and hybrid AC/DC distributed energy microgrid power systems for buildings and communities. This is accomplished through EMerge Alliance vanguard standards and promoting market development.

[Become a Member!](#)

"Members of the Alliance include products manufacturers, software and service providers, system design, integration and construction firms, relevant governmental agencies, trade groups and academia as well as public and private utilities."

Through these organizations, a broad range of interests are represented in the generation and utilization of both standard and alternative electric energy. See who's involved at each membership level.



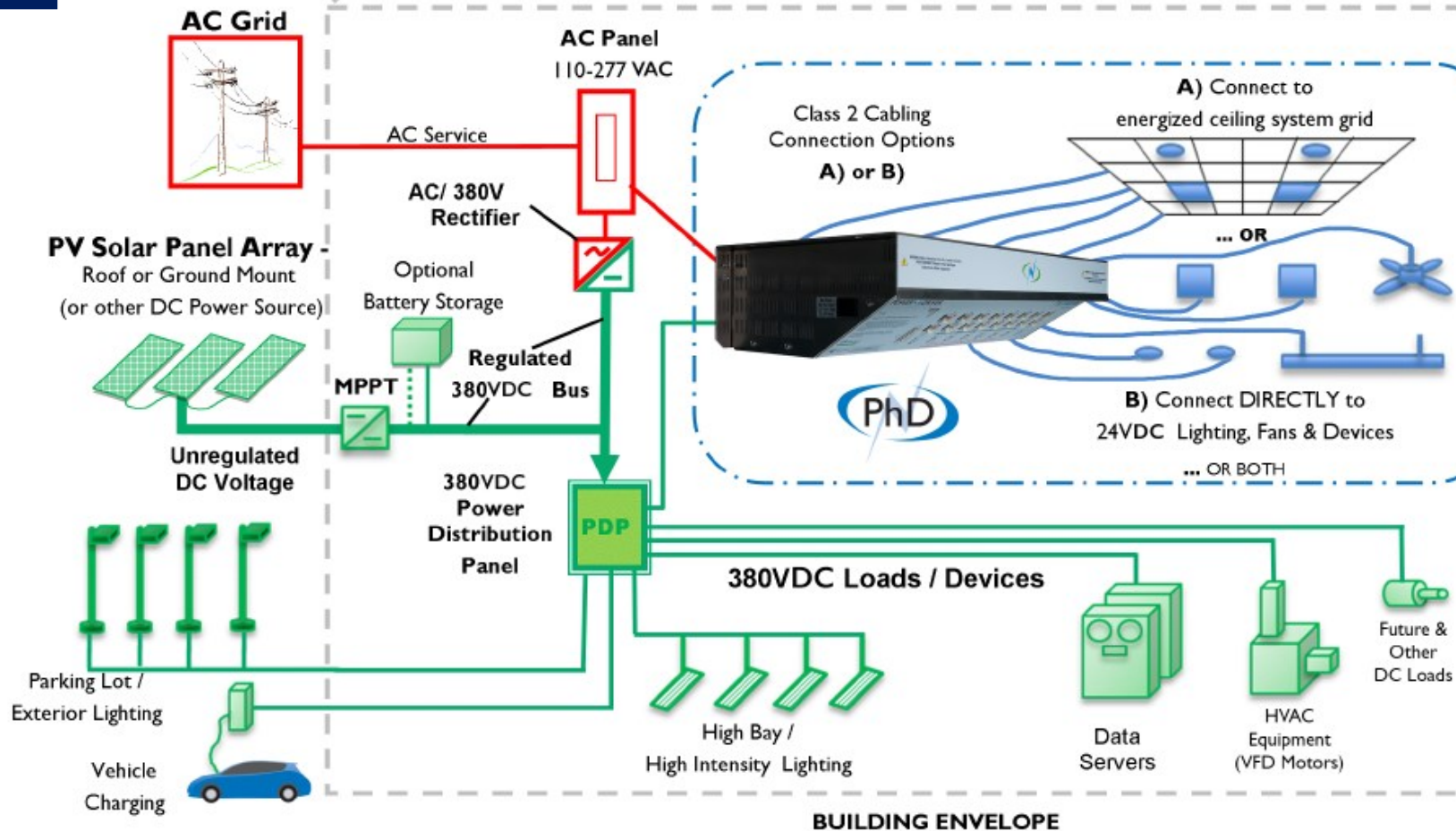


Photos Courtesy of AGU.

