Alternating Direct Current (ADC)-
A New Form of Efficient Energy Transmission

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Outline

- Outline
- Introduction
- Background
- ADC architectural concept
- Benefits and advantages
- Results and discussions
- Ongoing efforts
- Summary and conclusions
- Acknowledgements
- References

Introduction

- The prevailing means of electricity transmission through Direct Current (DC) and Alternating Current (AC) have limitations with the ongoing transition to renewable energy sources.
- In this paper, we discuss a new form of energy transmission, known as alternating direct current (ADC) that would provide significant savings in energy consumption and simultaneously allow efficient utilization of generated energy from renewable sources.
- This has become possible due to substantial advances in electronics and optoelectronics technologies since the days of Nicholas Tesla and Thomas Edison.
- Recent efforts of implementing the proposed ADC technology in relevant environments have demonstrated significant energy savings and opened a new paradigm that has the potential to provide an efficient and cost-effective pathway for transition to renewable energy sources even with the existing grid infrastructure.
- **The proposed solution aligns with two specific EO mandates:**
  - **EO 14057, Sec. 102(iii) "a net-zero emissions building portfolio by 2045, including a 50 percent emissions reduction by 2032;" and**
  - **EO 14057, Sec. 102(vi) "climate resilient infrastructure and operations."**

Background: Shortcomings of vintage AC vs DC

- AC is the global standard for energy transmission methodology because of events that took place over 135 years ago involving Thomas Edison, Nikola Tesla, and George Westinghouse. In general, the vintage platform is central, coal/gas/oil generation, high voltage grid distribution, with step down and rectification into buildings and houses, and further conversion at the final load.
- Approximately 50 years ago, the introduction of semiconductors in computers, telecommunications, internet, and consumer electronics pivoted to ever increasing DC voltage consumption at the end load, and accelerated demand for DC solutions for electric vehicle (EV) charging, battery storage, and DC generation from solar panels and hydrogen cells.
- **CHALLENGE:** Presently, our world is committed to becoming fully "electrified." A permanent pivot to renewable energy has already occurred, and with this pivot, DC is the new energy paradigm. Solar panels generate in DC, batteries are DC devices, hydrogen fuel cells generate in DC, all microchip-based loads are DC voltage (telecommunications, data centers, computers, internet, cell phones, consumer electronics).
- Because our vintage platform is AC, multiple points of wasteful conversion, inversion, rectification is mandatory in the vintage AC "or" DC platform. Daily use of AC adapters to charge DC voltage electronics, phones, electric vehicles (EV). Likewise solar panels and batteries require energy conversion from DC to AC (panel to battery), AC to DC (charge the battery), DC to AC (battery to load), and a final conversion AC to DC at the load, e.g., laptop, phone, data center server.
- Distributed energy resources, e.g., solar farms, wind farms, batteries, hydrogen fuel cells, present new challenges in the advancement of and critical need for DC systems-based solutions and alternatives to the vintage platform e.g., intermittency, harmonics, and grid instability.

Renewable Energy Conversion Issues

As the capacity of PV generation in power distribution systems grows, utility companies become increasingly concerned that **the noise and harmonics from the PV inverter systems will** adversely impact the power quality or affect the operation of other equipment and **cause it to malfunction or otherwise disrupt the stable operation of the power distribution system**

GENERATED IN DC POWER:

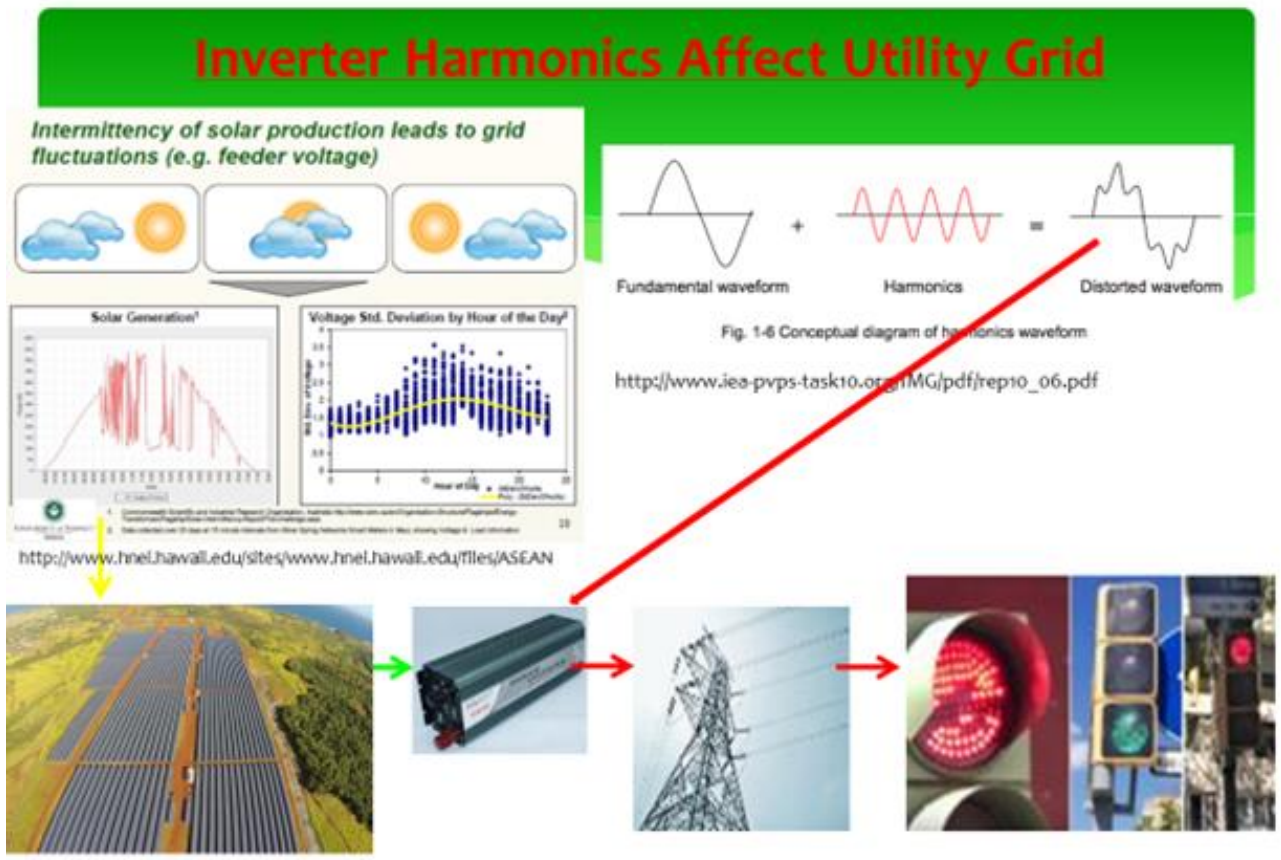
INVERTER WASTE
- Conversion loss/heat
- Harmonics, Non Linear

