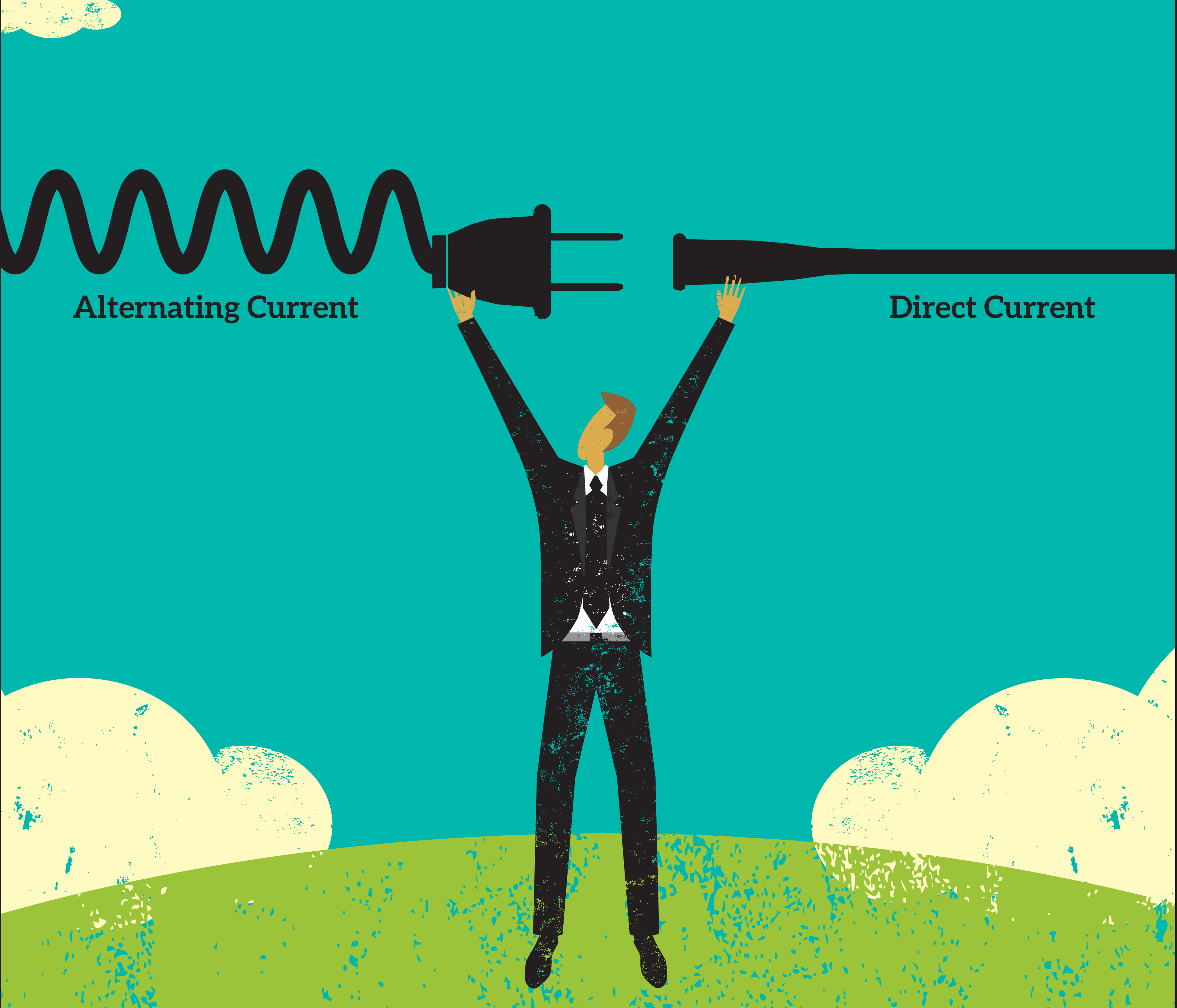
NATIONAL ASSOCIATION OF ELECTRICAL DISTRIBUTORS
NAED



Opportunities in DC Power

Prepared by Aqila Teen, NAED Researcher

ELEMENTS OF POWER

Quoted from American Society of Civil Engineers 2011

Electricity relies on an interconnected system that is composed of three distinct elements:

- Generation facilities—including approximately 5,800 major power plants and numerous other smaller generation facilities;
- High-voltage transmission lines—a network of over 450,000 miles that connects generation facilities with major population centers;
- Local distribution systems that bring electric power into homes and businesses via overhead lines or underground cables.

