



Advanced Energy Partnership for Asia

Electric Vehicle Supply Equipment: Tariff Design Support to the Lao PDR

Owen Zinaman, Kaylyn Bopp, Nathan Lee and Laura Beshilas
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NOTICE

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1. Electric Vehicle (EV) Tariffs for Personal Vehicles
2. EV Tariff Design Principles
3. Where and How Do We Charge?
4. Home Charging – EV Tariff Design Considerations
5. Public Charging – EV Tariff Design Considerations
6. Retail Customer Charges for Public Electric Vehicle Supply Equipment (EVSE)

EV Tariffs for Personal Vehicles

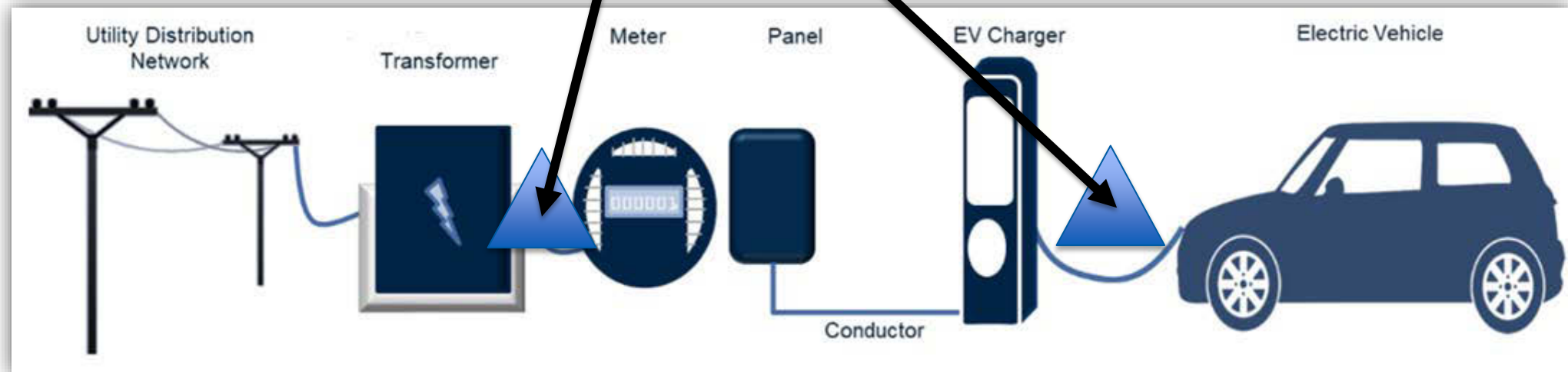


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- **Designing retail tariffs for personal use vehicles in public and at home**
- **EVSE business models are very relevant for today's discussion**
 - Tariffs can be designed for:
 - EV owner who charges at home
 - Public EVSE owned by electric utility
 - Public EVSE owned by private company
- **Two kinds of tariffs we can discuss**
 1. Tariff between EVSE owner and customer
 2. Tariff between electric utility and EVSE owner



UTILITY CHARGES: Component of a retail electricity tariff designed to collect revenue from customers. At a high level, different kinds of charges include:

ENERGY CHARGE [\$/kWh]:

A utility charge designed to collect revenue based on the volume of electricity consumed

DEMAND CHARGE [\$/kW]:

A utility charge designed to collect revenue based on the maximum instantaneous demand of the customer (stated in \$/kW or \$/kVa)

CONNECTION CHARGE [\$/month]:

A utility charge designed to collect a fixed amount of revenue from a customer each billing cycle, regardless of their consumption behavior

TAXES [%]:

A government levy that is a fixed percentage of charges

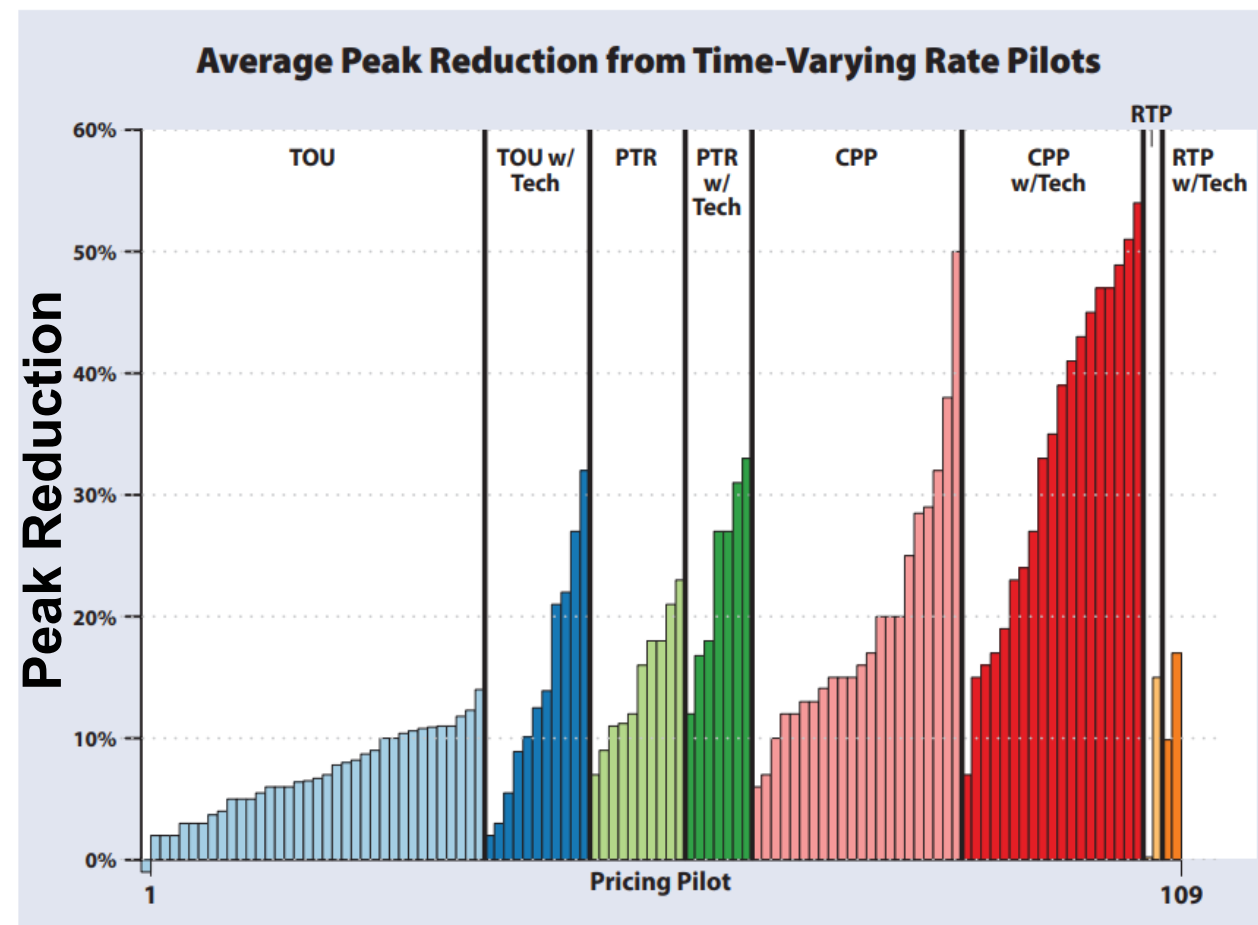
EV Tariff Design Principles



Why Create Special EV Tariffs?

- **Tariffs can be used to influence customer behavior to benefit the electricity system**
- **EV tariffs can be designed to:**
 - *Discourage* charging during critical peak times, which stress infrastructure
 - *Encourage* charging when electricity is cheap and abundant and existing infrastructure is not fully utilized

Example: Time-of-use rates can reduce peak demand

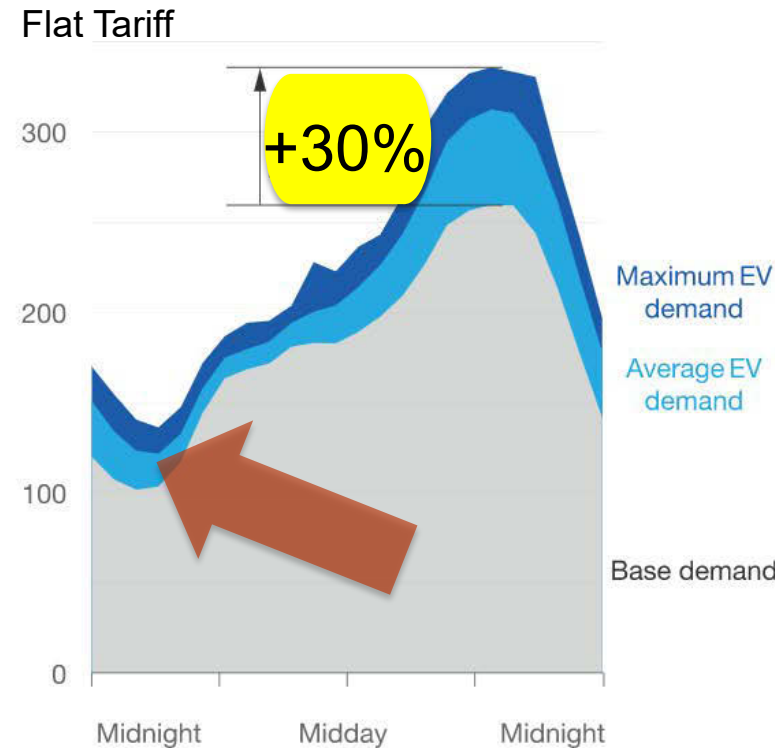


Time-varying and dynamic rate design

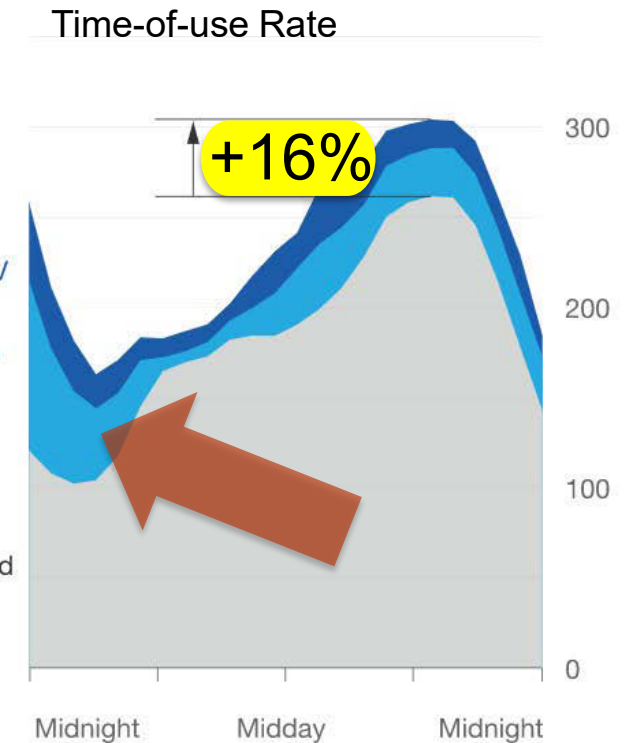
Why Is Charging Behavior Important?