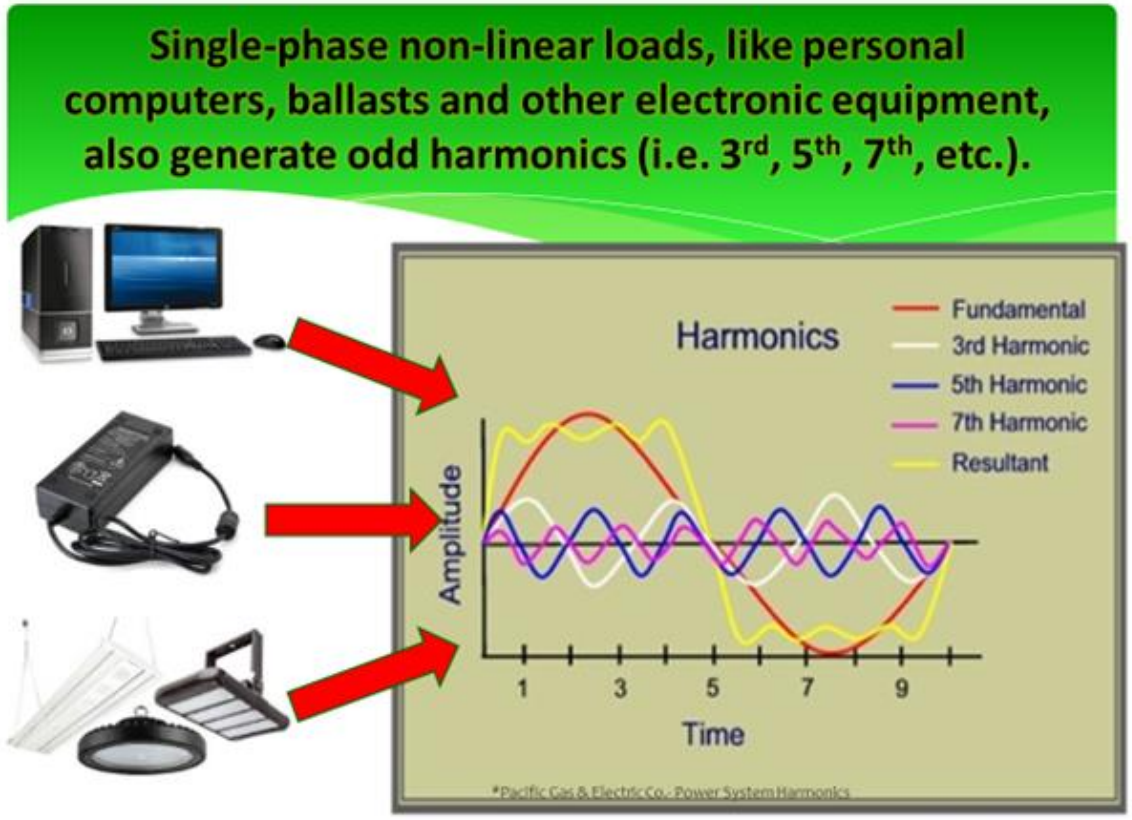
INEFFICIENT:
- ~22% solar (avg. on the market) [cleantechnica.com/2014/02/02/which-solar-panels-most-efficient/...citing NREL]
- ~1% wind

UNRELIABLE
- Night, clouds, rain…

ENVIRONMENT IMPACT
- Massive infrastructure

Conversion Issues (Contd...)





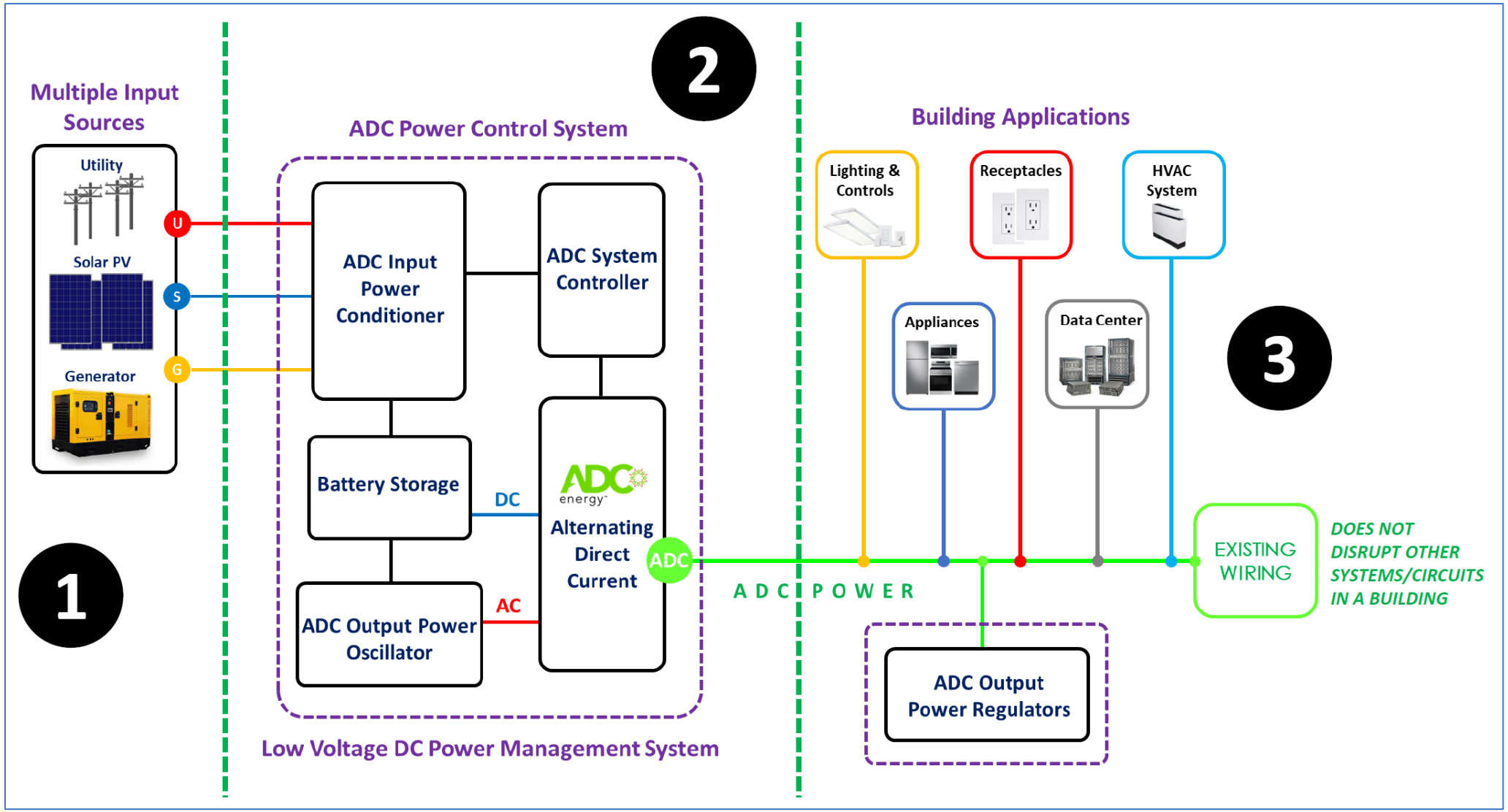
Key Aspects of ADC Transmission

- Simultaneous transmission of Alternating Current and Direct Current on existing wire infrastructure—a new form of energy transmission
- Long-distance transmission of clean DC power without line loss. The "clean DC power" is defined as DC power without non-linear loads from inversion/conversion.
- ADC transmission offers safety, efficiency, and resiliency in various segments of power utilization
- ADC Energy integrates in a safe manner with existing infrastructure and is amenable to energy scaling
- Potentially, a global solution to eliminate non-linear loads.

