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ADC ENERGY HYBRID DC TRANSMISSION WITHOUT VINTAGE CONVERSION 23 ERD 01 EPIC

Additional submitted attachment is included below.

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Project Title: Electric Program Investment Charge

Submitting Party: ADC Energy USA, Inc.

1. What DC components and equipment are needed to enable more efficient integration of DC devices with other DC devices? What is the current technology readiness level (TRL) of these devices? What specific research is needed to advance the TRL (e.g., design work, laboratory testing, pilot and/or commercial demonstration)?
    a. The transition to electrification can easily and immediately start within the envelope of building, residential and other end/edge uses including DC to DC EV charging stations. Substantial edge loads are already operational at DC voltages, e.g., LED lighting, controls, electronics, data centers, electric water heaters, DC appliances, EV charging, VFD HVAC. The current platform supplies only AC voltages into the building, which after multiple redundancies, are finally converted to DC at the end/edge load (inverters, adapters, rectifiers, step down, etc.). On a 24/7 habitual basis, tens of millions of consumers in CA use/charge a cell phone, laptop, EV, TV, to engage in the end conversion of their building AC voltages to DC.

       The solution to "enable more efficient integration of DC devices with other DC devices" within the 3-5 year term starts within the building envelope and provides multi-voltage input and multi-voltage output that can retrofit and operate on existing infrastructure/wiring.

       ADC Energy solution: hybrid power management which superimposes a DC bus on AC wires to provide multi voltage input with hybrid multi voltage output flexibility to eliminate the need for vintage energy conversion.

    b. **ADC Energy building level is at TRL – 9.** ADC Energy power electronics systems have already launched in several pilot programs and are operational. We are currently upgrading our systems to reduce size, weight, and appearance form factors. "ADC AIR" combines our low voltage power electronics with a 48vDC geothermal assisted heat pump. This combination of DC based efficiencies substantially reduces (estimated up to 50%, or more if PV/battery based input) the largest load in every building: heating, ventilation and air conditioning (HVAC).

By reducing the HVAC load, ADC AIR releases existing capacity, which can be redirected to other loads, e.g. EV charging.

c. Additional research on our TRL – 9 systems is to secure final safety certification of our upgraded 2.0 designs, pilot at several locations within the State, implement workforce development and training, then mass deploy ADC power management and/or the ADC AIR combined HVAC solution. Mass deployment is the solution to release existing capacity back to the utility/consumer to then redirect to EV charging. This first milestone can be achieved within 3-6 months. Mass deployment can occur with the assistance and support of stakeholder utilities within 3 years.

   ADC hybrid, multi voltage Transmission and Distribution TRL - 5: On a 5+ year time scale, additional research to increase ADC Energy operational voltages from the building level into distribution, substation, transmission levels will require cooperative efforts between stakeholders including the State, ISOs, CPUC, CEC, utility sectors. Initial design requires input from power engineers and pilot test sites provided by the utilities. Test and pilot sites would provide ADC electrification solutions to disadvantaged, remote, rural, native, disadvantaged communities. The end goal is an ADC hybrid grid, i.e.: DC bus superimposed on existing, operating transmission and distribution infrastructure.

2. What are the TRL, cost effectiveness, efficiency, and availability of the following technologies?
   a. DC-DC converters that provide high voltage and high current to enable high power transfer or bi-directional transfer between various DC equipment.
      1. ADC is at TRL 5 on higher voltages. Additional research and pilot programs are needed for additional data on cost effectiveness, efficiencies, and availability.

b. Solid-state transformers for integration of renewables, electric vehicles (EV), and energy storage.

    1. At the building level, ADC is at TRL 9. "Cost effectiveness" will vary on the load being replaced by ADC, e.g., "ADC AIR" has a higher retail price than a traditional 5ton Home Depot HVAC unit; however, the monthly savings from ADC AIR performance can completely offset the initial capex, and via financing/leasing on a monthly basis can be mass deployed on an "energy as a service" basis for immediate and affordable deployment. The efficiencies achieved to date reflect up to 50% energy savings compared with traditional AC voltage HVAC.

c. DC revenue-grade meters to measure, collect, and store real-time data for DC power systems.