- EVs can have a large impact on a utility's load
- This large, new demand can help OR hurt a utility
- **Tariffs are used to manage this new demand in a helpful way**

Utility Load with EV Charging (Before Tariffs)



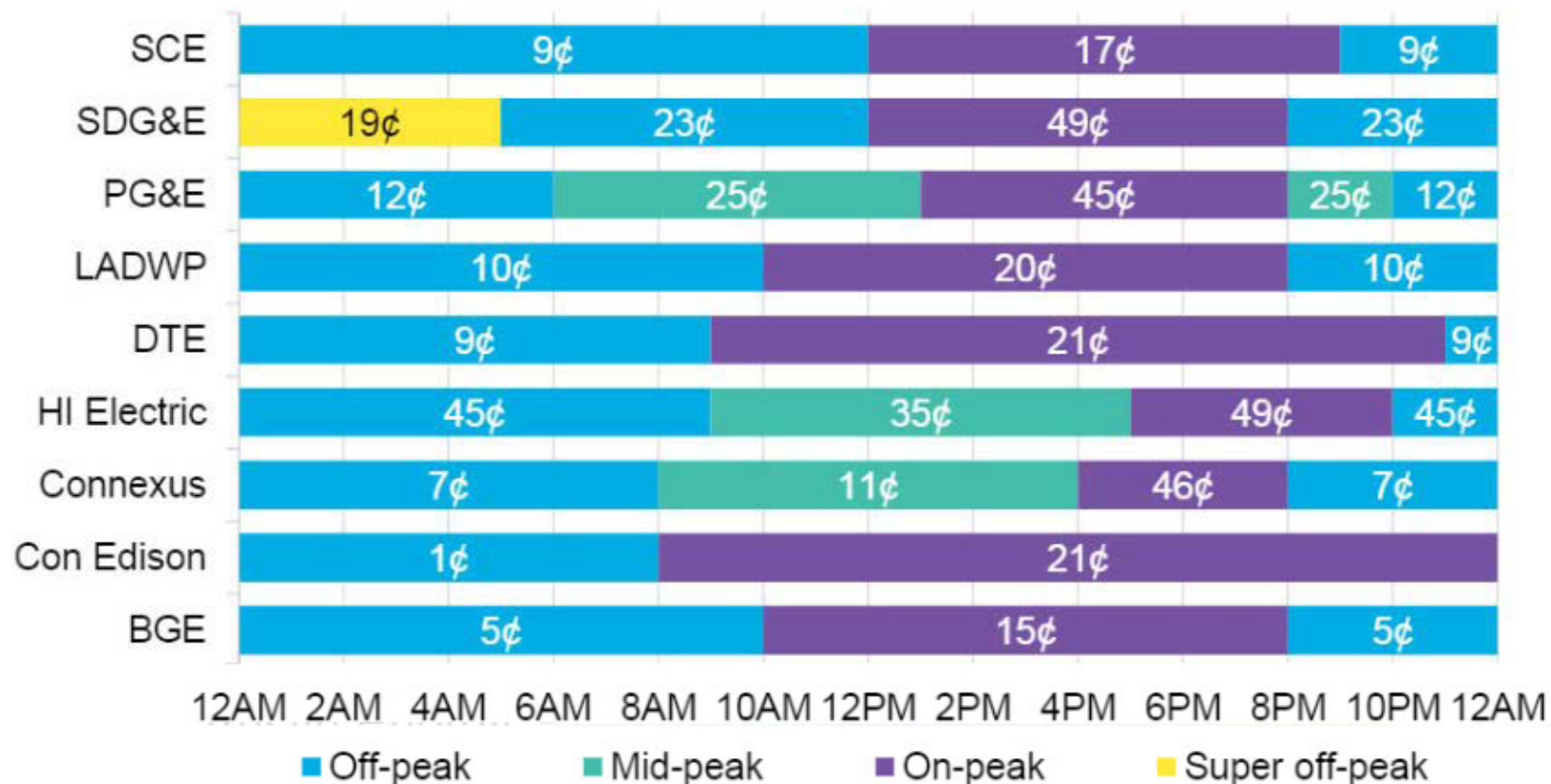
Utility Load with EV Charging (After Tariffs)



Example: Using Time-of-Use EV Energy Charge

U.S. Utilities

Tariff hours and rates (¢/kWh)



TARIFF DESIGN OBJECTIVES

Tariffs are designed to:

- Ensure cost recovery for utility
- Ensure revenue stability for utility
- Fairly apportion the cost of service to different customers based on “cost-causation”
- Encourage energy conservation and “grid-friendly” behavior