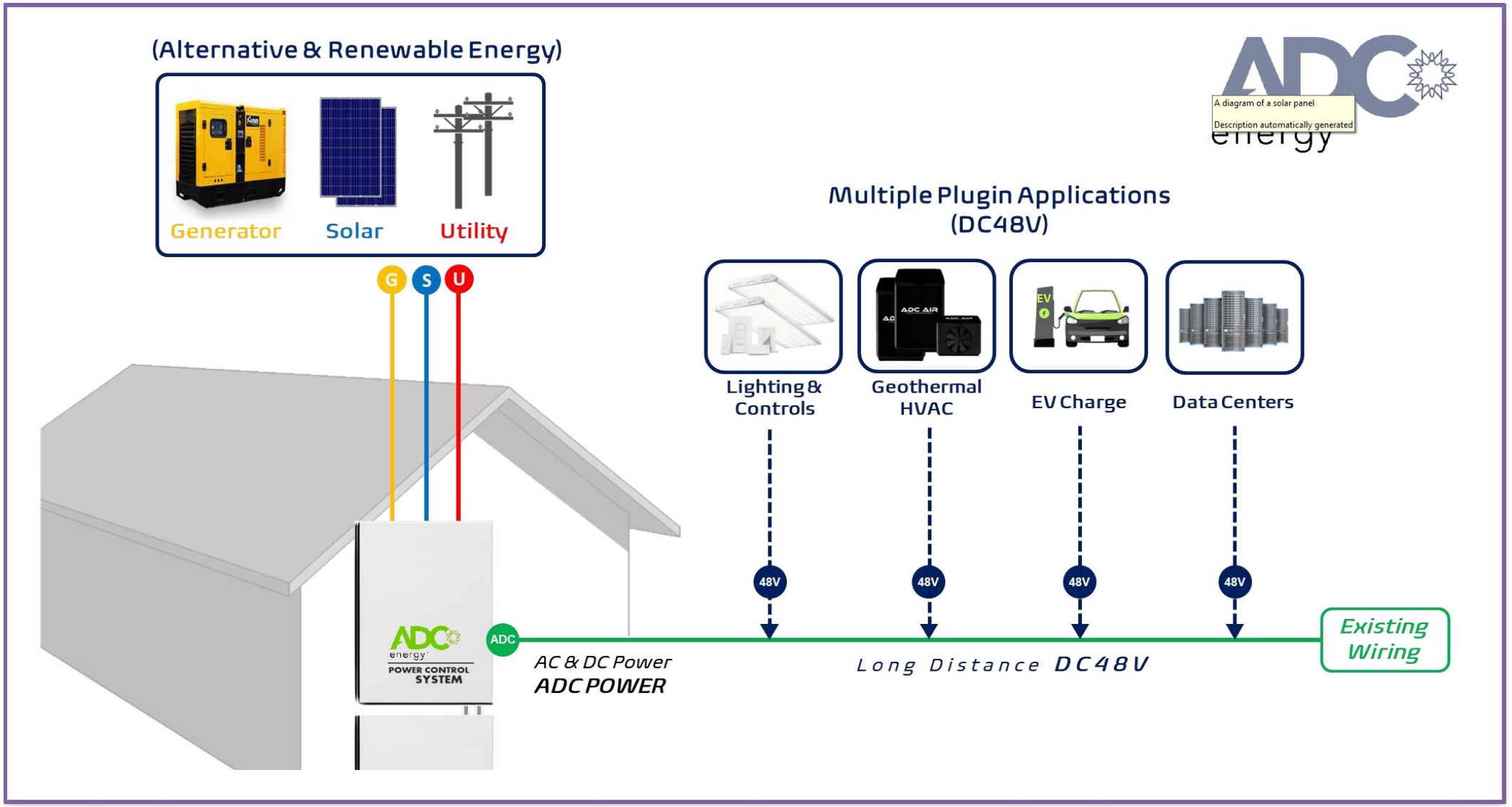
ADC Concept

- ADC transmission methodology is a proprietary and patented “ecosystem” of electrical and electronics engineering combined with artificial intelligence to create the two proprietary functionalities.
- The key to ADC transmission is that it attaches to and operates on existing AC infrastructure to upgrade, without disrupting, existing AC power performance. Both AC and DC power co-exist via “piggybacking” DC power flow onto existing AC power transmission lines.
- AC power no longer acts as a power source, but now is a “carrier” to piggyback DC to DC power loads, such as LEDs, electronics, sensors, controls, and other DC power loads. Additional functions include autoregulation of both AC and DC voltages, allowing seamless access to either voltage by the load, e.g., AC power loads access AC voltages, while DC power loads access DC power loads only.
- Further DC voltages are likewise auto-regulated, e.g., loads from 5V to 24V self-regulate via ADC Energy.

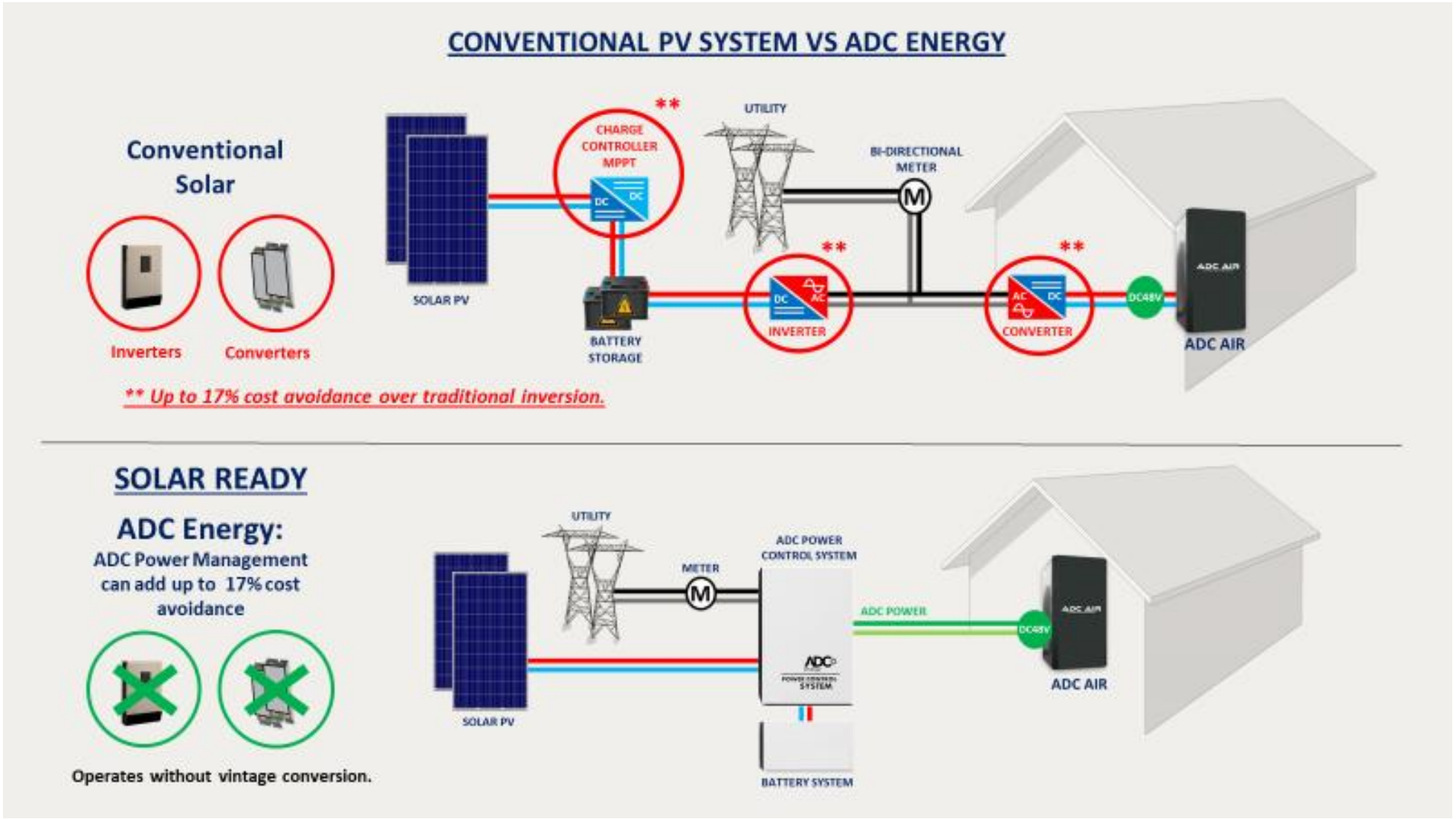
ADC Transmission Architecture



ADC Scheme for Installation



Comparison Between Conventional PV and ADC solution



Advantages of ADC transmission

- The proposed ADC energy transmission is a systems-based solution for renewable energy.
- ADC's hybrid format allows integration of DC voltages at generation (PV, Batteries) and at load (electronics, computers, lighting) without vintage conversion problems (harmonics, heat, waste, etc.), but at the same time, the key advantage is ADC operates on existing AC grid infrastructure.
- The DC bus operating on existing AC wires is the innovation that offers a solution that currently does not exist in vintage systems which are wholly based on energy conversion back and forth from AC-DC.
- The ADC technology enables the "transition" from vintage energy infrastructure to a renewable/electrification structure. EVs are a perfect example. DC motor, DC battery, but charging is energy converted from AC because generation and transmission are AC.
- With ADC, charging can be DC (solar panels) directly into the battery (DC). Eliminating vintage conversion reduces heat and avoids waste and unwanted harmonics.
- Systemically, we have vintage AC-based generation and transmission methodologies which are conflicting with renewable generation and batteries that are DC.
- Systemic use of inverters/rectifiers/converters is the only known solution used in this transition to electrification. ADC technology offers a systems-based solution to the conflict of technologies by eliminating the need for energy conversion.

