Vehicle-Grid Integration Research at UC Berkeley's TSRC

Transportation Research Board
Washington, DC

January 8, 2017

Timothy Lipman, PhD
Co-Director - TSRC
telipman@berkeley.edu

tsrc
UNIVERSITY OF CALIFORNIA Berkeley
Transportation Sustainability
RESEARCH CENTER

ITSBerkeley
Institute of Transportation Studies

THE UNIVERSITY OF CALIFORNIA BERKELEY 1868

Overview

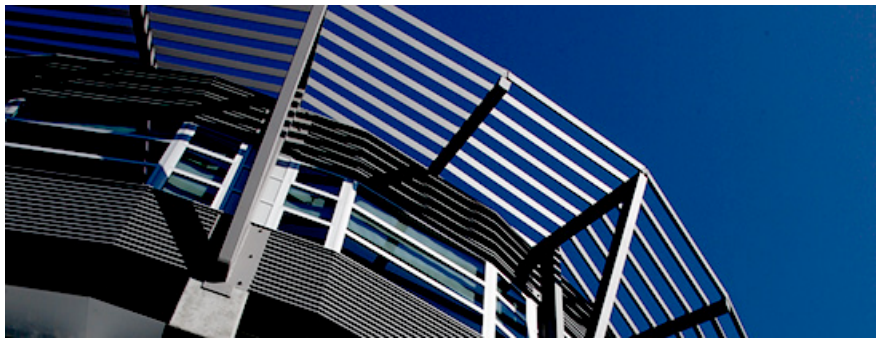
1. Introduction - UC Berkeley TSRC
2. New Smart Charging Test Bed at the Berkeley Global Campus
3. ISO 15118 - Overview
4. California Energy Commission EPIC Project 15-013 – “XBOS-V”
5. BMW i ChargeForward 2.0 project (tentative)

Tim Lipman – Bio Overview

- BA in Environmental Studies - Stanford (1990); MS in Transp. Technology and Policy - UC Davis (1998); PhD in Ecology - UC Davis (1999)
- Co-Director of UC Berkeley TSRC Since 2006
- Research Affiliate with the Lawrence Berkeley Lab
- Chair of TRB Committee on Alternative Transportation Fuels and Technologies (ADC80)
- Member of U.S. DOE Hydrogen and Fuel Cell Technical Advisory Committee (HTAC)
- Member of BAAQMD Advisory Board

Transportation Sustainability Research Center (TSRC) Locations

- Main office is at Berkeley Global Campus - Richmond



TSRC Program/Project Areas

- **Advanced Vehicles and Fuels**

  Electric-drive vehicles and infrastructure; lifecycle analysis of biofuels, tar sands and other non-traditional fuels, hydrogen, and electricity; transportation-related emissions; and feebates
- **Energy and Infrastructure**

  Smart grid integration, advanced fuel infrastructure, intelligent transportation systems applications, ecodriving for private vehicles
- **Goods Movement**

  AB 32 and goods movement, smart parking for trucks, ecodriving for trucks
- **Transit and Travel Connections**

  Smart parking for transit, carsharing, bikesharing, and ridesharing
- **Mobility for Special Populations**

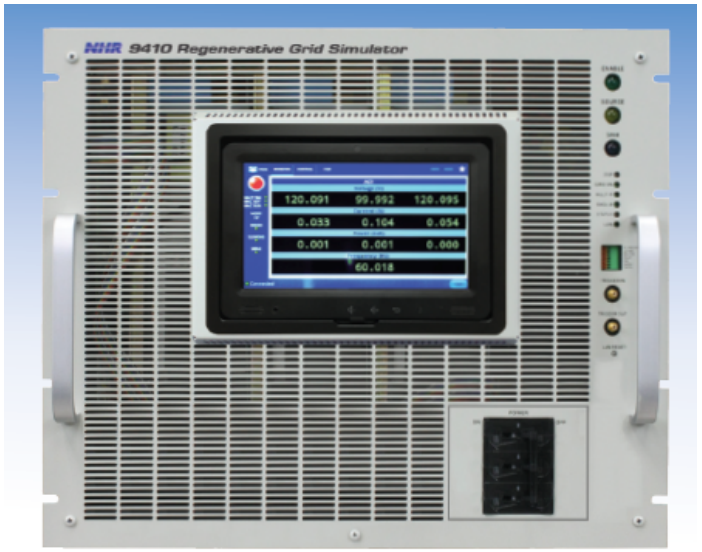
  Non-traditional modes, transit and non-motorized travel