Pathway to Net Zero Energy

USGBC CASE STUDY:
AGU Headquarters Renovation

Washington



EXAMPLE OF A CANADIAN INITIATIVE



**Commercial real estate:
Regus has launched a
new co-working brand
with Gastown project**

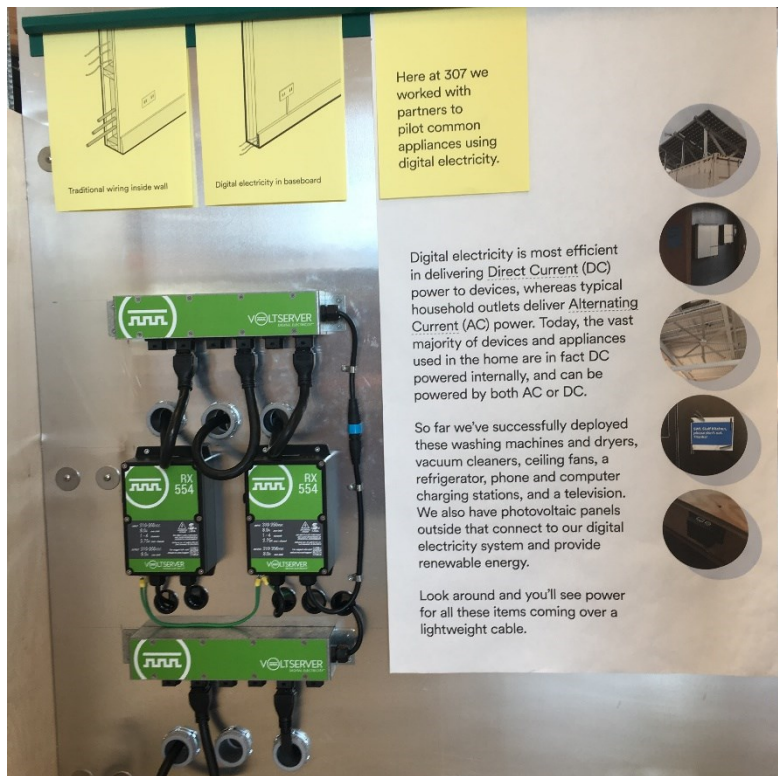
BENEFITS

- Cost and time-saving installation
- Wide selection of high quality driverless light fixtures to support any range of design
- Fully integrated wireless lighting controls system
- Reduced total cost of ownership (TCO) thru significant maintenance and energy savings
- 10-year warranty



	Chicago	Toronto	Vancouver
Year Complete	2019	2018	2018
DC Power \$/SF	\$1.24	\$0.90	\$1.14
Control \$/SF	\$1.15	\$0.90	\$1.18
Total SF Lighting	71,000	15,204	24,500
Lighting Watts	32,145	8,250	13,000
Lighting Watts/SF	0.45	0.54	0.53

Sidewalk Labs



Traditional wiring inside wall

Digital electricity in baseboard

Here at 307 we worked with partners to pilot common appliances using digital electricity.

Digital electricity is most efficient in delivering Direct Current (DC) power to devices, whereas typical household outlets deliver Alternating Current (AC) power. Today, the vast majority of devices and appliances used in the home are in fact DC powered internally, and can be powered by both AC or DC.

So far we've successfully deployed these washing machines and dryers, vacuum cleaners, ceiling fans, a refrigerator, phone and computer charging stations, and a television. We also have photovoltaic panels outside that connect to our digital electricity system and provide renewable energy.

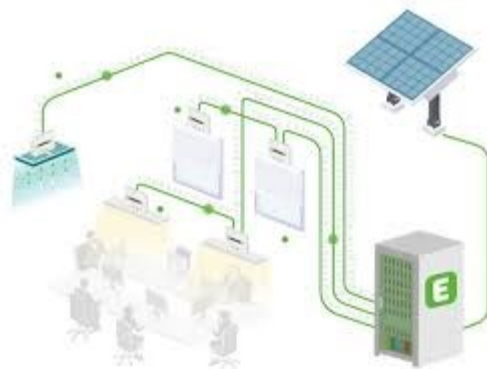
Look around and you'll see power for all these items coming over a lightweight cable.



EXAMPLE OF A FRENCH INITIATIVE

PROJECT in Saint-Ouen

35 200 m² de bureaux



Chaque port PoE délivre une puissance électrique de 100 W (soit 5600 W par switch).
Gestion Technique du Bâtiment (GTB) totalement IP grâce au POE (data + DC).