    1. N/A.

d. DC power systems for buildings that can be directly coupled with distributed energy resources (DERs) to reduce energy losses with fewer redundant stages of power conversions.

    1. ADC Energy is at TRL – 9. ADC Energy power management creates a DC to DC solution [PV panel (DC) >> battery (DC) >> load (DC)] to replace vintage inverter based operations. ADC operates on existing wires for easy retrofits. Multi voltage inputs directly couple with existing solar/battery installations, also operates with utility sources, but can be retrofit into buildings that can later upgrade to add solar/battery input.

       Unrelated third party research indicates that each stage of redundant power conversion results in up to 17% loss of energy. Further, it is undisputed that power factor suffers tremendous loss from power conversion, resulting in further efficiency loss.

       ADC AIR is at TRL – 9 and also provides substantial savings solution to transition to electric heat pumps, all operating on DC to DC without vintage redundant power conversions.

       ADC AIR is already approved for "energy as a savings" financing plan to provide cost effective mass deployment.

e. DC-based end-use equipment (e.g., refrigeration, cooktops, lighting, motor-driven loads) that can be integrated into an efficient DC-based power system.

    1. ADC Energy is at TRL – 9 and can provide full building level DC based power management. Lighting and controls are already operational. ADC AIR provides a low voltage DC replacement for vintage HVAC. ADC can be sized to power existing DC based end use equipment and/or be sized to be ready for future electrification needs. At the same time, although not an ideal use of ADC functionality, ADC provides AC voltages to the end load.

       AIR is at TRL – 9 to provide substantial savings solution to transition to electric heat pumps, all operating on DC to DC without vintage redundant power conversions.

       ADC AIR is already approved for "energy as a savings" financing plan to provide cost effective mass deployment.

DC Adoption Pathways and Use Cases

3. What are the most likely commercial applications for DC-based power systems in the short (3-5 years) and long terms (5+ years)?

    1. GENERATION/INPUT: Solar panels and batteries, both of which are DC voltage platforms.

    2. EDGE/LOAD: Lighting, controls, electric heat pumps, electric water heaters, plug load, data centers, and most importantly EV charging. Quick comment: EV auto industry adoption of a direct DC to DC charging platform is a simple elimination of the the internal rectification within the vehicle so the battery receives a direct DC charge from a DC source, rather than multiple, redundant conversions, e.g.:

       PV (DC) >> battery (DC) >> charging station (DC) >> car battery (DC)

       See Figure 1: ADC provides DC voltage directly to DC load on existing wiring without vintage conversion. DC voltage originates from ADC building power control panel which includes batteries; DC bus superimposed on existing building wiring; DC voltage from ADC power panel/batteries distributed directly to the outlet; existing three prong plug automatically accesses DC voltage; DC voltage direct to DC load (laptop) without AC adapter (battery removed to show DC is sourced from the plug):

4. What are the recommended ideal locations (e.g., where on the distribution grid, geographically, or at particular facility types like electric vehicle supply equipment stations) to deploy DC-based power related demonstrations and what technology(ies) would ideally be demonstrated?

    1. ADC AIR: Commercial buildings with heavy HVAC consumption would be ideal deployments of ADC AIR. Deployments in both Northern California with colder climate and Southern California with warmer climate would reflect performance and functionalities in the different climate geographies.

        Suggestions: Public schools, low income housing, disadvantaged commercial sectors, Native American tribal communities, urban high rent locations, public sector buildings.

5. What kind of buildings/facilities are the best fit for early DC-based implementation and why?

1. ADC's mission is to "Power Everyone" which means to mass deploy our solutions where most needed. We support the CEC and California's commitment to ESG's, DEI, and inclusion of disadvantaged communities which would receive the most benefit from energy availability, efficiency, and clean indoor environment.

   Suggestions: Public schools, low income housing, disadvantaged commercial sectors, Native American tribal communities, urban high rent locations, public sector buildings.