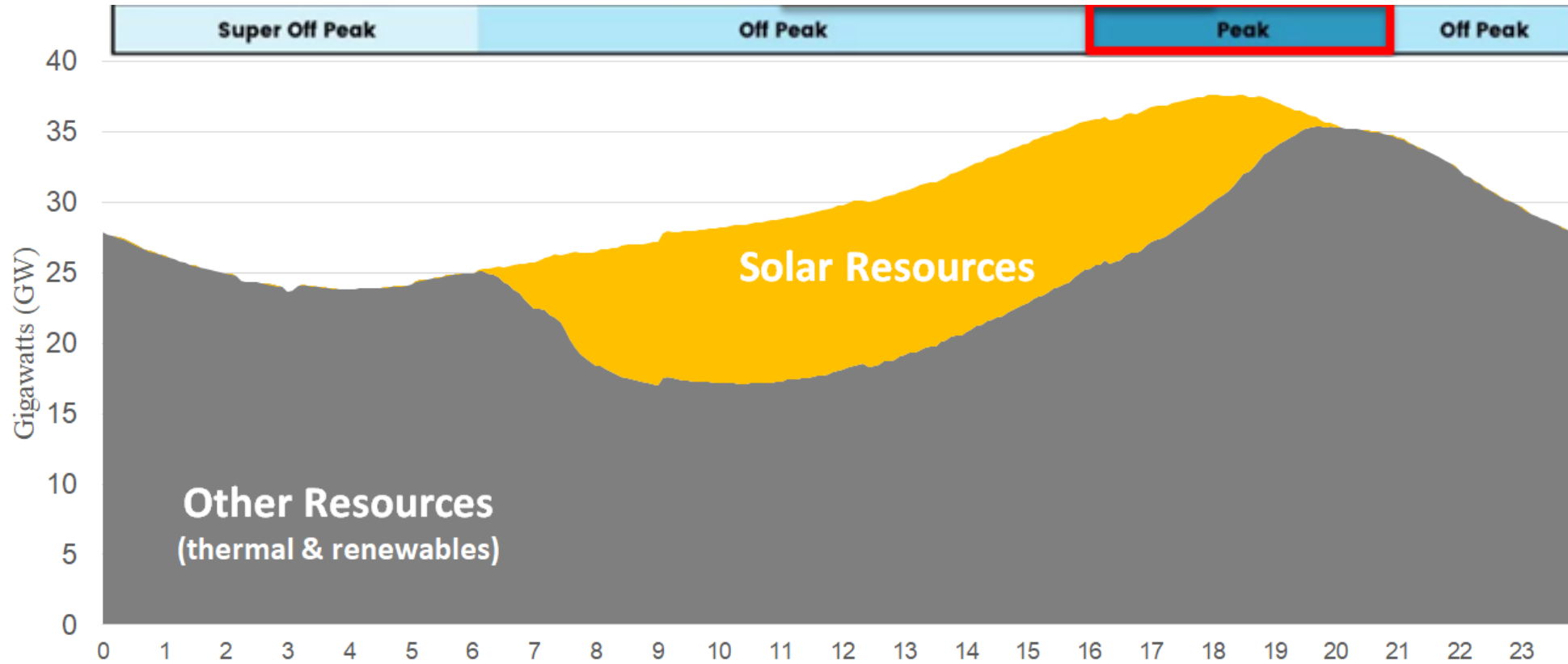
TARIFF ATTRIBUTES

Tariffs should be:

- Simple
- Understandable
- Feasible to implement
- Publicly acceptable

Example: CAISO Hourly Supply

February 14, 2019



CAISO – California Independent System Operator

Figure adapted from data from:

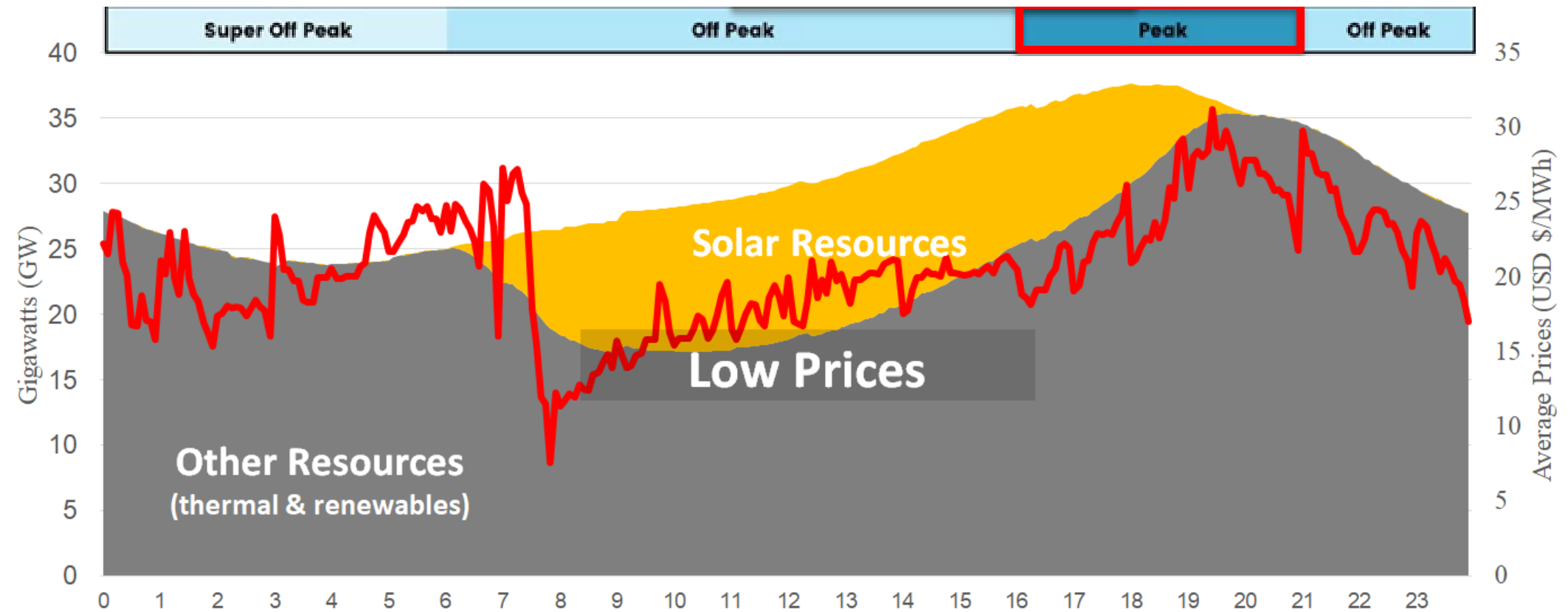
<http://www.caiso.com/TodaysOutlook/Pages/default.aspx>;