ADC Energy Transmission Scheme

- Applications of ADC transmission at the facilities level create an onsite low-voltage DC-powered microgrid on existing wire infrastructure.
- Generation or source of energy can be either or both existing AC power input from the utility, and/or solar panels, as well as other combinations of generation, e.g., wind, generators.
- From generation, the AC energy electrical panel receives the energy feed to store and charge its internal batteries.
- From the ADC panel, the low voltage microgrid is now operational on existing wires to specifically feed DC loads, e.g., LEDs, sensors, switches, security, communications, and networks.
- Creating a DC to DC (DC generation, clean DC transmission to DC power load) microgrid is multifunctional, with ease of installation, and can operate in commercial, office, and residential facilities whether such facilities have solar panels already installed or not.
- Further, ADC transmission technology has an automated voltage regulator that allows installation in different geographic voltage standards, e.g., Asia, America, and Europe.

Advantages of ADC transmission

- What about amperage? Unique to the ADC transmission technology is that its low voltage operations do not mandate an increase in amperage.
- Due to its functionality of hybrid transmission of a DC bus operating on existing wiring, the DC functions in ADC are hybrid in nature.
- In other words, low voltage DC in the ADC system can travel longer distances like AC, but anywhere along the ADC circuit, low voltage DC can be directly tapped without amperage increase.
- Thus, the proposed ADC technology eliminates waste, heat, and rectification risks, and increases power efficiencies. The flexibility of ADC Energy installation allows facility-level installation to occur at larger quantities/scales of facility locations.

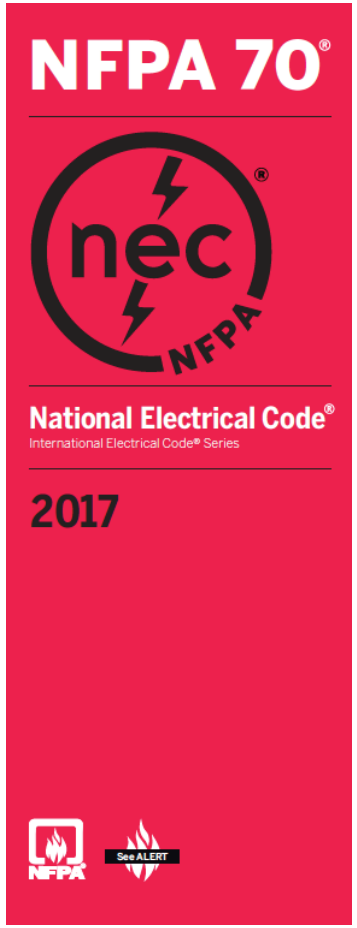
ADC Advantages

ADVANTAGES:

- Easily attaches and operates on existing wires
- Generation agnostic: Multiple inputs, AC/DC, solar, wind, utility, generator
- Battery agnostic
- Code compliant
  - (U.S., Europe, Asia)
- Patented
- Safety Certified: UL, CE, BSI, FCC, IEC, IEEE Compliant

CONDITIONS	AC Power [Coal, petroleum]	DC Power [Solar]	ADC Energy Hybrid [All generation forms]
Long Distance	✓		✓
Clean AC transmission	✓		✓
Clean DC transmission		✓	✓
Harmonics free			✓
Carbon free		✓	✓
Grid Stability			✓
Existing wiring	✓		✓
Safe battery storage		✓	✓
Safe Islanding			✓
Heat/Fires	✓	✓	
EASY to Install	N/A		✓
Back up power		✓	✓

NEC Code



ARTICLE 411
Low-Voltage Lighting

411.1 Scope. This article covers lighting systems and their associated components operating at no more than 30 volts ac or 60 volts dc. Where wet contact is likely to occur, the limits are 15 volts ac or 30 volts dc.

Informational Note: Refer to Article 680 for applications involving immersion.

411.3 Low-Voltage Lighting Systems. Low voltage lighting systems shall consist of an isolating power supply, low-voltage luminaires, and associated equipment that are all identified for the use. The output circuits of the power supply shall be rated for 25 amperes maximum under all load conditions.

411.4 Listing Required. Low-voltage lighting systems shall comply with 411.4(A) or 411.4(B).

(A) Listed System. The luminaires, power supply, and luminaire fittings (including the exposed bare conductors) of an exposed bare conductor lighting system shall be listed for the use as part of the same identified lighting system.

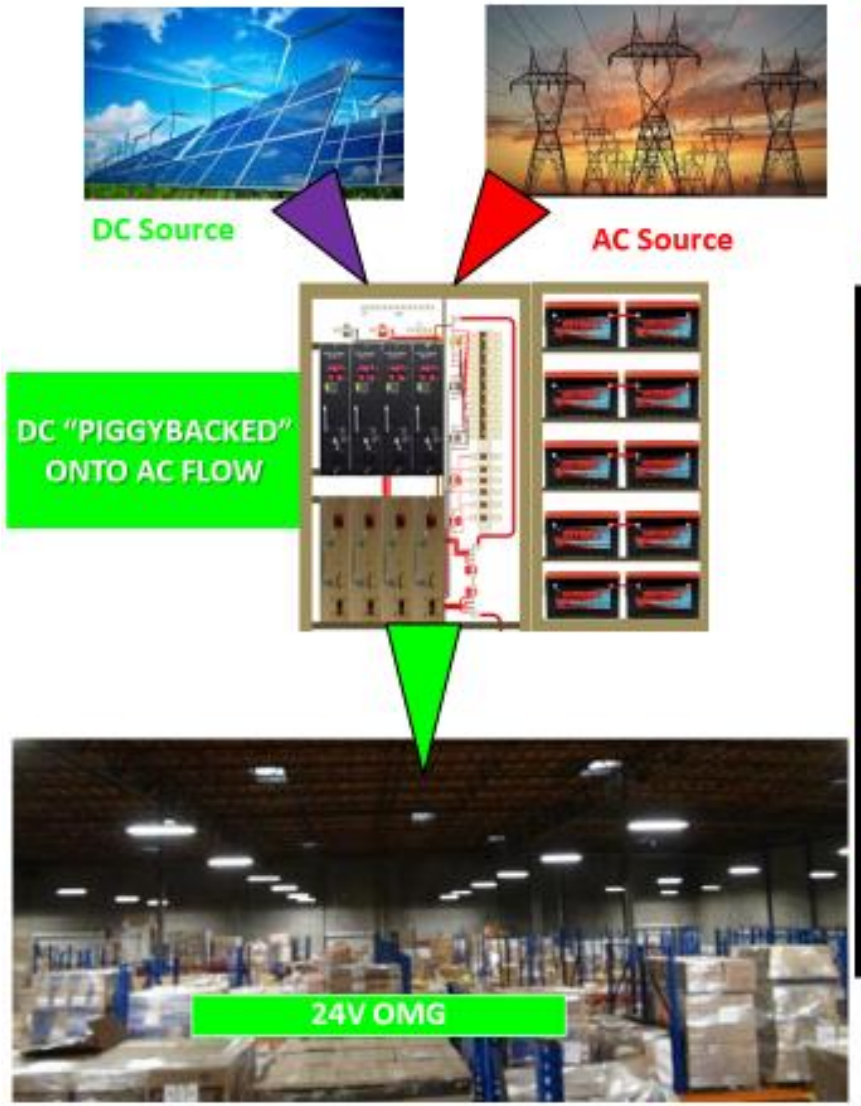
(B) Assembly of Listed Parts. A lighting system assembled from the following listed parts shall be permitted:

(1) Low-voltage luminaires
(2) Power supply
(3) Low-voltage luminaire fittings
(4) Suitably rated cord, cable, conductors in conduit, or other fixed Chapter 3 wiring method for the secondary circuit

Recent Implementation

- Recently, ADC transmission technology was installed in a commercial training facility, superimposing DC power on existing AC infrastructure to energize DC lighting and controls.
- This is a 10,000 sq. ft commercial training facility for engineers, electricians, and contractors to stay updated on codes, regulations, and new technologies.
- To effectively demonstrate the advantages of ADC transmission, thirty 2x4 fixtures from AC 277 V to DC 24V, direct DC to DC format without vintage conversion, heat, and line loss were installed.
- The superimposing of DC power on existing AC wiring was carried out, eliminating the need for new wiring and infrastructure cost on materials and labor. In this case, 8 car batteries to transmit clean DC power and as a UPS backup in the event of a blackout without any operation interruptions were incorporated.
- This effort allowed for energizing a total of 1.6 kW of lighting/control load, saving up to 17% of conversion lost at every fixture, utilizing existing infrastructure, and no disruptions to existing power systems or other circuits with ADC transmission. Eliminating the need for vintage power converters and inverters, delivering "clean" DC power from batteries to load. ADC Energy functionality was observed with low voltage (24 V) facilities lighting installed and operating on existing AC building wiring.
- Live demonstrations of electrical outlets flowing both AC power and DC power were also observed, observing seamless voltage regulation between AC equipment and DC equipment accessing each voltage from the same outlet. DC voltage was also regulated as the 5 V appliance was operational from 24 V flowing from the outlet.