The first two elements are usually referred to as the bulk power system. The United States' system of generation, transmission and distribution facilities was built over the course of a century. Centralized electric generating plants with local distribution networks were started in the 1880s and the grid of interconnected transmission lines was started in the 1920s. Today, we have a complex patchwork system of regional and local power plants, power lines and transformers that have widely varying ages, conditions and capacities.

The aging of equipment explains some of the equipment failures that lead to intermittent failures in power quality and availability. The capacity of equipment explains why there are some bottlenecks in the grid that can also lead to brownouts and occasional blackouts. These concerns make it critical to understand what investments may be needed to keep the system in a state of good repair, and what implications any shortfall could have on the nation's economy.

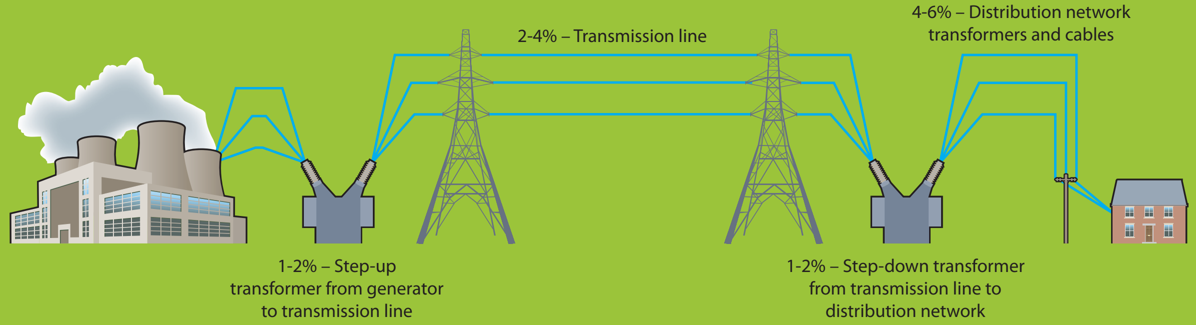
The needs to maintain and update existing electric energy infrastructure, to adopt new technologies and to meet the demands of a growing population and evolving economy over the next 30 years will impose significant requirements for new energy infrastructure investment. In the near term, there is close to adequate capacity to meet demand. From 2011 through 2020, national growth in generation is expected to be 8% and demand for electricity in all regions is expected to average 8-9% based on projections from the U.S. Energy Information Agency.

THE CHALLENGE

Quoted from Schonek 2013

Electricity has to be transmitted from large power plants to the consumers via extensive networks. The transmission over long distances creates power losses. The major part of the energy losses comes from Joule effect in transformers and power lines. The energy is lost as heat in the conductors. Considering the main parts of a typical transmission and distribution network, below are the average values of power losses at the different steps.

The overall losses between the power plant and consumers is in the range between 8 and 15%.



Most plug-in devices must internally convert AC back to DC (that's what's going on inside the brick of your laptop cord). That conversion wastes a lot of energy (think of all the heat coming from the brick of your laptop cord). Major studies are beginning to examine ways in which AC and DC power can work together with modern energy-harnessing technology, to run our overall grid more efficiently.
Quoted from Sandford 2012.

HOW CAN NEW TECHNOLOGIES HELP?

Quoted from U.S. Department of Energy 2014

The grid is currently undergoing a major evolution with new technologies enabling shorter power outages, clean energy and energy efficiency options and providing a platform innovative consumer services and products.

Microgrids

Microgrids help distribute power, but can also disconnect from the larger grid and function as an electrical island in case there's a disruption on the grid.

Energy Storage

Energy storage technology helps integrate renewable energy into our power grid by managing the electricity supply, storing excess energy and distributing it as needed.

Smart Meters

Smart meters enable two-way communication between consumers and utility companies. This allow utilities to immediately know when your power is out enabling faster restoration.

WHAT ARE MICROGRID BENEFITS?

Quoted from National Electrical Manufacturers Association (NEMA) 2014

Power Quality

Microgrids limit the impact of power-quality events such as dips or spikes in voltage which can negatively impact computers and other electrically sensitive equipment.

Savings for Customers

Microgrids can decrease dependence on and charges from public utilities. Some systems can even sell electricity back to the main grid.

Electrical Independence

Microgrids provide a continuous supply of electricity with or without the traditional power grid.