PROJECT in NANTES



Proposal title HybridLayers
Proposal full title Hybrid AC/DC Grid Layers for Future
Call ID LC-SC3-ES-10-2020
Type of action IA Innovation Action
Coordinator VTT Technical Research Centre of Finland Ltd

List of participants

No	Participant organisation name	Acronym	Country
1	VTT Technical Research Centre of Finland Ltd	VTT	Finland
2	Electricité de France	EDF	France
3	SP Energy Networks	SPEN	UK
4	Städtische Werke AG	NSG	Germany
5	Elektro Ljubljana d.d.	LJU	Slovenia
6	Alginet Distribución Energía Eléctrica S.L.U.	ADEE	Spain
7	Schneider Electric Industries SAS	SCHN FR	France
8	Schneider Electric España SA	SCHN ES	Spain
9	Ibérica de Aparellajes S.L.	IBER	Spain
10	Software Imagination & Vision S.R.L.	SIM	Romania
11	Galéo	GAL	France
12	Artelia	ART	France
13	PNO Innovation N.V	PNO	Belgium
14	Fraunhofer Institut für Energiewirtschaft und Energiesystemtechnik	FRA	Germany
15	Instituto Tecnológico de la Energía	ITE	Spain
16	University of Strathclyde	USTRATH	UK
17	Asociación Española de Normalización	UNE	Spain
18	European Distributed Energy Resources Laboratories e. V. (DERlab)	DER	Germany

DC R&D project International groupment Hybrid AC/DC Grid

Electric power system is increasingly merging with other sectors: for instance district heating/cooling network, gas network or transportation system. Consequently, management of more complex system increasingly happens through communication networks and data platforms. Also end-user appliances are more connected to internet and cloud services. This development results in huge amount of new data points with access to electricity network as well. Cybersecurity is definitely an increasing concern in terms of system resilience and needs to be addressed in all smart grid architectures.

Direct Current (DC) based technology can offer solutions addressing these challenges. Since most electronic devices are by default DC, their system integration can be enhanced when interconnected through DC. For instance PV panels, fuel cells or batteries operate as DC. Even though they typically need voltage level conversions, the effectiveness of DC/DC conversion is better than AC/DC conversion. More generally, wider use of DC can reduce the number of conversion throughout the whole system, leading to better overall system efficiency. Figure 1.2 depicts the amounts of conversion when integrating various components.

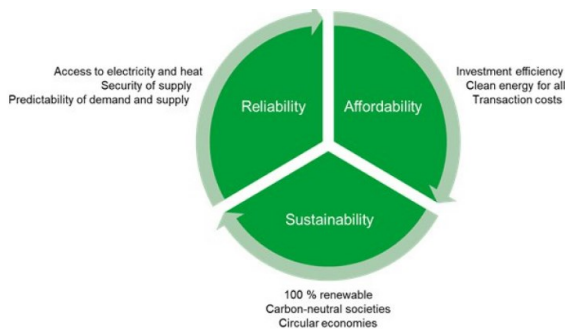


Figure 1.1. Cornerstones of energy system.