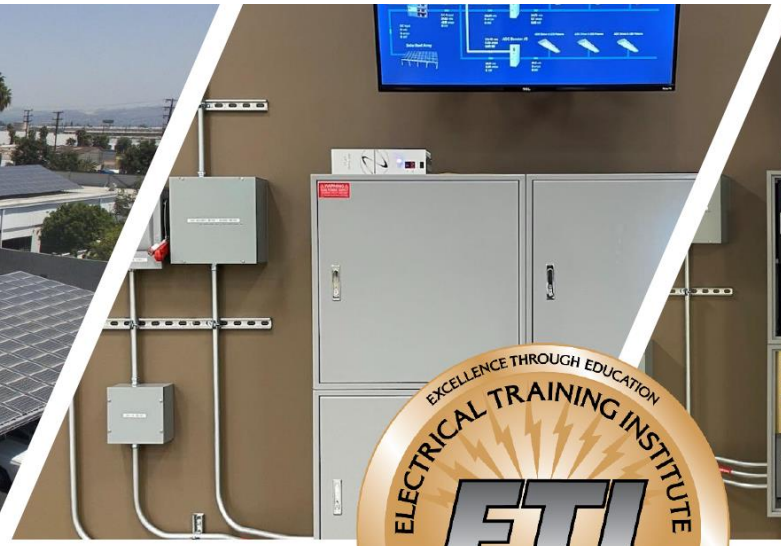
ADC Energy Transmission

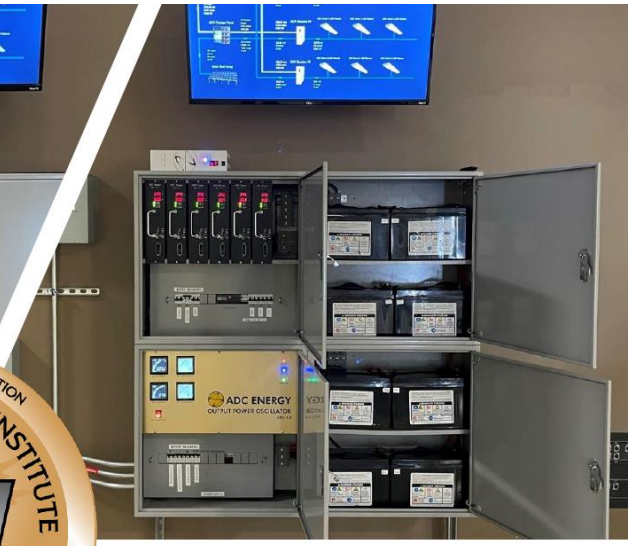


How ADC Energy Works

- ✓ ADC subpanel attaches to existing AC panel
- ✓ DC "piggybacked" onto AC
- ✓ ADC Boosters provide long distance DC transmission
- ✓ 24V "OMG" created
- ✓ Unprecedented DC power use and AC savings

ADC Based Smart Buildings





ADC Smart Buildings

ADC provides a renewable energy “power management” system which attaches next to the existing building/house power panel. ADC then powers the building starting with one or more circuit loads, then adding more load to become the “onsite power provider.”
Benefits: Easy installations, 17%-50% savings, solar/renewable, job creation.

In the USA, ADC has contracted with the largest association of electrical contractors (60,000 companies) and electrical workers union (750,000 members) to provide a turnkey solution for:

EMPLOYMENT OPPORTUNITIES, JOB TRAINING, WORKFORCE DEVELOPMENT

EXCELLENCE THROUGH EDUCATION
ELECTRICAL TRAINING INSTITUTE
ETI
OF SOUTHERN CALIFORNIA
SPONSORED BY IBEW & NECA

Operational Commercial Deployments

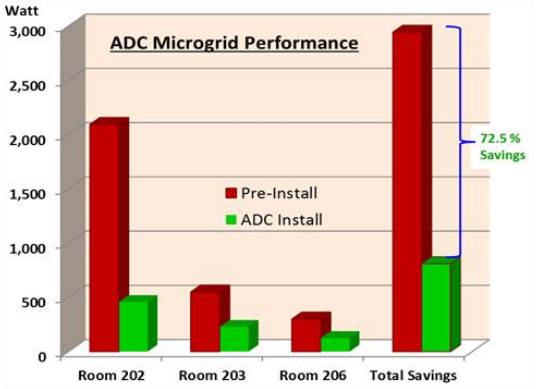
Commercial Warehouse Size: 100,000 Sq.ft. ADC Phase 1: Power/Lighting Status: Operational Since 2013 Performance: Estimated 25% Savings	**NASA Langley Research Center** ADC Phase 1: Power/Lighting Status: Operational Since 2018 Performance: Tech Validation; Estimated 90% Lighting Efficiency Gains; ISRU Pending	**ADC R&D Facility** Size: 20,000 Sq.ft. ADC Phase 2: Fully Off-grid Status: Operational Since 2018 Performance: Solar Island	**ADC Office (United Kingdom)** Size: 10,000 Sq.Ft. ADC Phase 1: Power/Lighting Status: 2017-2020, Moved Performance: Estimated 25% Savings
Office Size: 17,000 Sq.ft. ADC Phase 1: Power/Lighting Status: 2013-2016 Moved To New Facility Performance: Estimated 25% Savings	**Retail** Size: 10,000 Sq.ft. ADC Phase 1: Power/Lighting Status: Operational Since 2015 Performance: Estimated 25% Savings	**Office** Size: 10,000 Sq.ft. ADC Phase 1: Power/Lighting Status: 2016-2018, Moved Performance: Estimated 25% Savings	**Office** Size: 7,000 Sq.Ft. ADC Phase 1: Power/Lighting Status: Operational Since 2018 Performance: Estimated 50% Savings
Training/Classroom Site ADC Phase 1: Power/Lighting (Proof Of Concept DC To DC) Status: Operational Performance: Solar Off Grid Lighting Demonstrated (Projected 100% Savings)	**CLTC (UC Davis)** ADC Phase 1: Power/Lighting Status: Demonstration Completed Program Ended	**Church** Size: 5,000 Sq.ft. ADC Phase 1: Power/Lighting Status: 2017-2021, 4 Year Program Ended Performance: Estimated 90% Lighting Efficiency Gains	**Residential** Size: 2,500 Sq.Ft. ADC Phase 1: Power/Lighting Status: Operational Since 2019 Performance: Estimated 25% Savings
Parking Lot (So. Korea) ADC Phase 1: Power/Lighting Status: Operational Since 2013 Performance: Estimated 25% Savings	**Church (So. Korea)** Size: 10,000 Sq.ft. ADC Phase 1: Power/Lighting Status: Operational Since 2013 Performance: Estimated 25% Savings	**Underground Parking Lot (So. Korea)** ADC Phase 1: Power/Lighting Status: Operational Since 2017 Performance: Estimated 25% Savings	**College Lecture Hall** ADC Phase 1: Power/Lighting Status: Operational Since 2017 Performance: Estimated 90% Lighting Efficiency Gains

Recent Successful Demos

Occidental College Lighting Upgrade

- 72.5% efficiency increase upon installation
- Increased lumens, less watts
- Lighting color improved
- Eliminated faulty AC drivers
- Replaced burnt wires/bulbs
- 10 year 24/7 warranty

Data Comparison of wattage use per room (bulbs+ballasts) pre ADC and post ADC



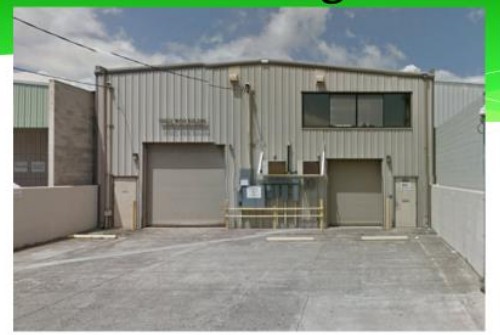
Commercial Facility

Cypress, CA – 17,000 Sq.Ft.

