



USING SOLID-STATE BREAKERS TO CHARGE AN EV FROM THE ELECTRICAL PANEL

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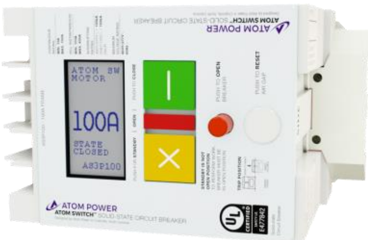
Introduction

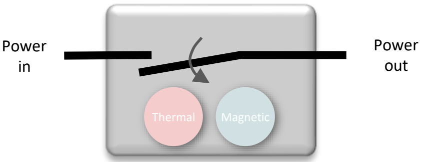
- Circuit Breaker patented by Thomas Edison in 1879
- Inverse Time Element Breaker released by Cutter Manufacturing in 1904
- Circuit Breakers relied on 2 main elements, thermal and magnetic
- Thermal heating caused by overloading a circuit would cause bimetal to heat and bend until the breaker opened
- Magnetic forces from high fault currents would force a breaker open
- In the 70s GFCI Breakers were introduced to reduce electrocution deaths
- In the 90s AFCI Breakers were introduced to reduce arcing fires

Solid-State Circuit Breakers

- 2019 the worlds first UL listed Solid-State Circuit Breaker was introduced by Atom Power
- Silicon Carbide transistor opens and closes the circuit
- Programmable TCC
- No Arcing
- Digital Control – Remote Operation

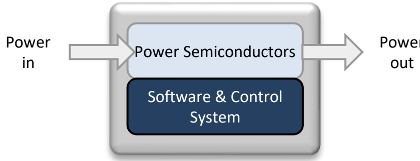


Traditional Circuit Breakers



Pure mechanical operation/breaking

Solid-State Circuit Breaker



Semiconductor breaking (no moving parts)

Breaker operations are digital via software

EV Charging 101

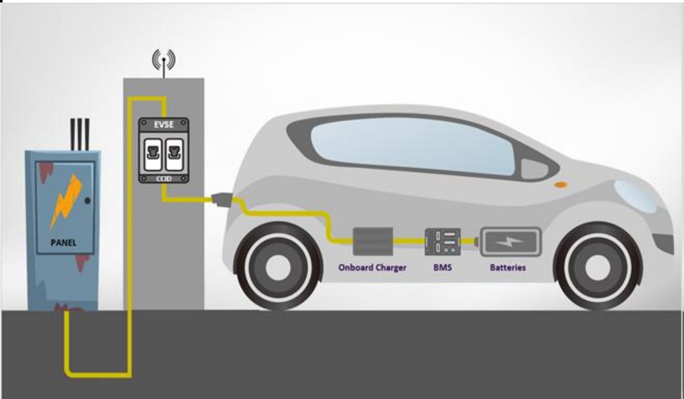
- Electric Vehicle Supply Equipment (EVSE) – The conductors, including the ungrounded, grounded, and equipment grounding conductors and the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the electric vehicle.

3 Levels of Charging:

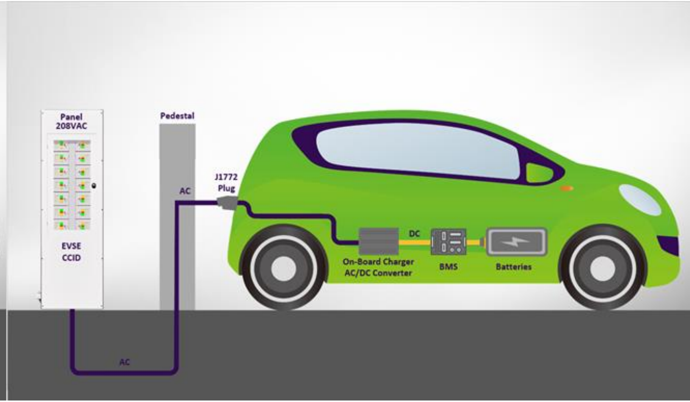
- Level 1 – 120VAC up to 1.9kW of power = Days to recharge
- Level 2 – 240VAC up to 19.2kW of power = Hours to recharge
- Level 3 – 400-800VDC up to 300kW of power = Minutes to recharge