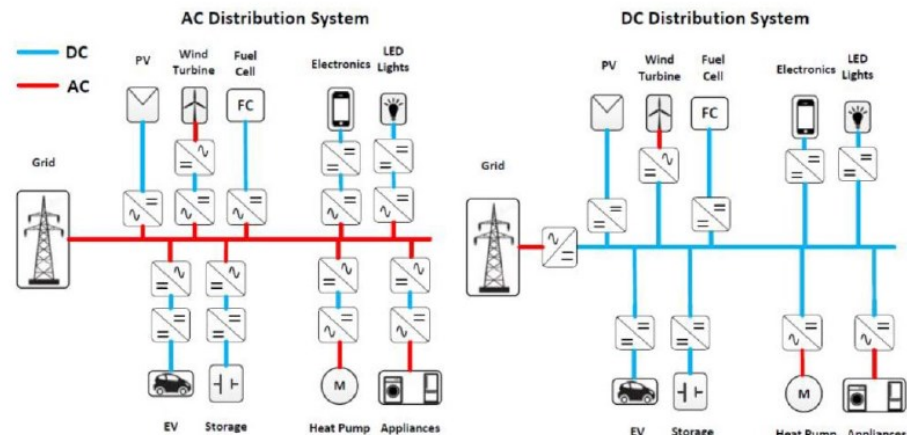
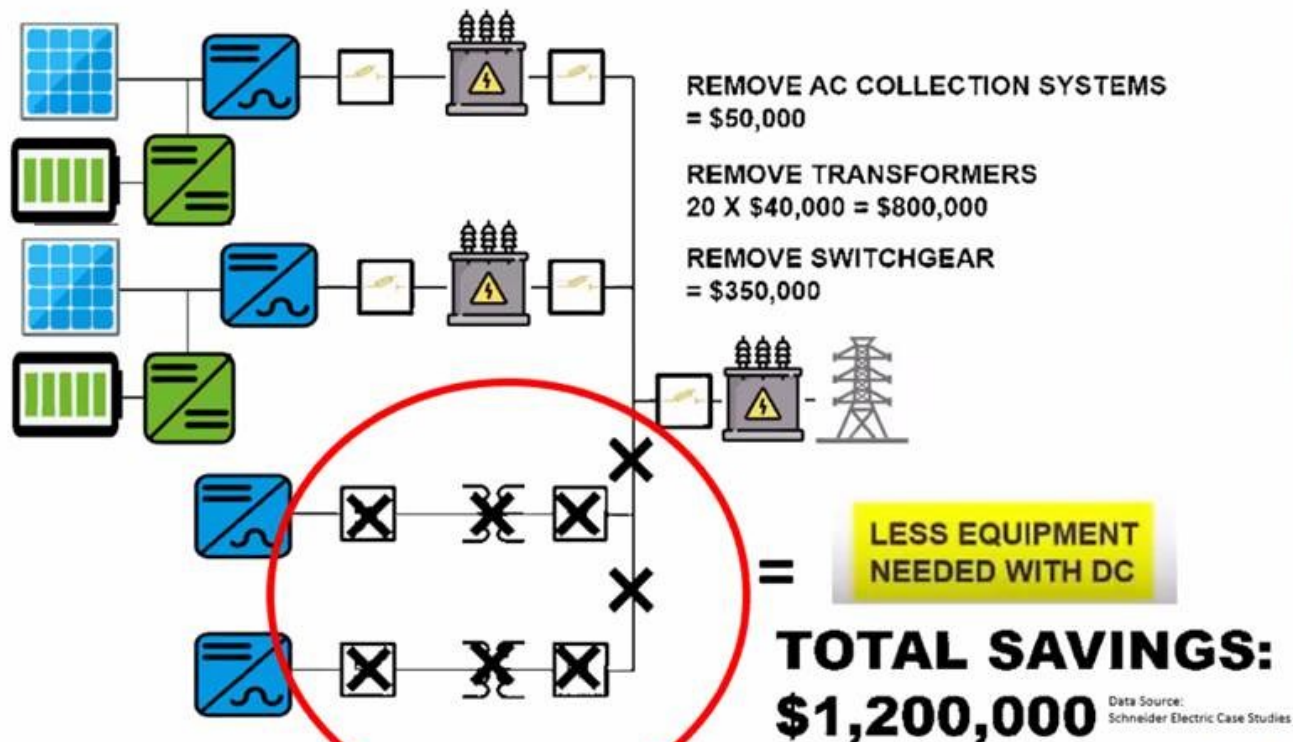


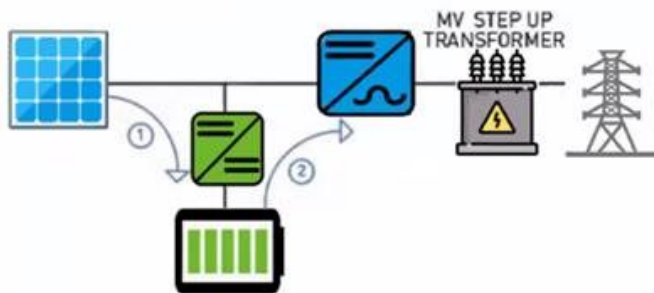
Figure 1.2. Needed conversions while integrating different components.¹

Cost Savings on a 20MW Solar + Storage System



Advance to the next animation or slide

Efficiency in a 20MW Solar + Storage System



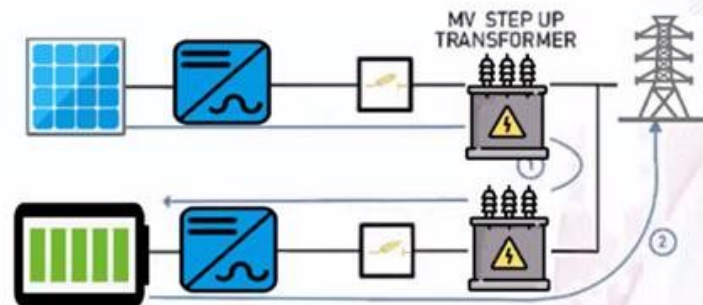
DC-COUPLED

- 3 power electronic conversions
- 1 battery charge and discharge
- 1 transformer conversion

