California Energy Commission EPIC Project:
EXtensible Building Operating System – Vehicles (XBOS-V)

Policy Innovation + Coordination Group
Transportation Electrification Workstream
California Public Utilities Commission

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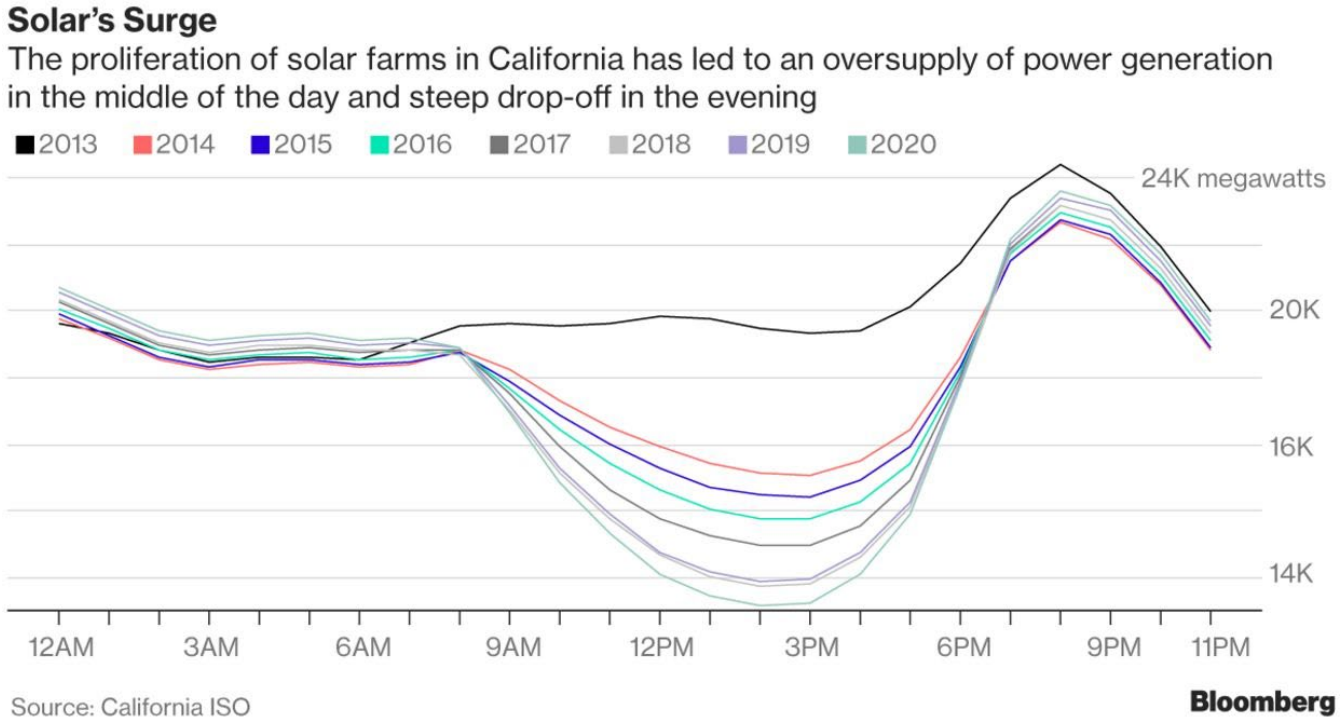
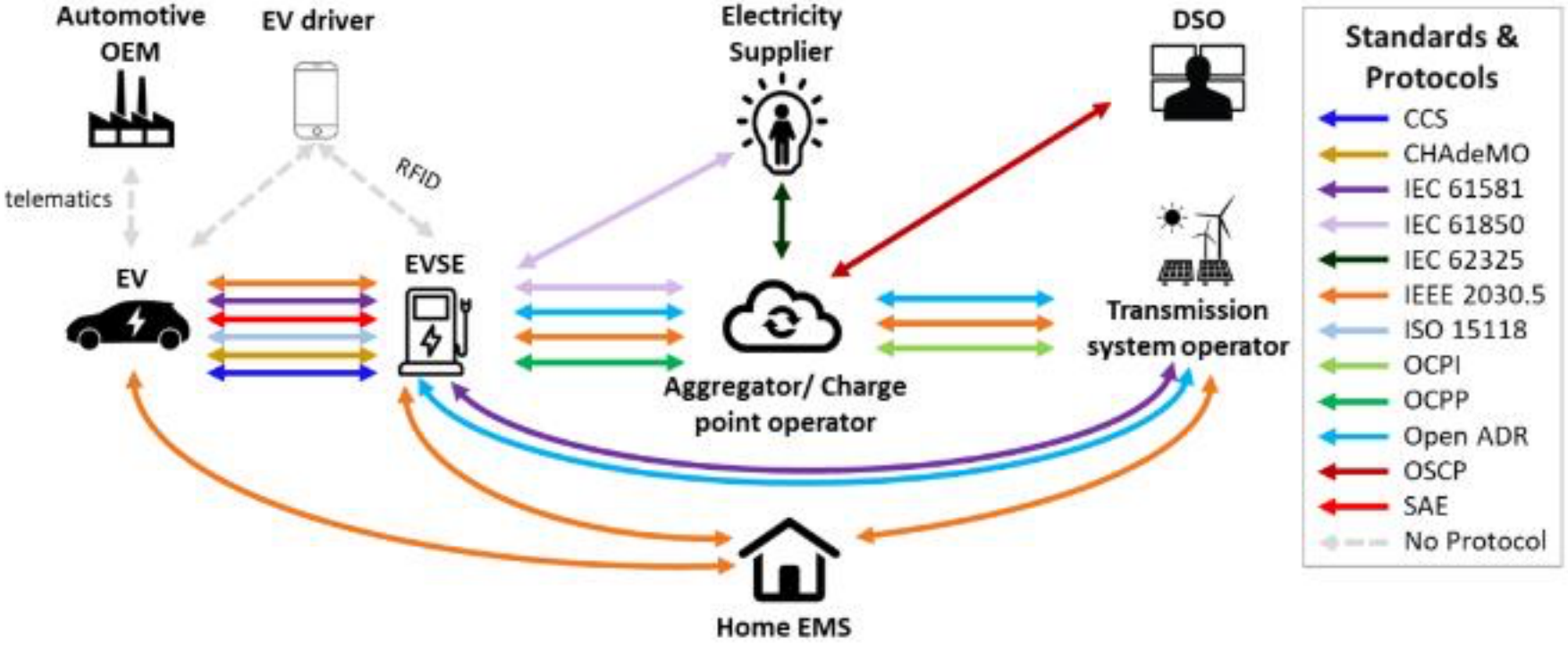
California's Utility Grid is Evolving Rapidly