TSRC – Early PHEV Research History

- 2010-11 Toyota-sponsored project included 10 conventional hybrid Priuses and 10 plug-in hybrid Priuses

New Smart Charging/Power Systems Test Bed at Berkeley Global Campus

- Combining a new ISO 15118 capable charger with an NHR power system visualization device, open-source software code, and remote telemetry



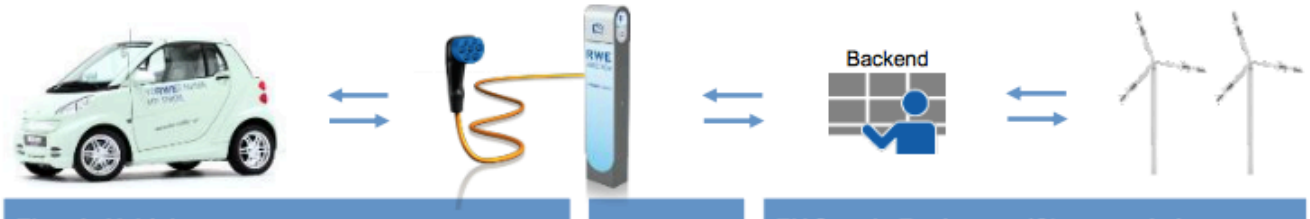
Model 9410 *single Power Module front panel view*

ISO 15118 – An Emerging International Standard for Vehicle-Grid Communication

- ISO 15118-2 Sections and Status:
  - Part 1: General information and use-case definition (International Standard (IS) available since 04/2013)
  - Part 2: Network and application protocol requirements (IS available since 04/2014)
  - Part 3: Physical and data link layer requirements (IS available since 05/2015)
  - Part 4: Network and application protocol conformance test (CD2 available since 02/2015)
  - Part 5: Physical layer and data link layer conformance test (CD available since 08/2015)
  - Part 6: General information and use-case definition for wireless communication (DIS available since 09/2015)
  - Part 7: Network and application protocol requirements for wireless communication (CD under development)
  - Part 8: Physical layer and data link layer requirements for wireless communication (CD under development)

ISO 15118 Charge Control Example

Data Communication controls Charging Session for better Integration of renewable Energy



Electric Vehicle		EV Supply Equipment (Charge point)
Cable connected, CP/PWM ok, ask for service available	1	Chose highest protocol version, send service list
I want to charge with costs, my contract ID is "1234"	2	Checking contract ID, perhaps request at eRoaming platform
Calculation of charging profile; chosen price table	3	Valid ID can be used for charging up to 22 kW; load & price table enclosed
Lock connector; I will charge from 2 AM to 6 AM at 5 kW	4	Capacity reservation, perhaps communication with Smart Grid
Charging	5	Contactor closed; send start meter reading
	6	Special wind offer: 4 AM to 6 AM, price minus 10%
Offer accepted: I will charge from 4 AM to 6 AM at 11 kW	7	Capacity reservation, perhaps communication with Smart Grid
I want to stop charging session; open contactor	8	Contactor opened
	9	Send stop meter reading; please sign meter reading
Signing drawn energy, unlock cable, end of communication	10	Provide charge data (Service Detail Record) for billing

Example: Controlling charging session according to ISO 15118-2

RWE The energy to lead

 PAGE 29

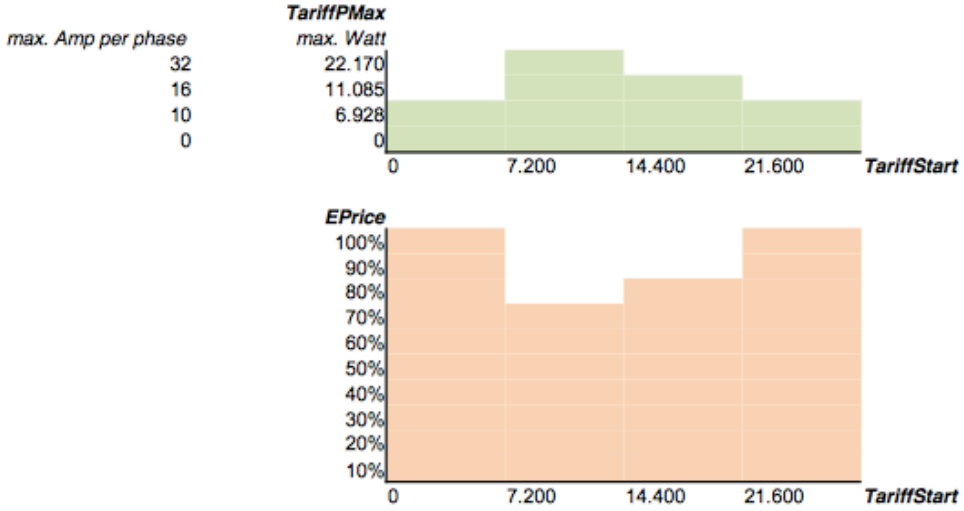
ISO 15118 uses P_{max} and Tariff Tables for easy Integration of EVs into Power Grid and Power Production