EV Charging from a SSCB

Traditional EVSE



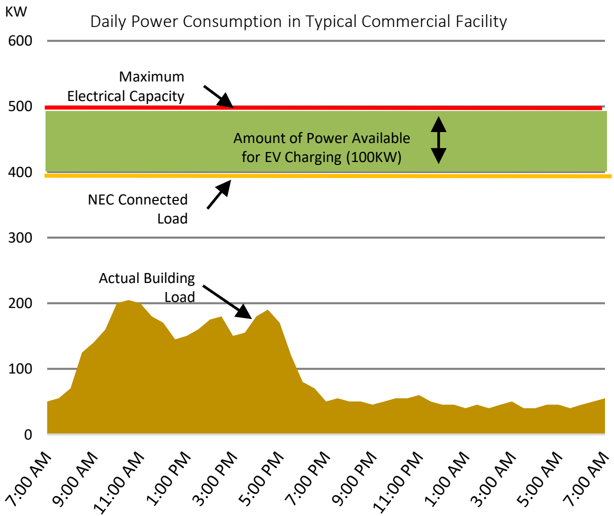
SSCB EVSE



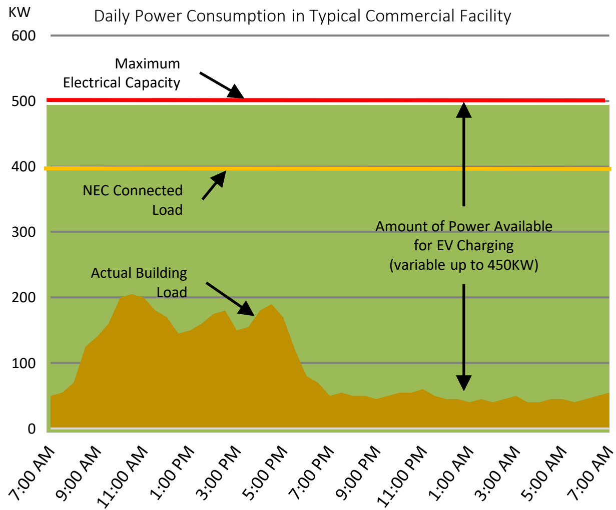
Energy Management

- NEC 625.42 Rating. …Service and feeder shall be sized in accordance with the product ratings. Where an **automatic load management system** is used, the maximum equipment load on a service and feeder shall be the maximum load permitted by the automatic load management system.
- With locally monitored energy management, utility service upgrades can be delayed or prevented entirely.
- Demand avoidance can have massive energy cost savings

Current Status Quo:



Dynamic Energy Management:



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NUMBER OF EVs[3] CHARGED PER DAY[4] WITH 208V

Available Electrical Capacity				Miles Driven Per Day			
400A Groups	# of Panels	Service Size (A)	Peak Demand (kW)	20	30	40	50
1	1-8	400	115	197	131	99	79
2	2-16	800	230	394	263	197	158
3	3-24	1200	345	591	394	296	237
4	4-32	1600	460	789	526	394	315

NUMBER OF EVs[3] CHARGED PER DAY[4] WITH 240V

Available Electrical Capacity				Miles Driven Per Day			
400A Groups	# of Panels	Service Size (A)	Peak Demand (kW)	20	30	40	50
1	1-8	400	115	228	152	114	91
2	2-16	800	230	456	304	228	182
3	3-24	1200	345	684	456	342	274
4	4-32	1600	460	912	608	456	365

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Increased Safety and Reliability

- Opening and closing circuit from the breaker means entire run deenergized while not actively charging
- Built in CCID for ground fault protection with auto-retry
- Integrated lockable disconnect for easy LOTO practice
- Lowest let-through current of any OCPD
- Lowest incident energy
- Rated at 200kAIC
- Millions of Operations
- Tested at the circuit breaker standards

SAFETY & RELIABILITY	EVSE UL 2231	CIRCUIT BREAKER UL 489	ATOM POWER UL 489/UL 2231
Overload Testing (489_7.1.3 vs 2231_27)	150% of rating 50x	600% of rating 50x	600% of rating 50x
Endurance Testing (489_7.1.5 vs 2231_28)	6,000 operations	10,000 operations	10,000+ operations
Surge Protection (489_SF4.5 vs 2231_24.10)	6kV	4kV	6kV
Short Circuit Test* (489_7.1.7 vs 2231_32)	3.5kA	5kA	200kA
Voltage to the Pedestal While Not Charging	Typically Present	N/A	No
How Fast Can You Stop Power	N/A	100ms	400µs
Let Through Current	Maximum Available Fault Current	Maximum Available Fault Current	1.5kA

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Decreased Costs

- All in one device means less equipment needed
- Expensive equipment in the electrical room
- No moving parts, no maintenance plans
- Single point of connection for lower cloud fees
- Avoid service upgrades
- Avoid high energy bills