Net Load or "Duck" Curve – What Generation Has to Supply After Must-Take Renewables



Emerging Suites of VGI Communication Standards

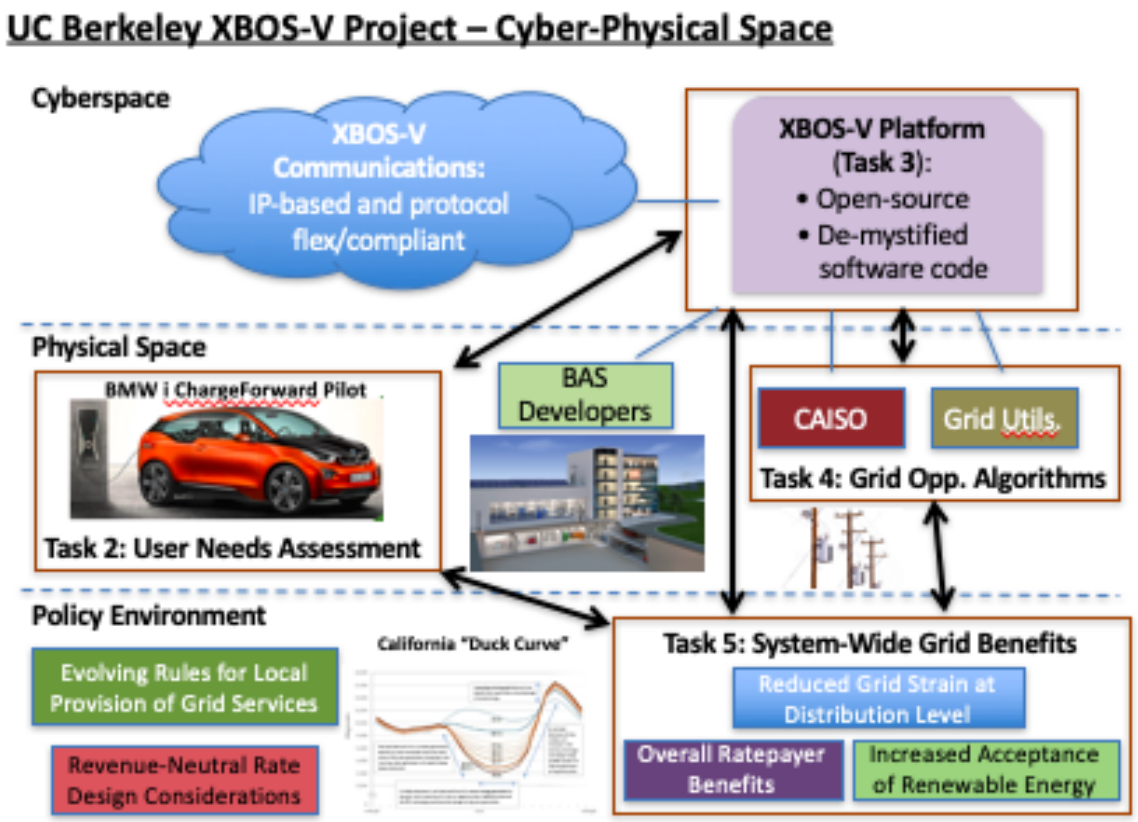


Source: ICCT Webinar, 11/19

California Energy Commission
EPIC 15-013 Grant – "XBOS-V" Overview

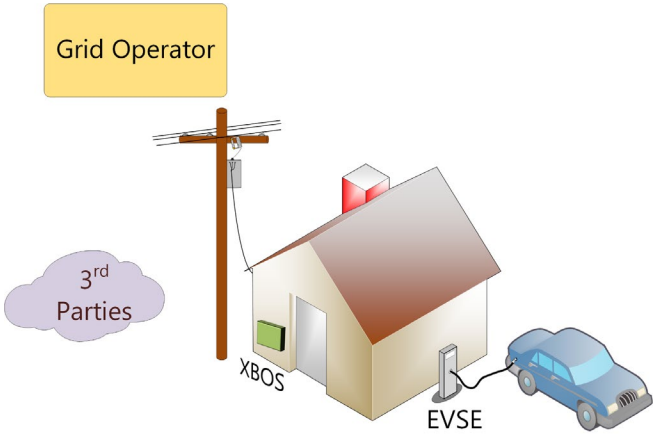
- UC Berkeley's TSRC, BECI, and ERG units with BMW
- $1.59M grant over three years, awarded April 2016 under PON 14-310
- Key idea is to aggregate local loads including EV charging for streamlined grid load control using *readily extensible, open code and architecture built on low-cost computing platforms*