<http://www.energyonline.com/Data/GenericData.aspx?DataId=20>

Importance of Resource Availability, Price, and Load

Example: CAISO Hourly Supply and Prices

February 14, 2019

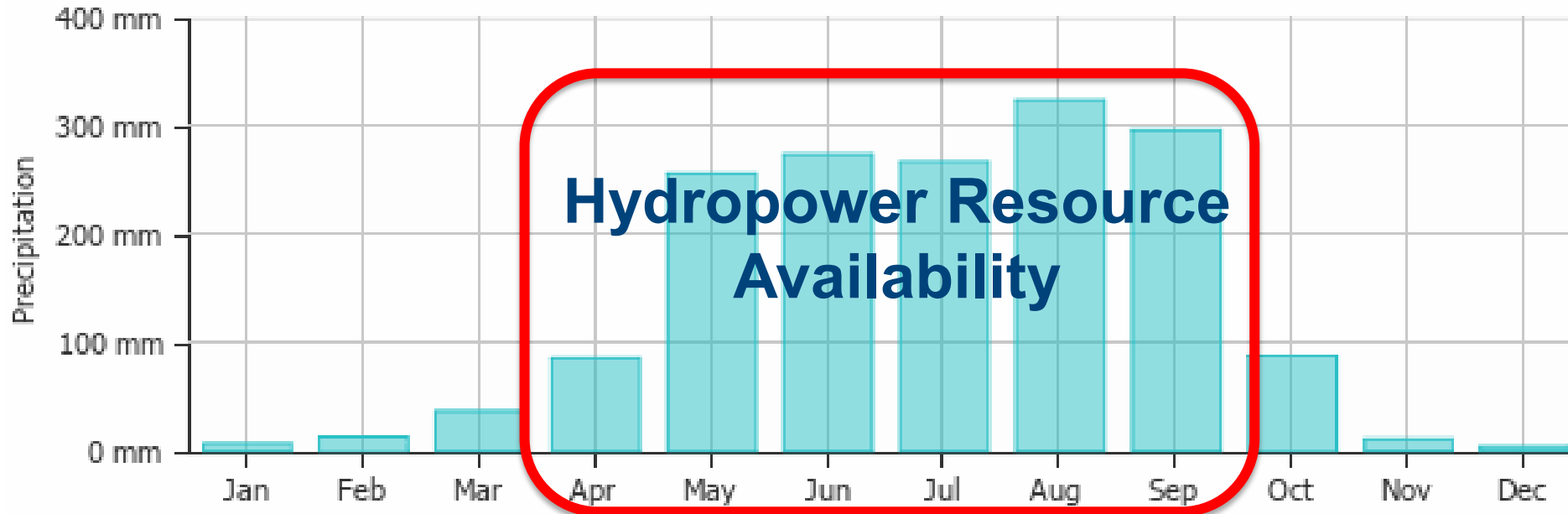


Tariffs can be designed that proactively influence load profiles if:

- The current load profile is understood
- The desired future load profile is understood
- How the resource availability and energy prices correspond with the load profile is understood

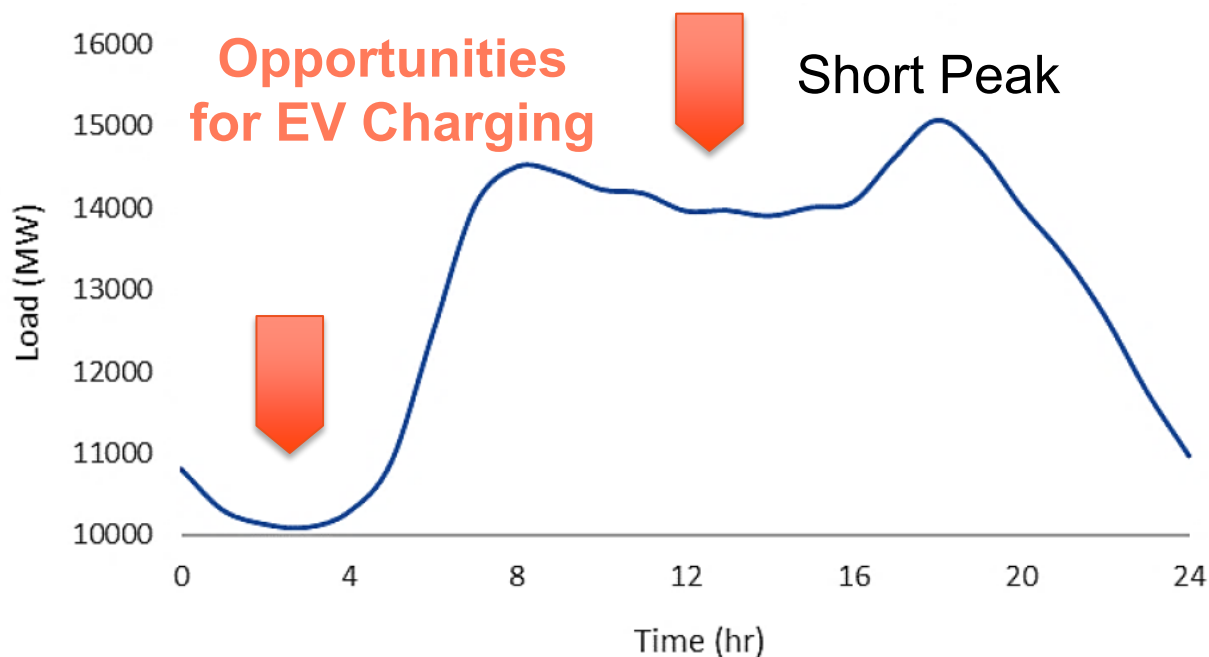
Importance of Resource Availability, Price, and Load