6. What are potential DC adoption pathways for residential and commercial buildings, and how could we structure a solicitation to best inform that transition to greater adoption?
   1. A viable DC adoption pathway requires a.) ease of installation/retrofit, b.) affordability, and c.) flexibility for future upgrades.
      a. A solicitation that requires proof of ease of installation is a key component because DC adoption suffers from infrastructure replacement, e.g., DC distribution generally requires increasing DC voltages (because DC does not easily transmit long distances), but increased DC voltages requires a "rip out replace" existing wiring with more expensive larger gauge wiring. Worse than just the cost of goods, the added labor expense, risk of injuries, and liability insurance becomes prohibitive. The capital expenditure required to retrofit to DC wiring would far outweigh the benefits. **Using existing wiring is the key to adoption** for ease of retrofit into existing building stock, and ease of design into new construction.
      b. Utilizing existing wiring is a critical capital expenditure needed to build an affordable financial model for all end user goals, including all retrofits and all new builds. Once that hurdle is cleared, any future solicitation should seek finance models for mass deployment for commercial and residential sectors. Are there existing financing models that already exist that can support mass deployment within 3-5 years?
         ADC and ADC AIR provides power management solutions with equivalent cost effectiveness of vintage

power conversion, and higher efficiencies than existing vintage HVAC. Our existing “energy as a service” model is already being piloted and is ready for review by relevant stakeholders for mass deployment.

c. Flexibility and readiness for future upgrades to integrate additional electrified DC loads should be a key consideration for any solicitation. First, will the DC solution address the current paradigm where many loads remain AC voltage? Second, once installed on existing wiring will the DC solution avoid vintage redundant power conversions to DC loads? Third, once installed on existing wiring, will the DC solution be compatible and upgrade to integrate additional DC based loads as electrification transforms to a full DC to DC paradigm?

7. What research is required to directly connect an EV via a DC bus to a residential/commercial building allowing for a more flexible and efficient bi-directional power flow? What components/equipment and research are required to accelerate the adoption of DC bi-directional power flow equipment in residential/commercial buildings and improve the overall system efficiency?

    1. See Answer to item 6 above. ADC functionalities can integrate bi directional flow, and research is required to pilot the proof of concept, and thereafter commercialize alongside the ADC deployment which is already underway at TRL 9.

    2. With the added efficiencies of ADC AIR joint deployment, the savings from reducing HVAC consumption can release existing capacity back to allocate into EV charging infrastructure.

8. What are the research opportunities to demonstrate DC building blocks for a local DC microgrid that increase the overall system efficiency and reliability when compared to a similar alternating current (AC) system?

    1. The same designs for ADC power management within a building can be expanded outwards via increased operational voltages to interconnect ADC enable structures, and have generation sourced via community solar, wind, hydrogen. Research in the specific area of increasing ADC operational voltages would expand from building level into DC building blocks.

Near-Term (3-5 Years) Opportunities

9. What are the high priority DC-related technologies and/or research needs to successfully integrate or transition to DC-based power distribution networks?
    a. N/A
10. What specific DC equipment (e.g., DC-DC converters) and components are required to serve as an enabling device for the integration of DERs with a microgrid or DC-related infrastructure?
    a. What are the research opportunities to advance the TRL to simplify the interconnection of microgrids to the grid in one package using only DC-DC related components and equipment and eliminating DC-to-AC followed by AC-to-DC conversion?
        1. See answer to item 6. Increased ADC operational voltages expands the TRL 9 building functionalities outwards to interconnect microgrids to provide a universal, "one package" that addresses all needs whether upgrading existing AC systems or transitioning to full DC operations. **ADC is already operating within building level voltages (48vDC) and eliminated DC-to-AC followed by AC-to-DC conversion.** See also Figure 1.
    b. What additional research is required to maintain the quality and reliability of DC-DC converters while minimizing unnecessary costs and improving the efficiency of the converters?
        1. N/A
11. What advancements are required in power electronics to enable DC and mixed DC/AC microgrid topologies that can reduce power conversion, increase efficiency, and improve reliability?
    a. See answer to Item No. 6.
12. What power electronics need to be advanced and demonstrated to provide reliability and stability to DC systems?
    a. See answer to Item No. 6.
13. What are the enabling or emerging technologies that can:
    a. Advance adoption pathways for DC power in buildings?