- Project also includes analysis of distribution system and larger grid benefits, and assessment of learnings from BMW "ChargeForward" pilot with PG&E

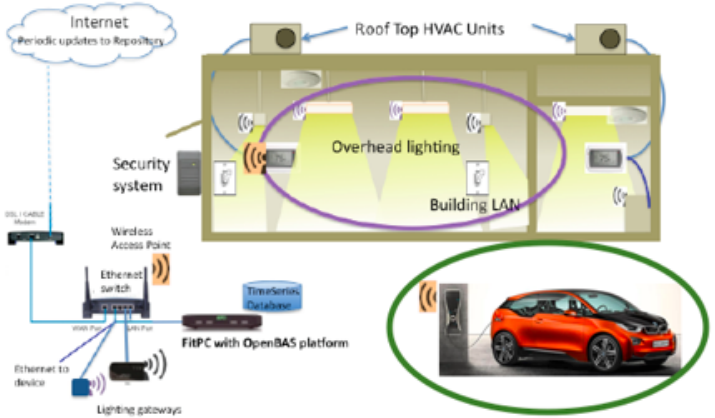
XBOS-V Project – Task Overview



XBOS-V Project – VGI Through Site-Level Building Control Systems

EXtensible Building Operating System (XBOS) for
Single Point of Grid Interface and Coordinated Control of Local Building Loads





PEV Charge Control in the Context of a Decentralized and Open-Source and Architecture Platform

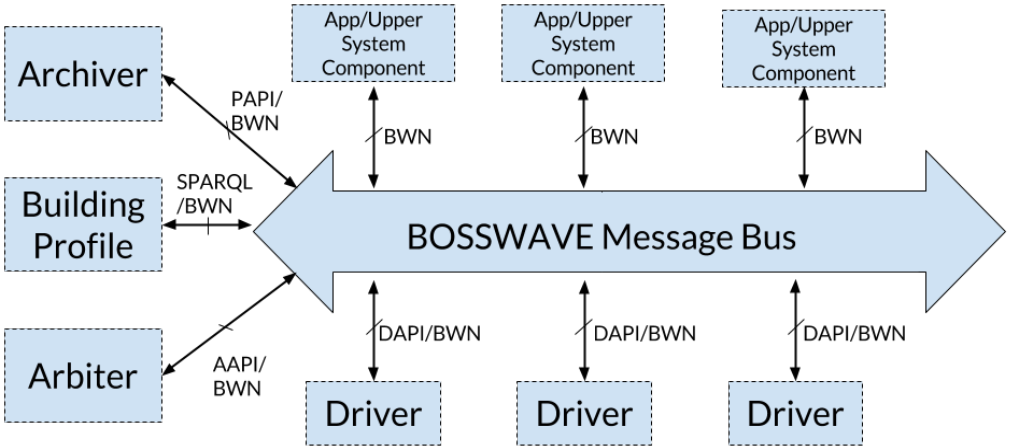
Task 3 – VGI Test Bed at Berkeley Global Campus