Efficiency = 89.2%

$$= .95 * .982 * .982 * .984 * .99$$

Data Source:
Schneider Electric Case Studies



AC-COUPLED

- 3 power electronic conversions
- 1 battery charge and discharge
- 3 transformer conversions

Efficiency = 86.2%

$$= .95 * .984 * .99 * .99 * .984 * .984 * .99$$

PROJECT in NANTES

Immeuble de bureau de 2846 m²

Panneaux PV en toiture

Cogénération à huile

Accord de principe avec Enedis et MOA:

Deux raccordements seront prévus pour les bureaux depuis le transformateur public:

- un raccordement AC pour les services généraux

- un raccordement DC avec convertisseur en pied d'immeuble pour les plateaux de bureaux

Fournisseurs d'énergie pouvant refacturer en DC à confirmer.

DC EQUIPMENTS available in France

LED LIGHTING

Manufacturer	Comment	Power & Voltage
Philips LED panels	With DC driver, Available in UK	53-77 V, 16-24 W
Zumtobel LED lights	With DC driver, Available in France	50 V, 20-25 W
LITED	With DC driver, Available in France	48 V, 15-25 W
CLAREO	With DC driver, Available in France	24 V, 52 W



For a PoE distribution, the DC driver is not required.

ELECTRICAL BLINDS

Many and various motors technology are suitable for any types of blinds
Voltage inputs are limited between 12 VDC and 24 VDC (48 VDC not found)



Manufacturer	Model	Power (W)	Voltage
SIMU	Motor T3.5 E Hz DC	17, 26,30	12VDC or 24 VDC
	Radio Motor T3.5 ESP Hz DC		
	SIMU T5 CC Motor		
CAME	VOILA-Shutter system	75	24 VDC
	Edison B3 - φ 25	10	12 VDC
ELERO	SunTop L-868 DC	120	12 VDC

LAPTOPS

Nowadays PCs contain USB-C port for charging and transferring data.

➤ Max power by USB-C port found → 100W, which limits the choice of laptops

Manufacturer	Model	Charging ports
Lenovo	ThinkPad L590	2 USB-C ports – 65W
Dell	Latitude 3301	USB C 3.1



WALL PLUGS



USB-C 100W WALL SOCKET OUTLET

The standard socket connected to a 350VDC grid. For powering small DC devices up to 100W conform the PD standard in the USB-C.

OCHNO USB-C PLATFORM



- Cloud-managed USB-C socket for integration into different physical environments
- Integrated power and communication infrastructure, connect anything with one cable
- Ochno Operated delivers additional IoT, power management and security services to any connected device

OCHNO USB-C PLATFORM

Includes a range of smart services to help get a full look at the work environment.

REFRIGERATORS

Used in offices, boats, camping car and trucks.

Manufacturer	Model	Power	Voltage
Domestic	DOMETIC CRX 50 U	40W	12/24VDC
	DOMETIC RMD 10.5T	170W	12VDC
	DOMETIC COOLMATIC CRX 50 S	40W	12/24VDC
Theford	T1090	48 W / 24 W	12 VDC



VENTILATION

The company *ebm-papst* provides a range of solution:

Technical Values	Axial Fan	Diagonal Fan	Centrifugal fan
Voltage	5-75 VDC, 11-440 VAC	9-72 VDC	6-72 VDC
Air flow quality	Up to 1220 m ³ /h	Up to 1100 m ³ /h	Up to 1600 m ³ /h
Power Consumption	0.1-275 W	19-360 W	1-190 W
Application	Up to 1500 Pa	Up to 1500 Pa	Up to 5200 Pa

DC EV Charger

	N. America	Japan	EU and the rest of markets	China	All Markets except EU
AC	 J1772 (Type 1)	 J1772 (Type 1)	 Mennekes (Type 2)	 GB/T	 Tesla
DC	 CCS1	 CHAdeMO	 CCS2	 GB/T	



No EU manufacturer of DC EV Charger

One Chinese manufacturer offers DC EV Charger :

Manufacturer	Power (kW)	Range for 30min of charging (miles)	DC Input	Voltage (V)
SETEC Power	50	75	Solar / PV	<400

DC PROTECTION

Several manufacturers can provide DC breakers for example in the US and Chinese markets.

Cost to decrease as demand increases.



Equipment not found yet for the French market

Printers

Video projectors

Heat pumps

Electrical water tank heater

HOW TO MOVE FORWARD ?

Difficulties and challenges in building DC



Standard

Lack of design standards, testing standards, acceptance criteria.



Product

Product have not yet been marketed and serialized.



Coordination

Different industries have different views, Lack of coordination.



Understanding

Public awareness of safety and stability, Professional ability improvement.

Thank You