Before:
6 x 20 Amp breakers driving 6 x 277V lighting Circuits.

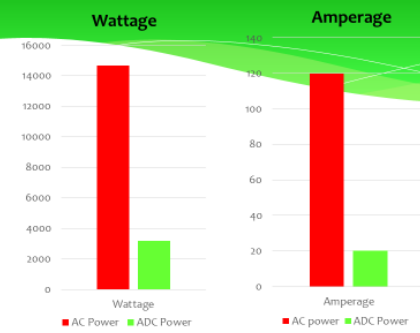
After ADC System:
1 x 20 Amp breaker
5 breakers off line.

Union Training Hall

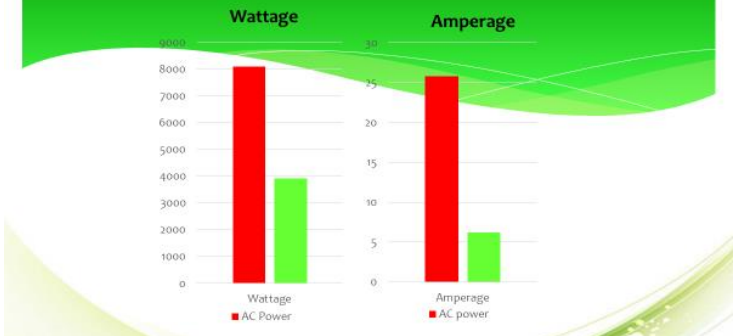


10,000 Sq. Ft. facility
9kW lighting system replaced with ADC 4kW system
56% Efficiency gains