Grid and Power Production Tariff Table

TariffStart	[Seconds from now]	0	7.200	14.400	21.600
TariffPMax	[Watt]	6.928	22.170	11.085	6.928
EPrice	[relative, in %]	100%	70%	80%	100%

TariffTableType

Currency	REL
Tariff	T1
EPriceUnit	1 (one percent)
EPriceMuliplier	1



Source: According to Committee Draft ISO 15118-2

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

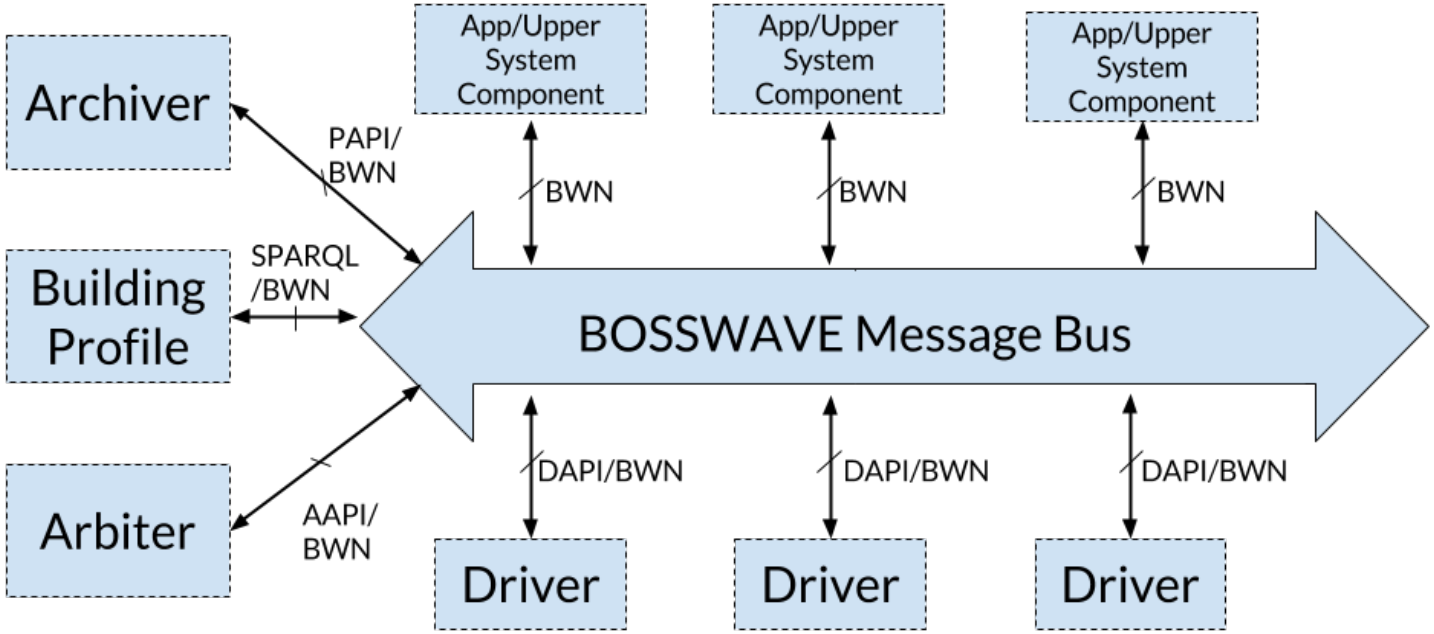
- UC Berkeley's TSRC and BECI units with BMW North America
- $1.59M grant over three years, awarded April 2016 under PON 14-310
- Key idea is to aggregate local loads including EV charging for streamlined grid communication interfaces and load aggregation
- Four primary project tasks including open-source software development and validation, distribution and larger grid benefits analysis, and assessment of learnings from BMW "i ChargeForward" pilot with PG&E
- Technical Advisory Committee being formed in Q1 2017