Example: Average Monthly Precipitation in Vientiane, Lao PDR

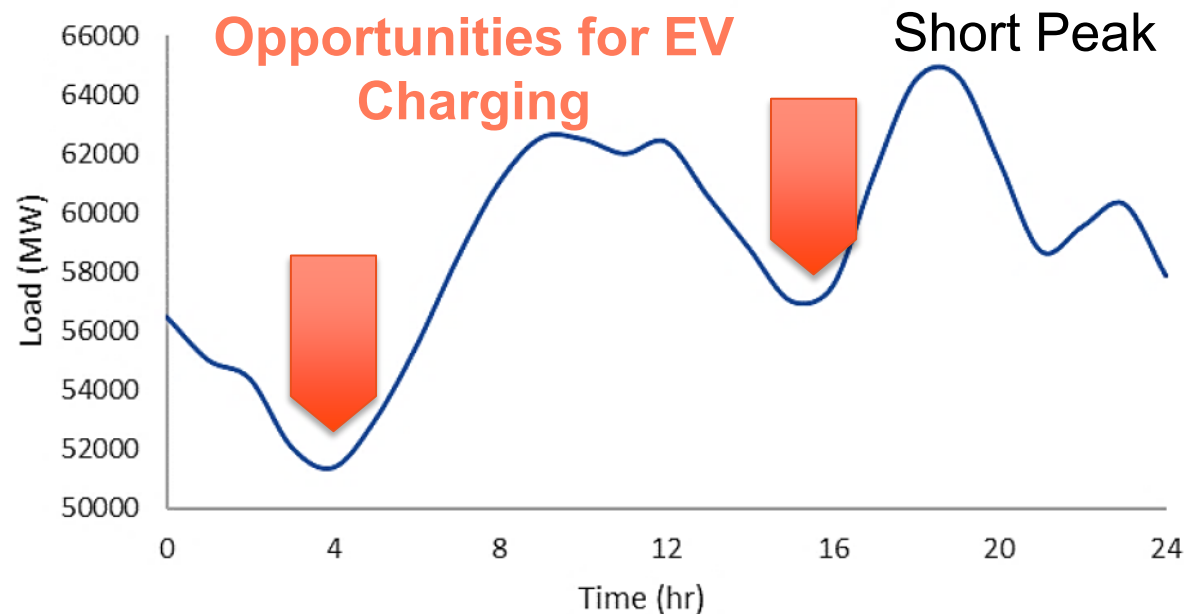


- Tariffs can be designed around seasonal resource availability if:
 - Seasonality of abundant, low-cost seasonal resources, such as hydropower is understood
 - Electricity demand patterns profiles during this season are understood
 - Appropriate seasonal tariff structure to capture these resources is identified
- Implementing seasonal tariffs does not require special meters

System 1 – Peak Day Load Curve



System 2 – Peak Day Load Curve



Existing distribution network capacity with tariff design can be exploited if:

- Network load profiles and utilization rates are understood
- Times with existing grid capacity for new loads, such as controllable EV charging loads, are identified

- **EV tariffs can be implemented using existing meters**
 - *Caveat:* Cannot distinguish between EV and non-EV load
 - *Caveat:* For time-variable tariffs, meter must have required capabilities
 - Typically need to measure electricity use over time
 - *Caveat:* For home charging, separate meter or ability to distinguish between EV and non-EV loads may be required
- **EV tariffs typically use new meters**
 - Allows EV and non-EV load to be separated
 - Allows custom design of meter capabilities
 - *Advantage:* Can more directly influence, measure, and bill for EV charging behavior
 - *Disadvantage:* Additional cost and administration needs
 - Government typically determines who pays for new meter

These considerations may also apply to general time-of-use tariffs.

Basic EV Charging vs. Smart EV Charging

Basic Charging



Erik Nelson, NREL

- ✓ Simple
- ✓ Affordable
- ✓ Less usage data available

Car-enabled Smart Charging



tesla.com

- ✓ User programs car to charge at cost-effective times
- ✓ More expensive EV required
- ✓ Less usage data available

EVSE-enabled Smart Charging



Matthew Staver, NREL

- ✓ EVSE can respond to utility signal
- ✓ More expensive EVSE required
- ✓ Less usage data available

Discussion Questions

1. What is the main goal of EV tariff design for your institutions?
2. What charging behavior do you want to see and why?
3. What was the motivation behind your current EV tariffs?
4. How could the EVSE tariffs for public EVSE users be structured in your jurisdiction?

Where and How Do We Charge?