Close to Load

By producing electricity close to its load and thus eliminating energy lost in miles of transmission lines, microgrids improve efficiency by 6-10%.

Scalability

Microgrids can be built in phases, growing or shrinking based on the need.

Should microgrids transport AC or DC current?

THE CURRENT WARS

Quoted from Lantero 2014

The question of AC current verses DC current started in the late 1880s between Thomas Edison and Nikola Tesla. Each with its own pros and cons.

On November 16, 1896, Buffalo was lit up by the alternating current from Niagara Falls. By this time General Electric had decided to jump on the alternating current train, too. It would appear that alternating current had all but obliterated direct current, but in recent years direct current has seen a bit of a renaissance.

Today our electricity is still predominantly powered by alternating current, but computers, LEDs, solar cells and electric vehicles all run on DC power. And methods are now available for converting direct current to higher and lower voltages.

Since direct current is more stable, companies are finding ways of using high voltage direct current (HVDC) to transport electricity long distances with less electricity loss.

So it appears the War of the Currents may not be over yet. But instead of continuing in a heated AC vs. DC battle, it looks like the two currents will end up working parallel to each other in a sort of hybrid armistice.

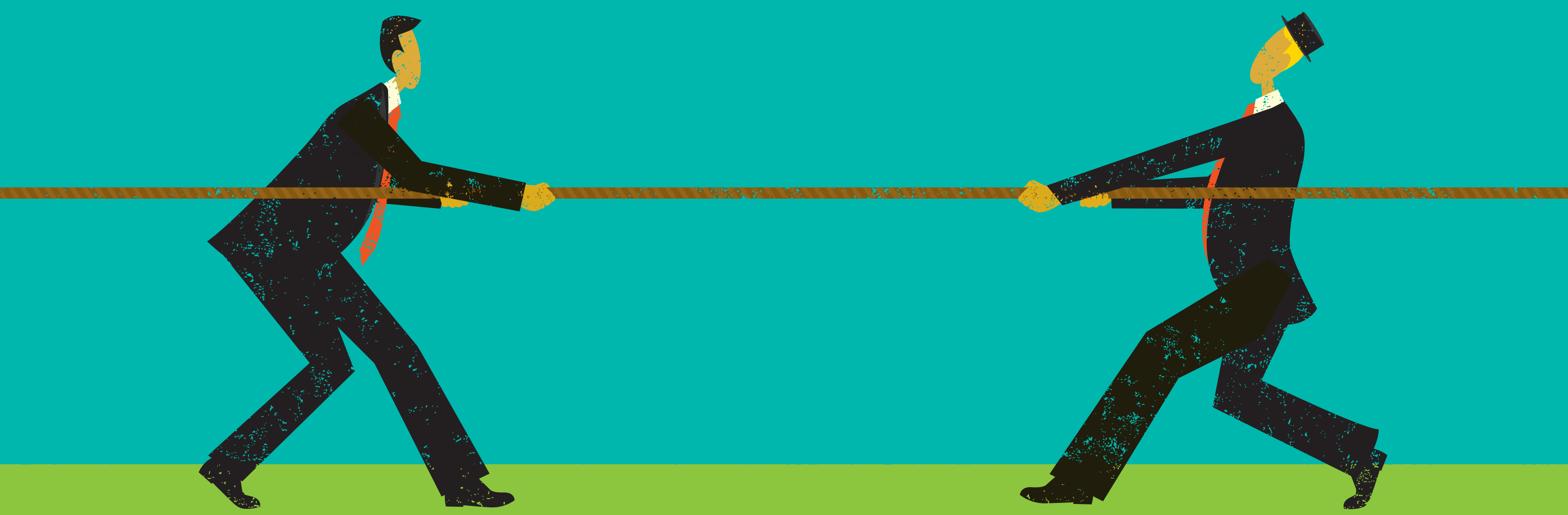
DC

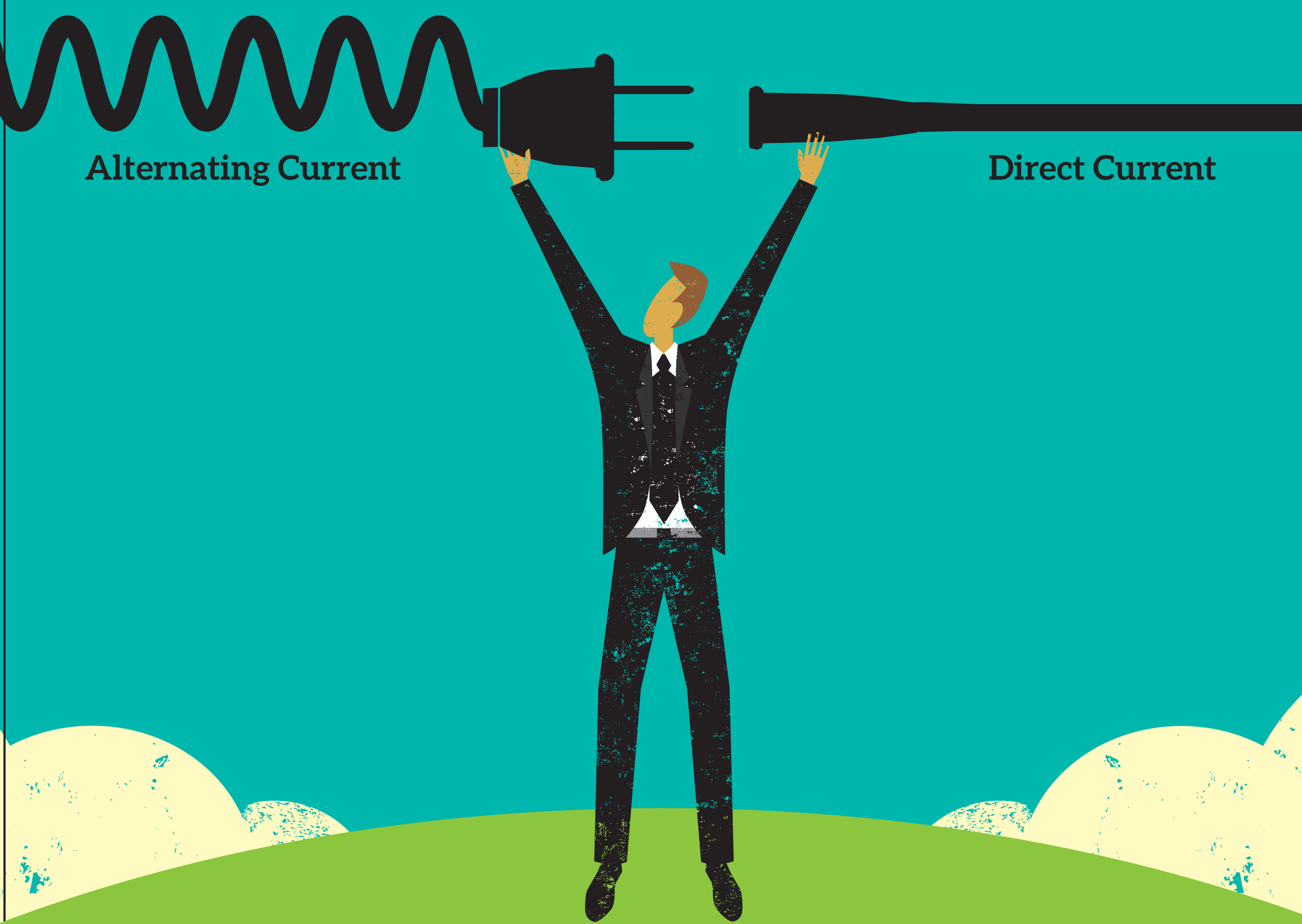
- Thomas Edison
- Historically challenging to transmit long distances
- Most devices need DC
- Sometimes requires batteries
- Many generating substations

VS

AC

- Nikola Tesla (Westinghouse)
- Easily transmitted long distances
- Does not require batteries
- Can be changed into DC easily when needed
- Few generating stations





WHY IS DC POWER MORE FEASIBLE NOW?

Quoted from Pham 2013

While AC was perfectly adequate for the conditions of much of the 19th & 20th centuries, the needs of the 21st century are showing its limits.