XBOS-V Project Team

- UC Berkeley
  - Tim Lipman, PhD, ITS/TSRC (PI)
  - Assoc. Prof. Duncan Callaway, ERG/BECI (Co-PI)
  - Prof. David Culler, EECS/BECI
  - Asst. Prof. Scott Moura, CEE/BECI
  - Sascha Von Meier, PhD, BECI
  - Therese Peffer, PhD, BECI
  - Graduate students and post-docs
- BMW North America
  - Adam Langton
  - Sebastian Kaluza
- CEC Agreement Manager
  - Matthew Fung

UC Berkeley XBOS Platform

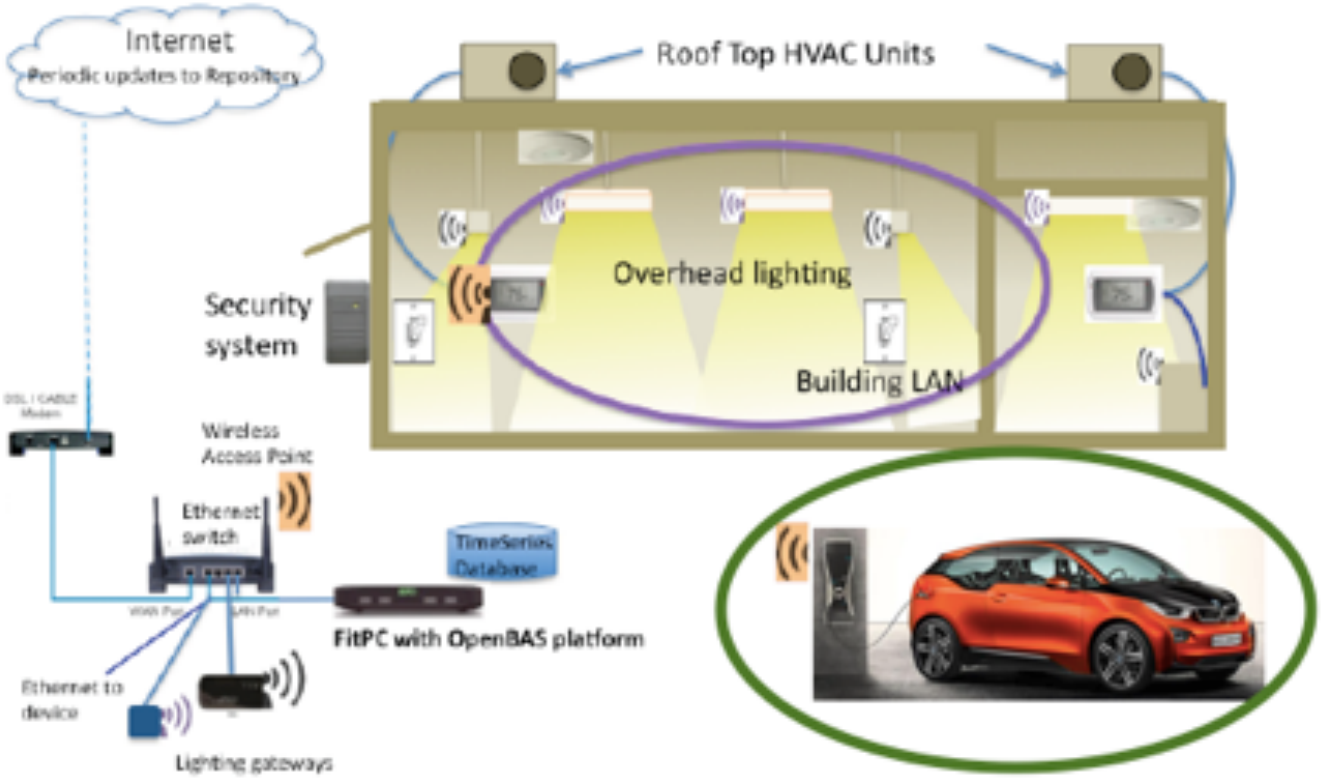
- XBOS = EXtensible Building Operating System



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

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

California Energy Commission
EPIC 15-013 Grant



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

California Energy Commission
EPIC 15-013 Grant – Task 2

- Collaborate with BMW North America to understand motivations and responses to the “i Charge Forward 1.0” project with 90 participants
- 1.0 pilot project phase ended late 2016
- Follow-on focus groups (planned February or March 2017)
- Participant “likes” and “dislikes” as well as desired levels of information, sufficient levels of compensation, etc.