ADC ENERGY: Hybrid 48vDC bus superimposed on AC wires

ADC AIR: 48vDC geothermal assisted electric heat pump

1. The transition to electrification can easily and immediately start within the envelope of building, residential and other end/edge uses including DC to DC EV charging stations. Substantial edge loads are already operational at DC voltages, e.g., LED lighting, controls, electronics, data centers, electric water heaters, DC appliances, EV charging, VFD HVAC. The current platform supplies only AC voltages into the building, which after multiple redundancies, are finally converted to DC at the end/edge load (inverters, adapters, rectifiers, step down, etc.). On a 24/7 habitual basis, tens of millions of consumers in CA use/charge a cell phone, laptop, EV, TV, to engage in the end conversion of their building AC voltages to DC.

   The solution to "enable more efficient integration of DC devices with other DC devices" within the 3-5 year term starts within the building envelope and provides multi-voltage input and multi-voltage output that can retrofit and operate on existing infrastructure/wiring.

   ADC Energy solution: hybrid power management which superimposes a DC bus on AC wires to provide multi voltage input with hybrid multi voltage output flexibility to eliminate the need for vintage energy conversion.

2. **ADC Energy building level is at TRL – 9.** ADC Energy power electronics systems have already launched in several pilot programs and are operational. We are currently upgrading our systems to reduce size, weight, and appearance form factors. "ADC AIR" combines our low voltage power electronics with a 48vDC geothermal assisted heat pump. This combination of DC based efficiencies substantially reduces (estimated up to 50%, or more if PV/battery based input) the largest load in every building: heating, ventilation and air conditioning (HVAC).

By reducing the HVAC load, ADC AIR releases existing capacity, which can be redirected to other loads, e.g. EV charging.

3. Additional research on our TRL – 9 systems is to secure final safety certification of our upgraded 2.0 designs, pilot at several locations within the State, implement workforce development and training, then mass deploy ADC power management and/or the ADC AIR combined HVAC solution. Mass deployment is the solution to release existing capacity back to the utility/consumer to then redirect to EV charging. This first milestone can be achieved within 3-6 months. Mass deployment can occur with the assistance and support of stakeholder utilities within 3 years.

b. Accelerate DC-based power distribution networks for efficient DC-DC integration of DERs?

    1. See above.

c. Enable residential/commercial buildings to better serve as DC building blocks for local DC microgrids?

    1. See above.

14. What are the opportunities for EVs to directly support a residential/commercial building directly via a DC bus that eliminates the requirement of an inverter and increases system efficiency and reliability?

a. **"ADC AIR" is at TRL – 9**. ADC Energy power electronics systems have already launched in several pilot programs and are operational. We are currently upgrading our systems to reduce size, weight, and appearance form factors. "ADC AIR" combines our low voltage power electronics with a 48vDC geothermal assisted heat pump. This combination of DC based efficiencies substantially reduces (estimated up to 50%, or more if PV/battery based input) the largest load in every building: heating, ventilation and air conditioning (HVAC).

    By reducing the HVAC load, ADC AIR releases existing capacity, which can be redirected to other loads, e.g. EV charging.

b. In addition, the EV battery directly connects within the ADC Energy DC to DC platform. The EV can both be charged via direct connection to the DC bus superimposed on existing AC wires, See Figure 1 above. AND, the battery of the EV itself can become a bidirectional source of DC voltages to power other DC based loads which are "plugged into" the ADC power management within the building.

Longer-Term (5+ Years) Opportunities

15. What are the opportunities for standardizing DC voltages and system design across various DERs, end uses, and DC plug-in electric vehicle chargers? How can research help to accelerate this process?

    a. See answer to Item No. 6.

16. What areas of research are required to potentially accelerate adoption of DC buildings and related technologies by residential and commercial developers and customers?

    a. A viable DC building adoption pathway requires a.) ease of installation/retrofit, b.) affordability, and c.) flexibility for future upgrades.