Consumption Comparison



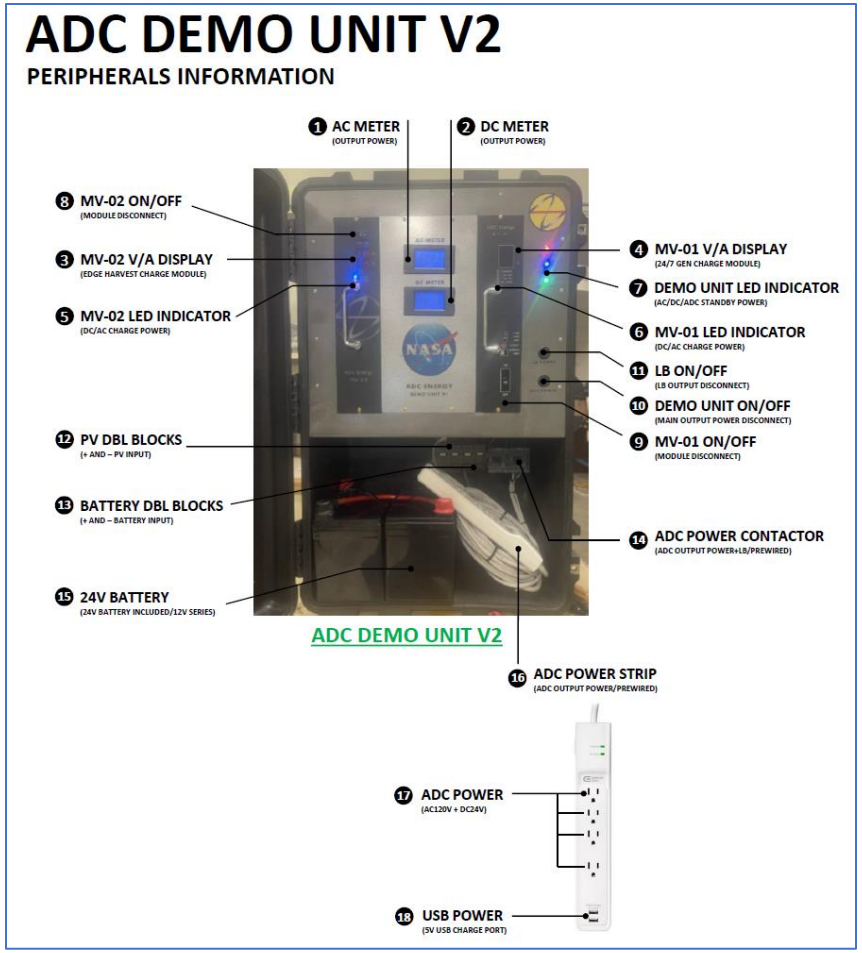
Consumption Comparison

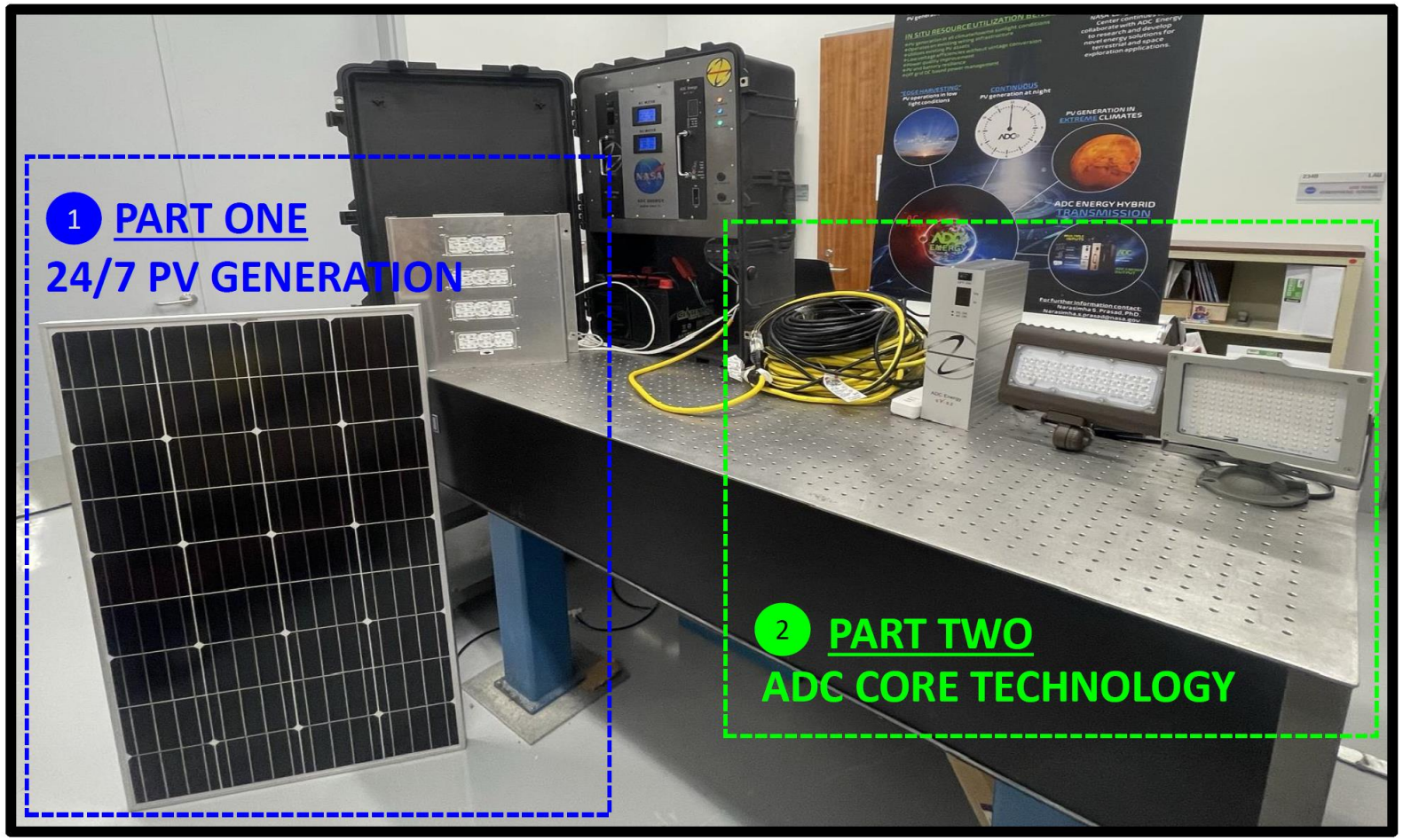


Test and Implementation at NASA laRC

- Over the course of several years of bench testing and observations, it was confirmed that the ADC scheme of Alternating current and Direct current on existing wire infrastructure is viable.
- The ADC DC bus superimposed on existing wires functionality does allow access to BOTH AC voltages and DC voltages on existing wires without vintage energy conversion devices.
- Also validated was the functionality of long-distance transmission of clean DC power without traditional line loss. The “clean DC power” is defined as DC voltages on existing wires without vintage conversion devices.
- From these validation tests, early conclusions indicate ADC transmissions offers safety, efficiency, and resiliency in various segments of power utilization.
- ADC integration in a safe manner with existing infrastructure was also tested.
- Future potential of higher voltage scaling and eliminating non-linear loads in existing system architectures are being explored.

Testing at NASA LaRC





The ADC transmission scheme is being explored for developing DC micro/nano grids for Lunar and Planetary Applications

Demo at NASA LaRC

Low Voltage Resilient Nano-Grid (DC bus on existing AC wires)

Trailer Structure: Internal and External Views

Top Left: The Trailer Structure
Top Center: The outside Electrical panel
Top Right: Inside View of the Electrical panel

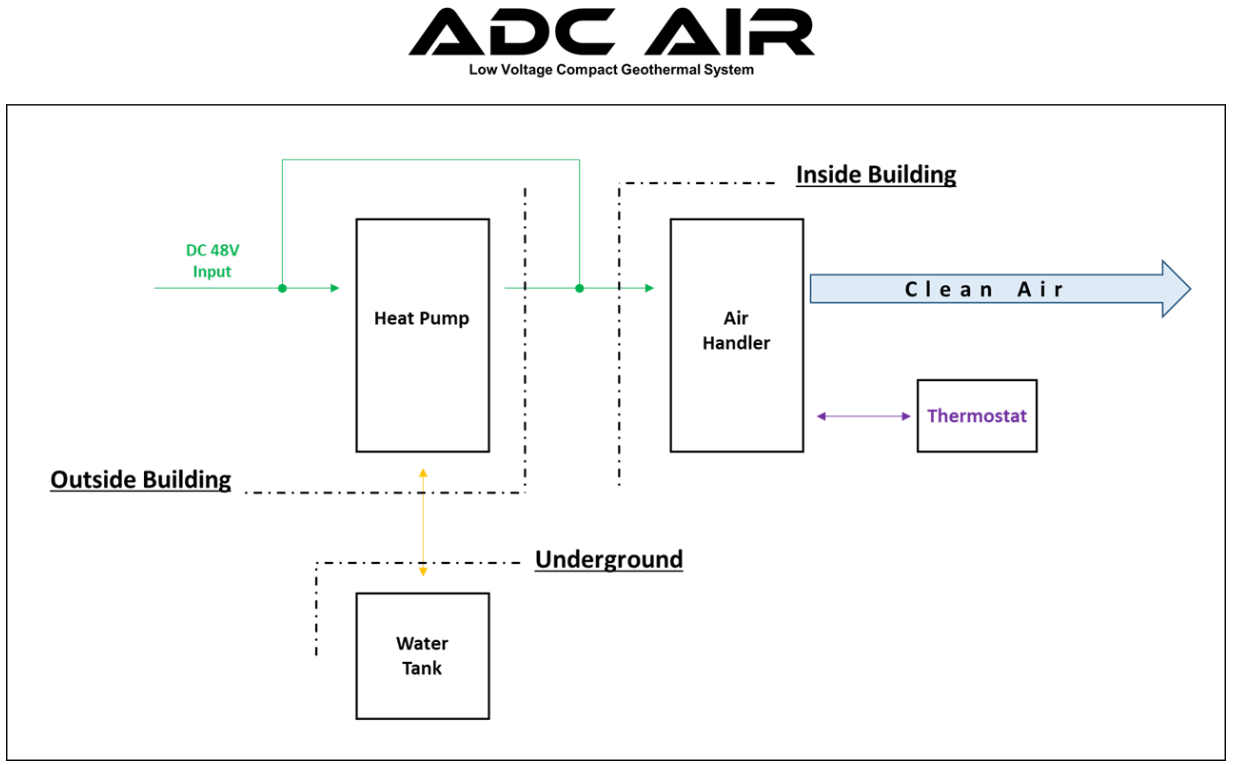
Bottom Left: Inside the Trailer Top
Bottom Right: Close up view of the panel

Low Voltage Resilient Nano-Grid
(DC bus on existing AC wires)

The work is ongoing with the objective to achieve Net Zero-Plus with incorporation of renewable energy sources.

ADC AIR
-Low Voltage Compact Geothermal system-

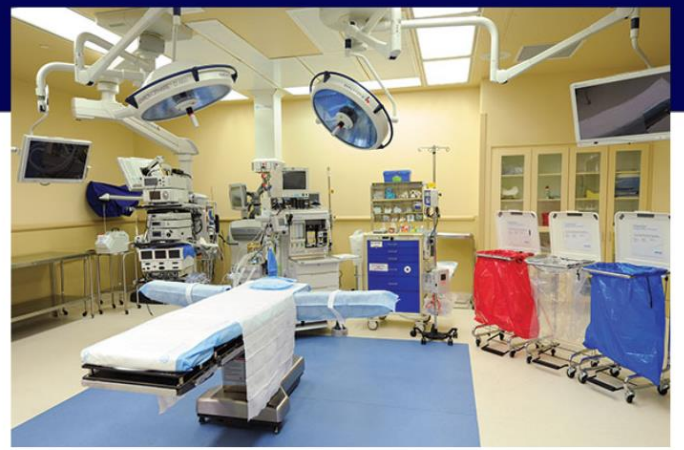
- The significance of low voltage applications is best appreciated by evaluating the loads which 48 VDC can energize.
- ADC Air is a solar-enabled, compact geothermal heat pump.
- Because of its low voltage in operations, the benefits include substantially lower, up to 75% less, kWh consumption.
- But performance-wise, the results are substantial. Offering heating plus cooling plus dehumidification, energy savings are coupled with indoor environmental controls and comfort.
- In addition, due to the innovative low voltage added benefit of humidity control, the environment is cleaner and can be healthier by avoiding molds, mildew, and fungus.
- The ADC Air low voltage application also recycles the water removed from the humidity in the air, which can be used as potable water or used in hydroponics for indoor agricultural applications.
- In the wake of global "electrification," plans are underway for commercially deploying a solution branded as "ADC Air."



Resilient Hospital Reference Model

Specific applications of ADC Air low voltage operations include providing multiple functionalities, including indoor air quality via low voltage based humidity control for containment and control within hospital surgery rooms. This multi functionality supports and supplements INCOSE's pathway in The Resilient Hospitals Handbook for immediate implementation in hospital industries.

In an operating room, two important conditions are controlling the cleanliness of the air and the humidity. Clean air in an OR requires removing airborne bacteria and pathogens that could be harmful to a patient. Without this, the patient is at greater risk of getting infections during surgery. Controlling humidity in an OR controls the growth of microorganisms. Relative humidity (RH) is an important component contributing to clean air. Since microorganisms tend to multiply in areas with a higher RH, a low RH then helps eliminate potential pathogens that would harm the patient. In addition to this, the longevity and integrity of sterile objects are also impacted by the RH of an OR. For these reasons, ORs in general use 3 to 6 times more energy per square foot compared to other areas in the hospital. By eliminating the need for energy conversion and traditional line loss with low-voltage DC transmission, ADC technology achieves these same tasks with less energy. This makes tasks quicker, more efficient, and cheaper with less energy waste.