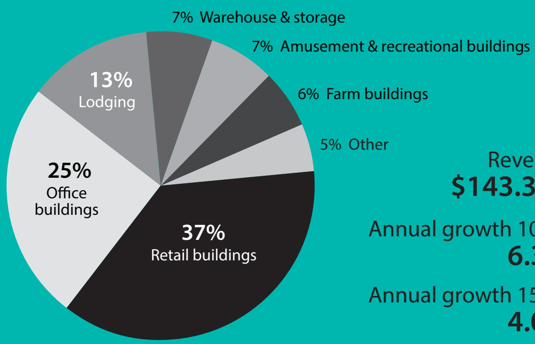
We are facing a revolution in the way our electricity is produced and used. More and more, electricity is being generated from renewable sources of energy in remote areas: hydropower plants (mountains far from urban centers), windfarms (people tend not to live in windy areas), offshore wind farms (have higher capacity factor, better alignment with peak demand), etc. DC is the only technology that allows power to be transmitted economically over very long distances, and DC is the type of power produced by photovoltaic panels.

On the consumer side, more and more equipment runs on DC: computers, cell phones, LED lights, CFLs, high efficiency motor drives which found in new HVAC systems, industrial, etc. ABB estimates the savings from using DC instead of AC in buildings could be in the order of 10 to 20 percent.

WHAT ARE CURRENT MARKET TRENDS?

Quoted from IBISWorld

Commercial Building Construction in the US

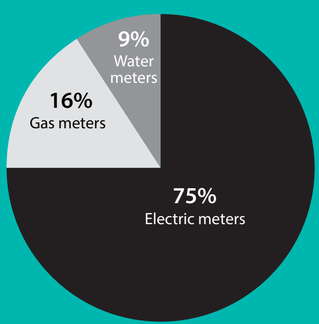


Revenue
$143.3bn

Annual growth 10-15
6.3%

Annual growth 15-20
4.0%

Smart Meter Manufacturing in the US

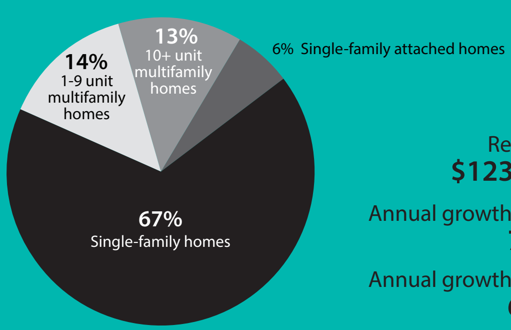


Revenue
$1.5bn

Annual growth 10-15
12.9%

Annual growth 15-20
16.8%

Housing Developers in the US

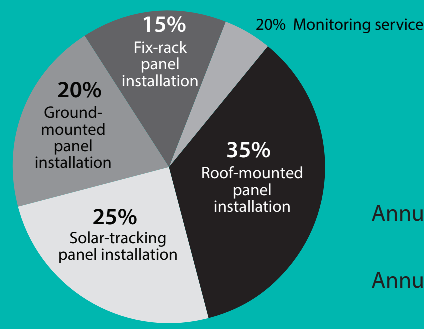


Revenue
$123.6bn

Annual growth 10-15
7.6%

Annual growth 15-20
6.5%

Solar Panel Installation in the US

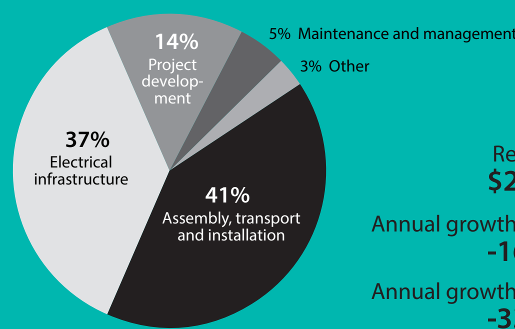


Revenue
$143.3bn

Annual growth 10-15
22.0%

Annual growth 15-20
9.1%

Wind Turbine Installation in the US



Revenue
$2.5bn

Annual growth 10-15
-16.4%

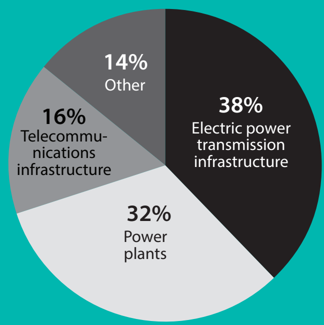
Annual growth 15-20
-33.9%

WHY IS DC POWER BECOMING MORE ATTRACTIVE?