- VGI Testbed combines a Wi-Fi capable charger, a sophisticated NHR power system control and visualization device, open-source software code, and remote telemetry

Model 9410 *single Power Module front panel view*

Task 3 - UC Berkeley XBOS Platform

- XBOS = EXtensible Building Operating System

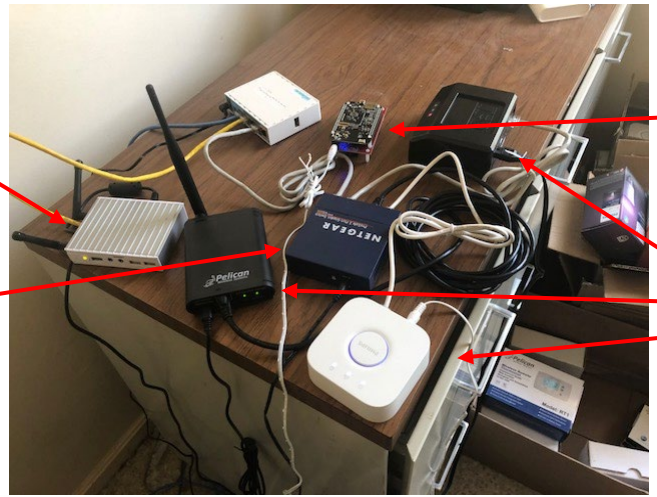


DAPI: Driver API
AAPI: Arbiter API
SPARQL: RDF query language
PAPI: Pundat API

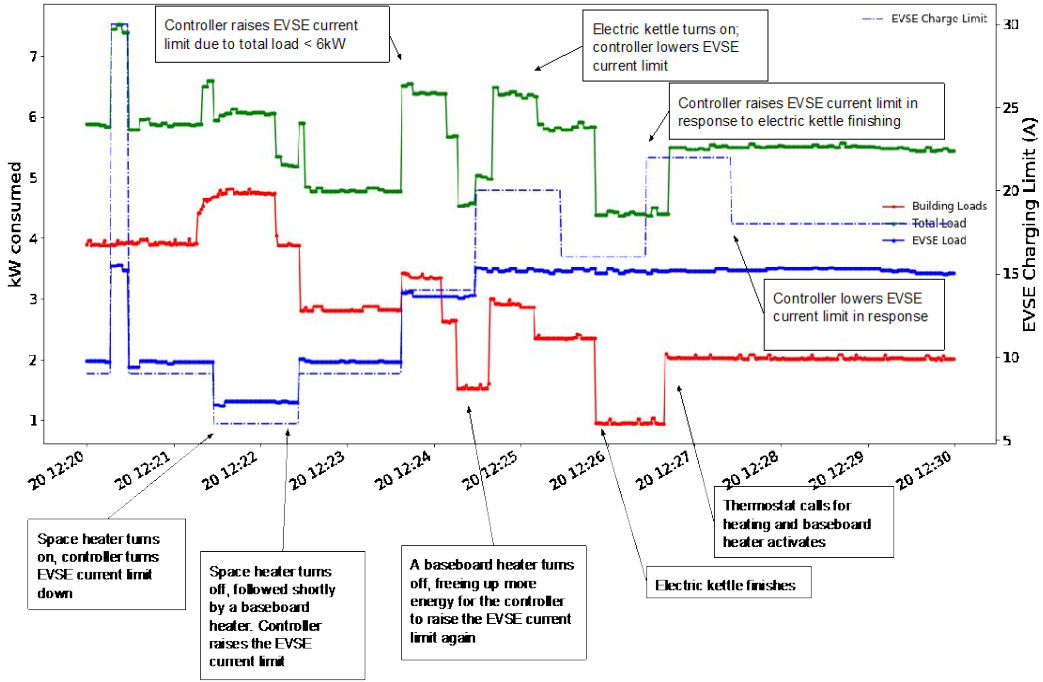
PAPI: Pundat API
BWN: BOSSWAVE Native Protocol (over TCP/IP)