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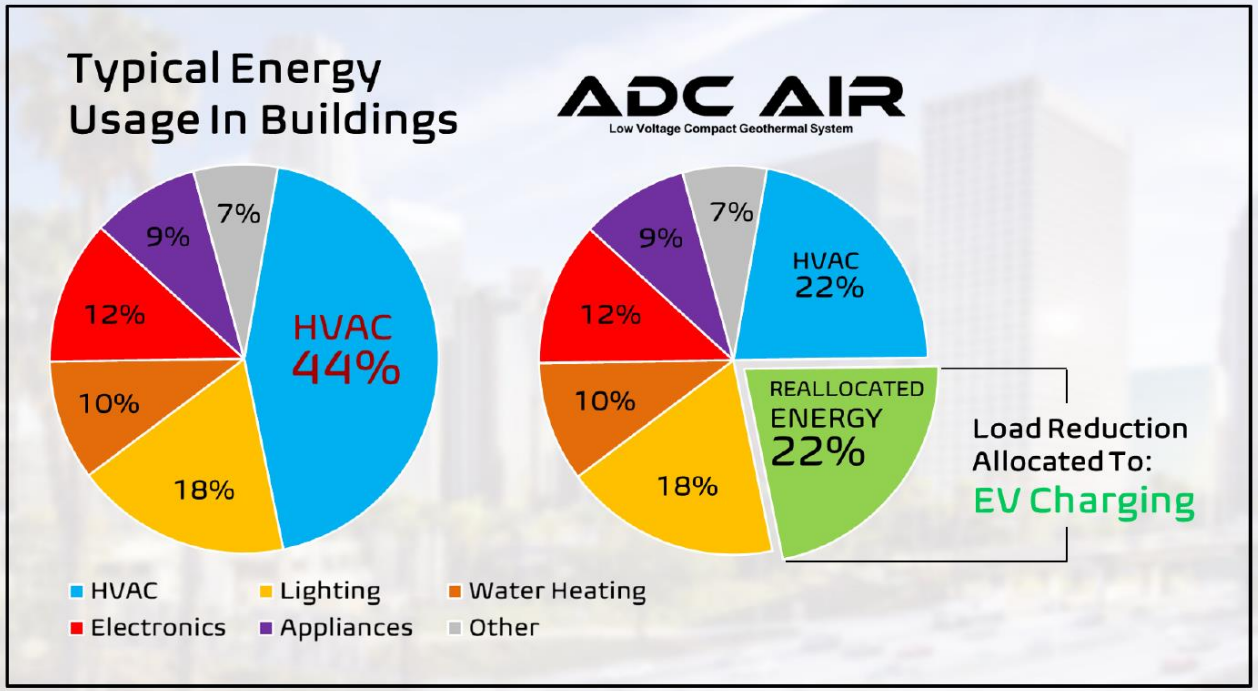
"Energy efficiency in the OR." Practice Greenhealth, Practice Greenhealth, https://practicegreenhealth.org/topics/greening-operating-room/energy-efficiency-or. Accessed 14 July 2023.

Benefits of ADC Air



ADC AIR HVAC OFFSET ANALYTICS

Energy generated in California in 2021:
277,764GWh

- 6% HVAC usage: 16,665GWh
- Average utility rate: $0.30/kWh
- Consumers paid: $5,000,000,000

WITH ADC AIR

- Utility capacity INCREASED
- Consumer's energy REDUCTION
- 8,332GWh allocated to EV Charging

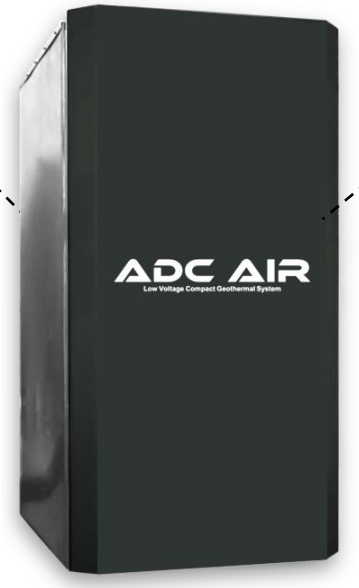
Sources:

https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation
https://www.energy.gov/energysaver/air-conditioning
https://www.energysage.com/local-data/electricity-cost/ca/

Low-Voltage Air Quality Management

Humidity Control

ADC Air not only controls the temperature, but also precisely controls the humidity levels simultaneously. This critical feature is the key for preventing and eliminating bacteria and viruses from developing and/or existing in the environment.



Eagle X Pro

ADC Air brings hospital grade, clean air directly into the indoor space with the Eagle X Pro component. This bipolar ionization produces the highest density of ions and emits virtually ZERO ozone pollution.

Installation Benefits

Real World Installation Data

Bryant Heat Pump, 14 SEER
Bryant 5-Stage Heat Pump, 18 SEER
Bryant Extreme System Heat Pump, 22 SEER

Vs

ADC AIR
Low Voltage Compact Geothermal System...*DC48V...*

System	Wattage	Run Time/Day	Monthly Cost (Utility Power $0.13/kWh)	Yearly Cost (Utility Power $0.13/kWh)
Bryant SEER 14	15,776 Watts	253,678 kWh	$989 *(Average)*	$11,868 *(Average)*
Bryant SEER 18	16,524 Watts	265,706 kWh	$1,036 *(Average)*	$12,432 *(Average)*
Bryant SEER 22	15,134 Watts	243,355 kWh	$949 *(Average)*	$11,388 *(Average)*
ADC AIR	5,000 Watts	80,400 kWh	$314 *(Average)*	$3,768 *(Average)*

Note:
1. Comparison of Systems Operating at 100% Capacity in a 95°F Day
2. Project Located in Robertsdale Al, 90,000 Sq.ft, Two Systems Installed

Carrier
...AC240V... Heating, Cooling and Dehumidification

Vs

ADC AIR
Low Voltage Compact Geothermal System...*DC48V...*

System	Wattage	Run Time/Day	Monthly Cost (Utility Power $0.23/kWh)	Yearly Cost (Utility Power $0.23/kWh)
Carrier HVAC	28,000 Watts	504,000 kWh	$3,478 *(Average)*	$41,736 *(Average)*
ADC AIR	8,800 Watts	158,400 kWh	$1,093 *(Average)*	$13,116 *(Average)*

Note:
1. Project Located in Brewton AL, 10,000 Sq.ft, Four Systems Installed

Amenable to Energy Scaling

- The ADC technology provides an opportunity to scale power capacity upward into utility level applications.
- Grid stability and grid security considering the massive deployment of distributed energy resources (DER) throughout the United States as well as globally have already reached critical mass, mandating preservation as well as upgrade of existing AC utility infrastructure.
- The unique advantage of utility-scale ADC technology is to allow the continued function of AC utility equipment and lines in a traditional fashion without disruption and without non-linear loads.
- At the same time, ADC Energy allows for simultaneous transmission of DC power generation from DERs, again without non-linear loads.
- This solution is a global one and with ADC Energy's auto voltage regulating technology, its utility-scale application can likewise be installed in variable utility conditions and geographic locations globally.

Summary and Conclusions

- A new form of energy transmission combining AC and DC architecture is presented
- ADC transmission is a viable solution to the global energy crisis.
- ADC transmission methodology attempts to provide grid stability and grid security solutions which currently do not exist in the two-transmission paradigm.
- By adding the ADC transmission critical failures of existing transmission technology could be resolved.
- This paradigm shift in transmission via ADC energy provides solutions and options that likely cannot be obtained in the converter/ adapter/inverter foundation that is our current, only option.
- Smart inverters may not be a long-term solution.
- ADC grid concepts are being explored for designing low voltage resilient nano-grids for lunar and planetary explorations

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