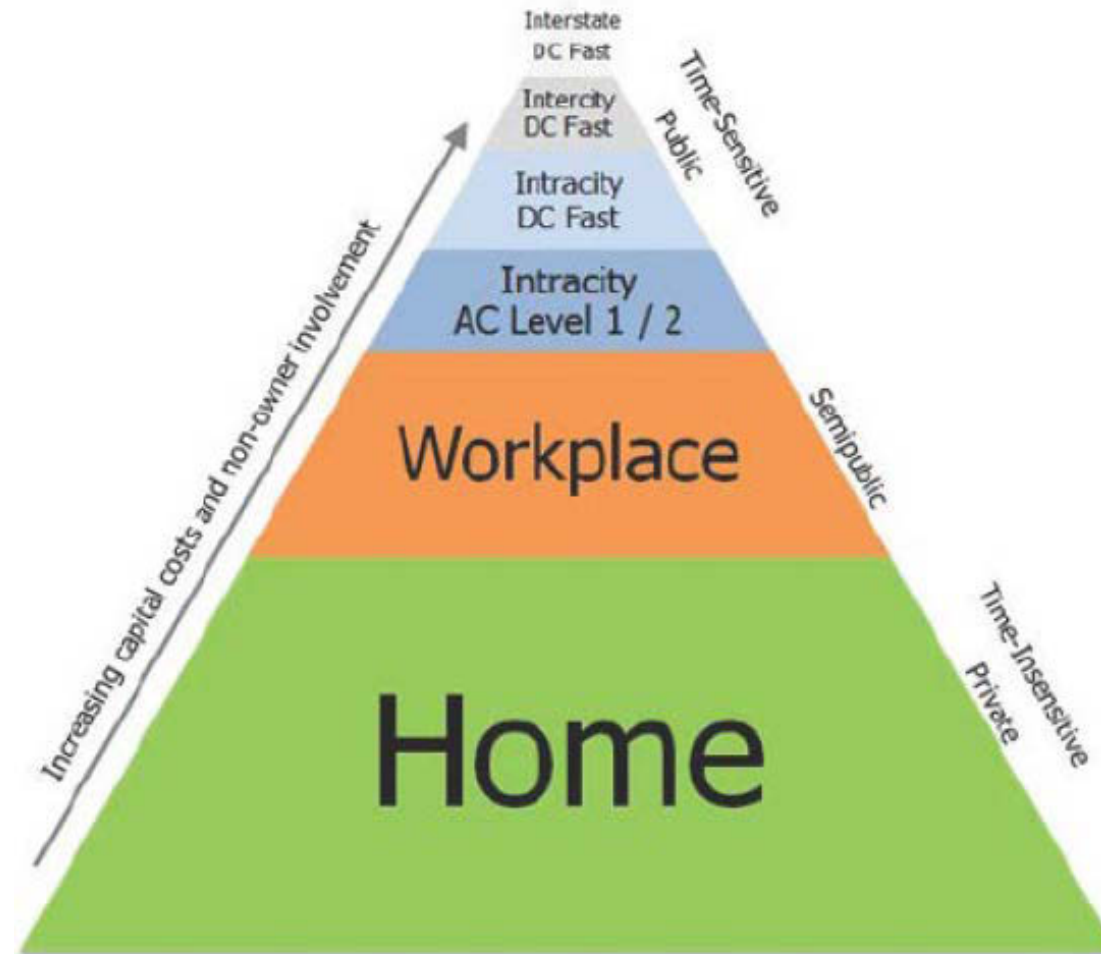


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Where and How Do We Charge?



Source: National Research Council. *Overcoming barriers to deployment of plug-in electric vehicles*. National Academies Press, 2015.

Comparing Home and Public Charging

Home Charging



tesla.com

Charging demand is more flexible and “elastic”
Drivers may park overnight or for a significant time

Long dwell (or stay) times

More flexibility on timing for charging

More responsiveness to tariffs

Public Charging



Kendall Septon, NREL

Charging demand is less flexible and “inelastic” Drivers want to charge immediately (like a gas/Shell/PTT Fuel station)

Short dwell (or stay) times

Less flexibility on timing for charging

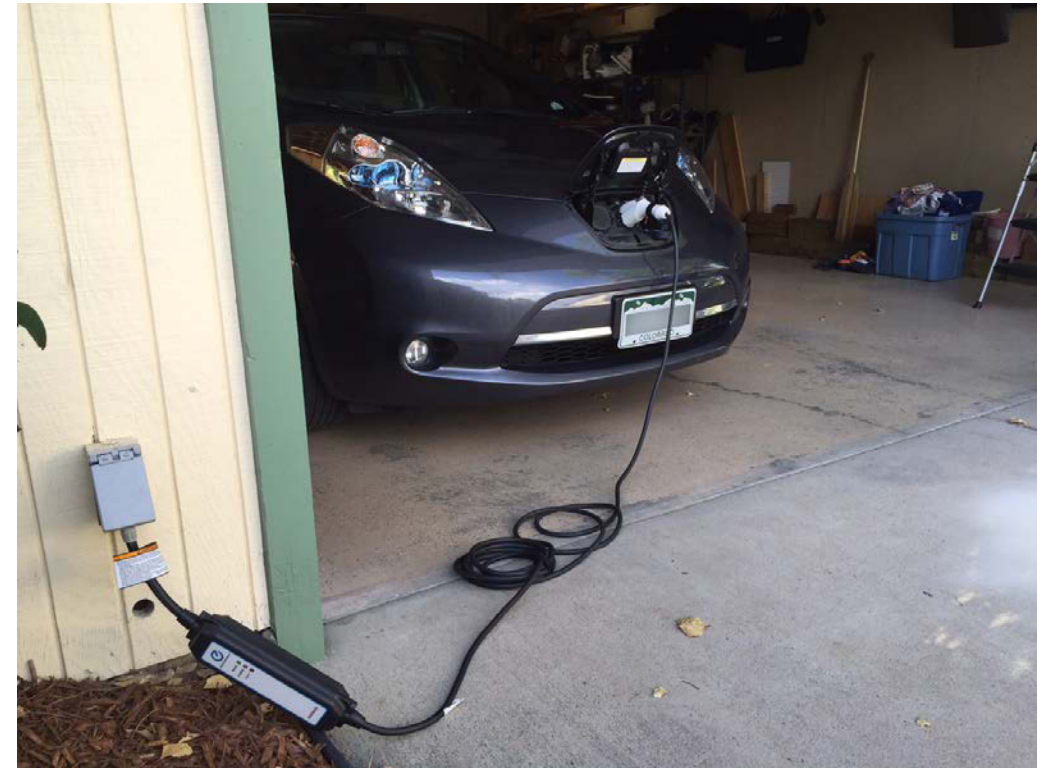
Less responsive to tariffs

Home Charging – EV Tariff Design Considerations



➤ Influence customer charging behavior

- Encourage home charging of EVs during desired times to reduce system costs
 - Improve utilization of existing network infrastructure
 - Manage growth in peak demand
- Avoid expensive transmission and distribution upgrades