        1. Proof of ease of installation/retrofit is required because DC adoption suffers from infrastructure replacement, e.g., DC distribution generally requires increasing DC voltages (because DC does not easily transmit long distances), but increased DC voltages requires a "rip out replace" existing wiring with more expensive larger gauge wiring. Worse than just the cost of goods, the added labor expense, risk of injuries, and liability insurance becomes prohibitive. The capital expenditure required to retrofit to DC wiring would far outweigh the benefits. **Using existing wiring is the key to adoption** for ease of retrofit into existing building stock, and ease of design into new construction.
        2. Utilizing existing wiring is a critical capital expenditure needed to build an affordable financial model for all end user goals, including all retrofits and all new builds. Once that hurdle is cleared, any future solicitation should seek finance models for mass deployment for commercial and residential sectors. Are there existing financing models that already exist that can support mass deployment within 3-5 years?
           ADC and ADC AIR provides power management solutions with equivalent cost effectiveness of vintage

power conversion, and higher efficiencies than existing vintage HVAC. Our existing “energy as a service” model is already being piloted and is ready for review by relevant stakeholders for mass deployment.

3. Flexibility and readiness for future upgrades to integrate additional electrified DC loads should be a key consideration for any solicitation. First, will the DC solution address the current paradigm where many loads remain AC voltage? Second, once installed on existing wiring will the DC solution avoid vintage redundant power conversions to DC loads? Third, once installed on existing wiring, will the DC solution be compatible and upgrade to integrate additional DC based loads as electrification transforms to a full DC to DC paradigm?

17. What pertinent data (e.g., performance and cost) are required to accelerate large-scale commercialization and deployment of DC-based end-use equipment?

    a. N/A

18. What current or upcoming communication standards or protocols should be demonstrated and/or developed to ensure successful DC-DC integration and interoperability?

    a. N/A

19. What specific codes and standards will the deployment of a DC-based power system help inform?

    a. Low voltage DC operations within the NEC building code, then expanded into higher DC voltages in transmission and distribution.

Safety and Protection

20. What power electronic solutions are needed and required to enhance the safety of a DC microgrid?

    1. See answer to Item No. 6.

21. What protection equipment is needed to interface with a DC/AC microgrid that will enable the reliable operation of the microgrid during disaster events?

    1. See answer to Item No. 6.

22. What are the opportunities to advance DC components/equipment to improve the protection and coordination and increase the resiliency and interoperability of multiple connected DERs?

    1. See answer to Item No. 6.

23. For DC-DC converters, what are the safety mechanisms (e.g., NFPA 79) that are required in manufacturing, and how can research help address issues related to fire protection and health and safety?

    1. N/A

24. What emerging technologies can be demonstrated to reduce the safety and electric shock risks associated with higher DC voltage operations?

    1. ADC Energy, see Items No. 6 and 16.

25. What further research and/or analyses are required to ensure DC components/equipment protection is developed and proper guidelines are established?

    1. See answer to Item No. 6.

EPIC Program Area and Funding

26. For each suggested area of research above, what are the initial and concluding TRLs of the technologies being recommended? What is required to advance each technology's market readiness?

    1. ADC Energy // ADC AIR: TRL 9 to mass deployment. Mass deployment requires final safety certifications, cooperation of stakeholders including the State and local municipalities, CPUC and utilities to incentivize and support deployment starting with disadvantaged communities.

    2. ADC Energy hybrid transmission and distribution voltages: TRL 5 to TRL 9. Requires design, engineering and field testing of ADC hybrid DC bus on existing distribution, and substation level operations. Stakeholder support from CEC, CPUC, and utilities is required, including upon readiness for mass deployment.

27. For each suggested area of research above, what is the recommended CEC funding amount? What percentage of the funds should be provided by the recipient in terms of match?

1. ADC Energy/ADC AIR TRL 9 to mass deployment:
   a. Recommended funding amount: $495,000
   b. Match: 40% in kind contribution

2. ADC Energy hybrid transmission and distribution:
   a. Recommended funding amount: $5.0 million
   b. Match: 10% in kind contribution