Task 3 - UC Berkeley XBOS Platform

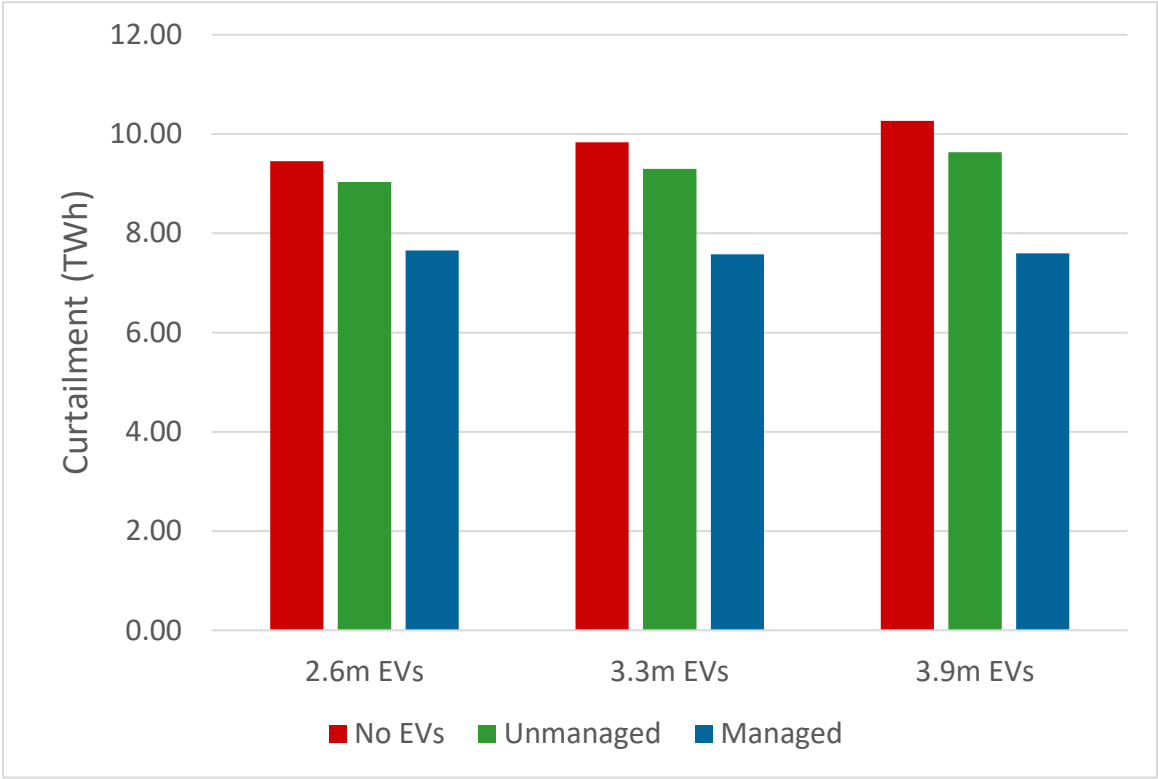
- Built on Low-Cost Computing Platform and Open-Source Code
  - FitPC ($100) + WiFi enabled EVSE ($50 upgrade) + standard internet router ($30) = <$200 per site +$50 per additional EVSE



Task 3 – Coordinated Load Control Including EVSE Using XBOS-V



Task 5 – 2030 California Grid Case With CPUC Grid Calculator Results



XBOS-V Task 5 – Key Findings

- Flexible load from PEVs can potentially (upper bound) reduce curtailment in California by about 500 GWh in 2024 and 2 TWh in 2030
- This equates to $10-60 million per year in grid cost savings at alternative wholesale generation costs of $10-$30/MWh
- Also indicates potential savings of approximately 72,500 tons (2024) and 290,000 tons (2030) per year of GHG emissions assuming generation with 290 lbs/MWh (avg.) of emissions otherwise needed to charge PEVs

Vehicle-Grid Policy Recommendations

- As EVs continue to proliferate, policies for ***expanded workplace charging*** with attractive charging costs is critical to provide more opps. for drivers to charge during the day
- All electricity consumers should become more exposed to ***time-varying rates through more dynamic pricing systems*** that incentivize charging at lowest cost and GHG emission times, on a day-ahead or even hour-ahead information basis
- Critical to ***continue to build the EV market in California*** through supportive policies to meet state goals

Questions?

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