Quoted from Reed 2015

- Higher concentration of residential, commercial and industrial DC loads
- Fewer conversions stages, reducing point load losses
- Inherently compatible with renewable energy sources
- Enhanced energy storage and EV (electric vehicle) integration
- Better performance with modern electronics technologies and devices (evolving consumer loads)

Transmission Line Construction in the US

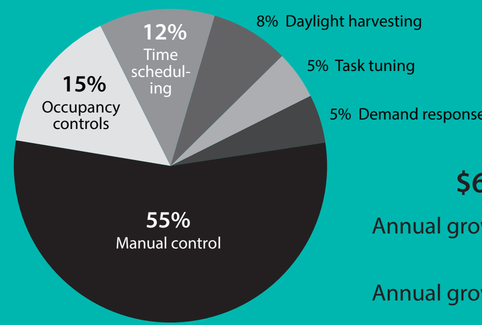


Revenue
$47.0bn

Annual growth 10-15
2.6%

Annual growth 15-20
4.4%

Lighting Control System Manufacturing in the US



Revenue
$638.6bn

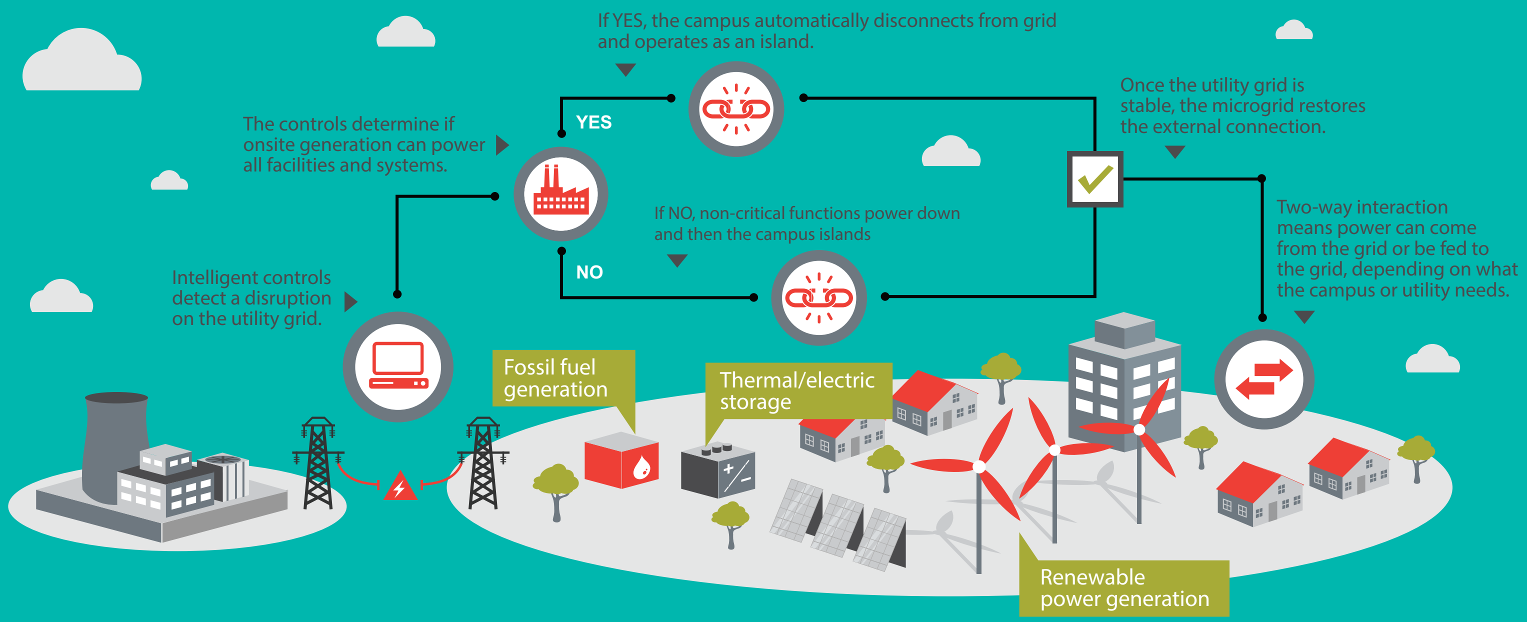
Annual growth 10-15
2.3%

Annual growth 15-20
4.7%

HOW DOES IT WORK?

Quoted from Honeywell

"Far more than "smart meter," a fully-functioning Smart Grid will feature sensors throughout the transmission and distribution grid to collect data, real-time two-way communications to move that data and electricity between utilities and consumers, and the computing power necessary to make that intelligence actionable and transactive." (U.S. Department of Energy 2009)



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