California Energy Commission
EPIC 15-013 Grant – Task 3

- Develop open-source software code based on XBOS platform
- Extend for “XBOS-V” module for control of EV chargers in residential and small commercial settings
- Test and validate code using UC Berkeley BGC testbed
- Initial plan is to use SEP 2.0 for building <-> EVSE communication and to investigate ISO 15118 for vehicle <-> EVSE communication

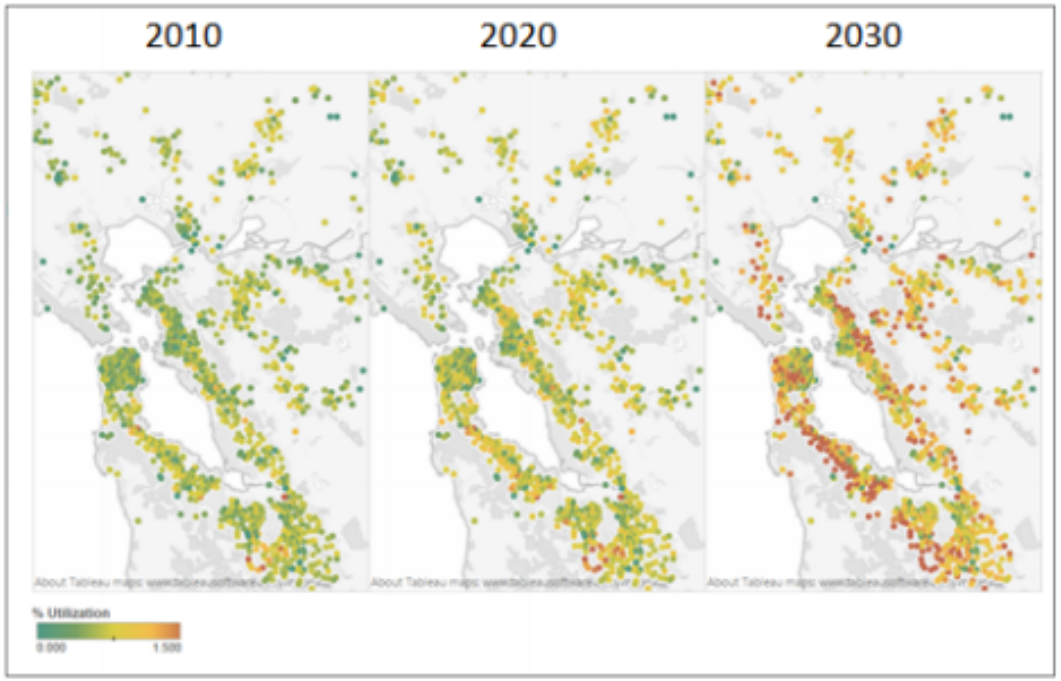
California Energy Commission
EPIC 15-013 Grant – Task 4

- Assess distribution-level benefits of VGI
- Local grid congestion relief through demand response
- Understand system power quality issues and potential for support from EVSEs (voltage support, VARs, etc.)
- Direct control and economic price “demand clearinghouse” concepts

California Energy Commission
EPIC 15-013 Grant – Task 4

- Previous research suggests that additional PEV loads can start to stress local distribution systems but that managed charging can mitigate these impacts