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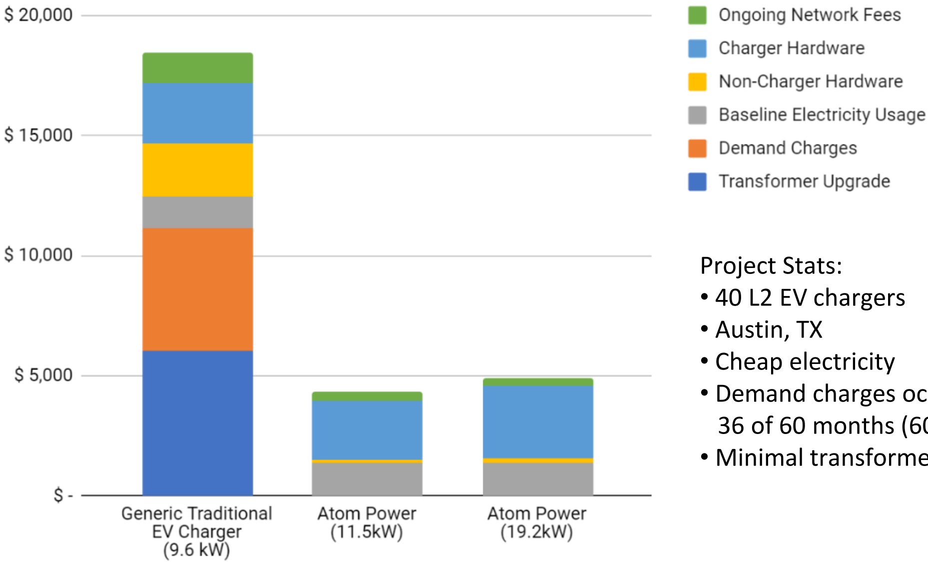
By Controlling Demand Charges and Delaying Transformer Upgrades, **Up to 80% Cheaper to Operate Over 5 Years**



Project Stats:
- 40 L2 EV chargers
- Austin, TX
- Cheap electricity
- Demand charges occurred in 36 of 60 months (60%)
- Minimal transformer upgrade

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Standards for SSCB and EVSE

- SAE – Society of Automotive Engineers
- UL – Underwriters Lab
- NEC – National Electrical Code
- IEEE vs ISO for Next Level Communication
- NIST vs ANSI for Metering

SAE – Society of Automotive Engineers

- J1772: EV Conductive Charge Coupler – Covers the physical, electrical, functional and performance requirements of charging an EV in North America. Defines the Levels of AC and DC charging. Defines the pilot wire communication between the EVSE and the EV.
- J1773: EV Inductive Charge Coupler - Covers wireless charging
- J2178-1/2/3/4: Class B Data Communication Network Messages
- J2894-1: Power Quality Requirements for Electric Vehicle Chargers

UL – Underwriters Lab

- 2594: Electric Vehicle Supply Equipment – Main safety standard
- 2231-1/2: Personnel Protection Systems for EVSE – Covers CCID and Grounding
- 2251: Plug, Receptacles and Couplers
- 489/489i: Circuit Breakers/Solid-State
- 67: Panelboards
- 1998: Software in Programmable Components

NEC – National Electrical Code

- Article 625 Electric Vehicle Charging Systems
- Important Revisions: 625.40 (2017), 625.42 (2014)
- 625.40 Electric Vehicle Branch Circuit: Each outlet for EV charging **shall** be supplied by an **individual** branch circuit.
- 625.42 Rating: load on a service and feeder **shall** be the maximum load permitted by the **automatic load management system**. Restricted access shall be accomplished by; (1) cover or door that requires a tool to open, (2) locked doors accessible only to qualified personnel, (3) password protected software
- 625.42 Disconnecting Means: Required on greater than 60A or 150V to ground.

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IEEE vs ISO for Next Level Communication

- IEEE 2030.5 (SEP) Standard for Smart Energy Profile Application Protocol
- CA requires on all solar inverters to connect to the grid
- Current V2G pilot program in CA to test standardization of protocol

- ISO 15118 (Plug & Charge) Vehicle to Grid Communication Interface
- Vehicle OEMs fully supported: Audi, BMW, Daimler, Ford, Lucid, Porsche, Volvo, VW
- CA considering requiring “hardware-ready” in 2023
- Power Line Communication between the EVSE and the EV
- Used with CCS

NIST vs ANSI for Metering

- NIST – National Institute of Standards and Technology
- NIST Handbook 44 – Specification, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices
- NIST HB 44 3.40 EV Fueling Systems: 1% accuracy at the point of dispensing

- ANSI - American National Standards Institute
- ANSI C12.1 – 1% accuracy for electric meters
- ANSI C12.20 - .5%, .2%, .1% accuracy for electric meters

Conclusion

- Solid-State breakers are the next evolution in circuit protection
- EV adoption is exponential over the next couple years
- Every electron must pass through a breaker to get to an EV
- Charging an EV from the breaker makes sense and has benefits
- Energy management will be crucial for large scale adoption
- Using a SSCB EVSE will have increased safety and reliability with decreased cost
- There are many standards being developed in safety and usability of EVSE. The industry is young and still has room to be influenced.

Questions?

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