Distribution Level Utilization with PEV Charging

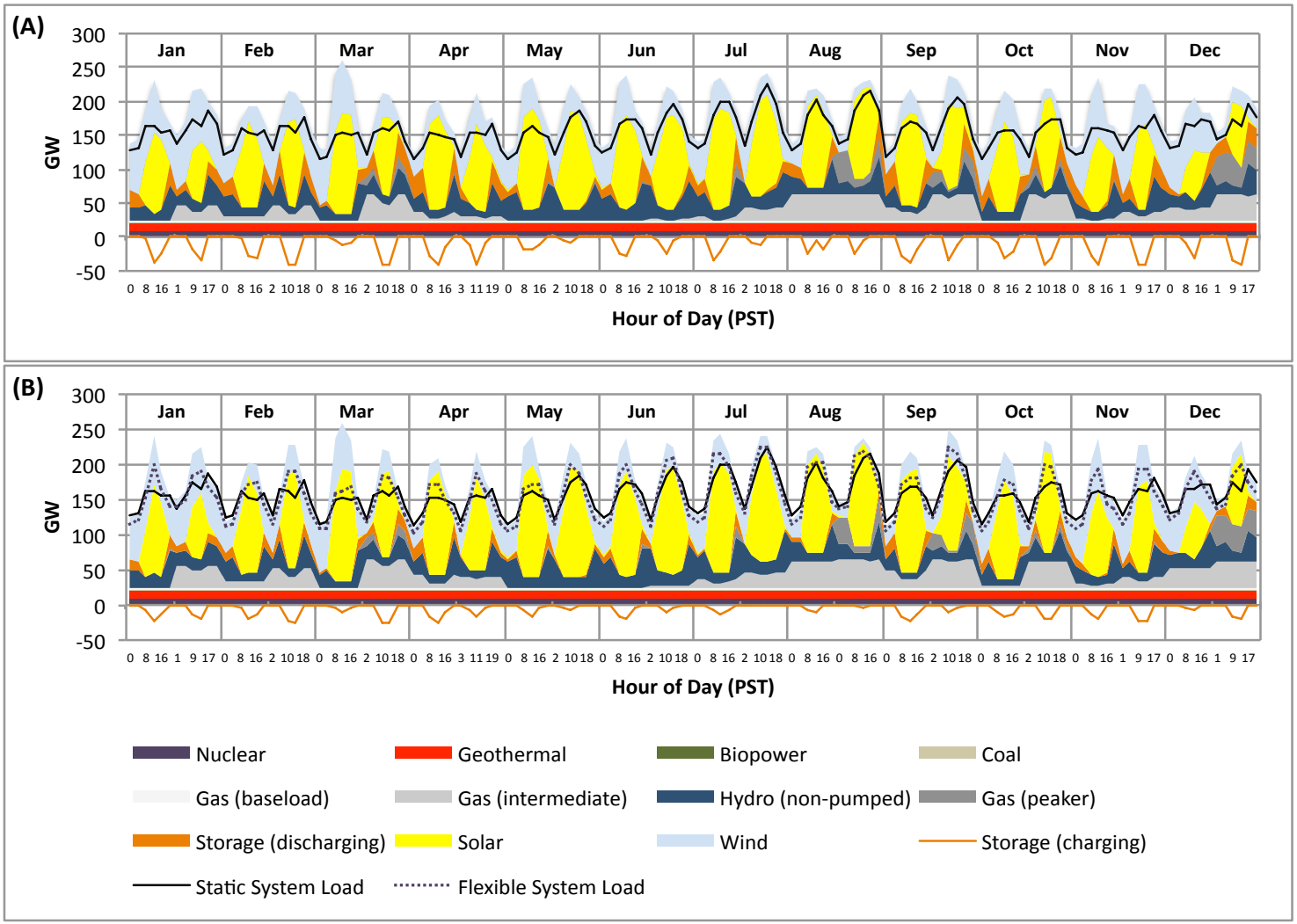


Source: E3

California Energy Commission
EPIC 15-013 Grant – Task 5

- Understand potential larger grid impacts and benefits
- Flexible load in the form of controlled EV charging can significantly reduce needs for dedicated grid storage as intermittent renewable resources become more highly utilized
- Expand on previous analysis with additional SWITCH and PLEXOS modeling of CA grid for 2020-2030

California Energy Commission
EPIC 15-013 Grant – Task 5



Source: UC Berkeley SWITCH Model

Conclusions

- UC Berkeley has a new research program related to open-source and open-architecture VGI concepts based on the XBOS platform
- Open source (non-proprietary) solutions can reduce adoption barriers
- ISO 15118 is an international standard that can help to facilitate vehicle-grid interaction by enabling vehicle-EVSE communication
- Various ways of addressing the “how” to unlock the potential grid benefits of VGI; establishing the “what” and the needed market mechanisms is a key need
- Tech. solutions are only part of the puzzle – consumer motivations and constraints are also critical to understand

tsrc

tsrc.berkeley.edu