Erik Nelson, NREL

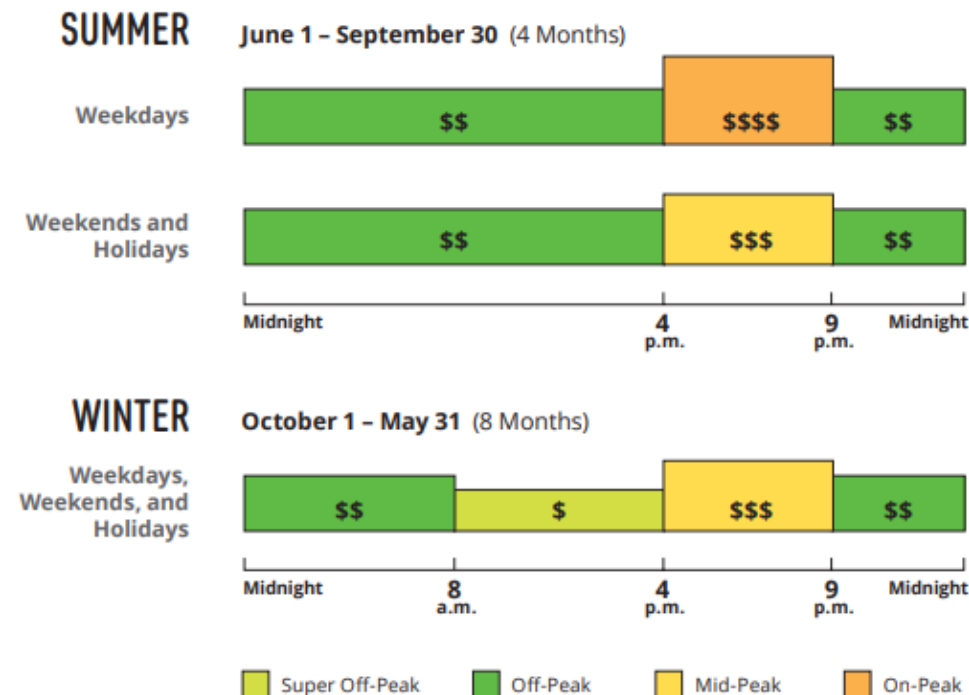
Tariff Considerations for Home Charging

Time-of-use energy rates

- If designed and communicated properly, residential customers can understand
- May require separate EV meter
- Aligned with system conditions, e.g., seasonal energy availability or hourly peak demand

Demand charges

- \$ per kW charge for peak demand
- Not typically applied to residential customers



Source: [https://www.sce.com/sites/default/files/inline-files/TOU-EV-7_8_9%20Rate%20Fact%20Sheet_WCAG%20\(2\).pdf](https://www.sce.com/sites/default/files/inline-files/TOU-EV-7_8_9%20Rate%20Fact%20Sheet_WCAG%20(2).pdf)

Metering Considerations for Home Charging

- **Issue:** Is an additional meter needed? What is the cost?
- **Issue:** Will EV charging occur at multi-family dwelling units?
- **Issue:** Will EV owners register for an EV tariff?



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- Car- and EVSE-enabled “smart” charging enables:
 - Customers to take advantage of a time-of-use tariff in an automated way
 - Utilities to reduce operational costs
- If more system-friendly charging behavior is desired, then this must be considered in program and tariff design
- Utility might offer a rebate for a smart charger (instead of offering for all chargers)



Matthew Staver, NREL

Discussion Questions

1. What EV home charging behavior do you want to create?
2. Are time-of-use or seasonal rates being considered?
3. Are new EV tariff meters required? Is “smart” EVSE required? Are rebates under consideration?

Public Charging – EV Tariff Design Considerations



- Ensure utility costs are recovered for serving public EVSE (if additional network investments are made)
- Ensure private sector businesses that own EVSE can recover their costs while charging EV owners a reasonable rate
- Ensure utility-owned or -franchised EVSE rates EV owners are charged are reasonable

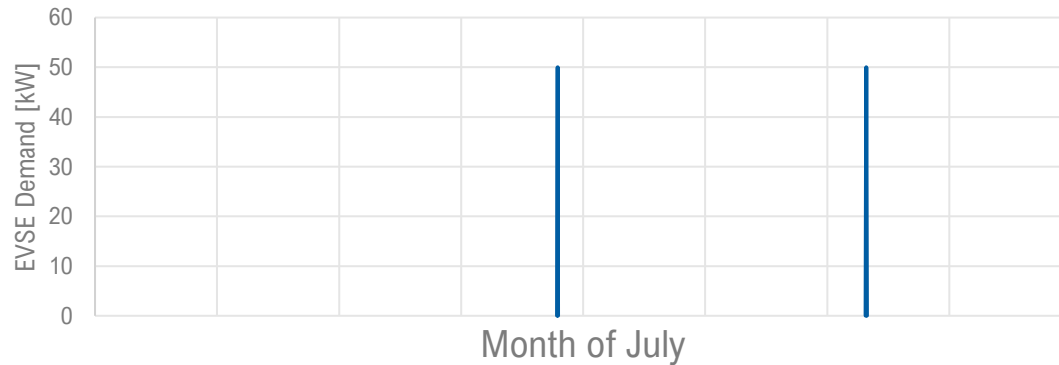


Photo by NREL

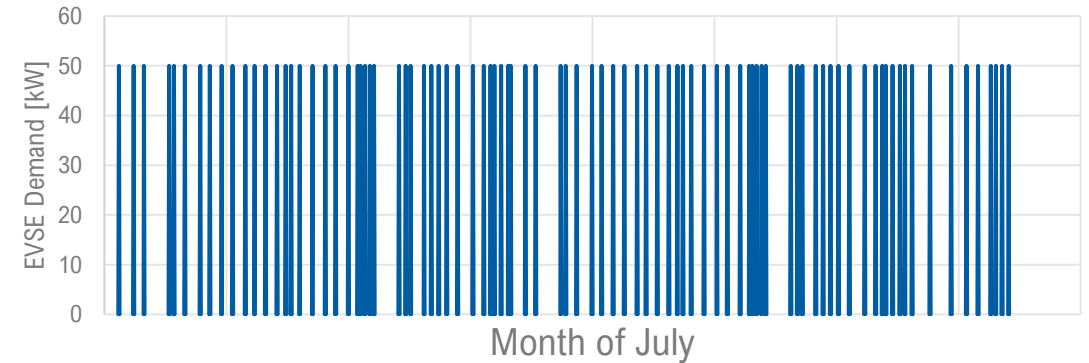
- **Customers are typically less concerned about price if they must charge at public EVSE**
- **Not all public EVSE in every location will be profitable, but it may be necessary for the public good**
 - Some public EVSE will have a low “utilization rate” (i.e., the percentage of time EVSE is being used by a customer)
- **Utility-owned EVSE is paid for by ratepayers and is inherently subsidized**
 - Profitability can be less of a focus
 - Still must decide on what rate to charge EV owners
- **Tariff design decisions strongly influence the profitability of privately owned EVSE (especially for low-utilization EVSE)**
 - “Make-ready” investments, direct subsidies, etc., also influence profitability
 - Subsidies are more important when an EV market is in its infancy

Demand Charges and Utilization Rates

Low Utilization DC Fast Charger

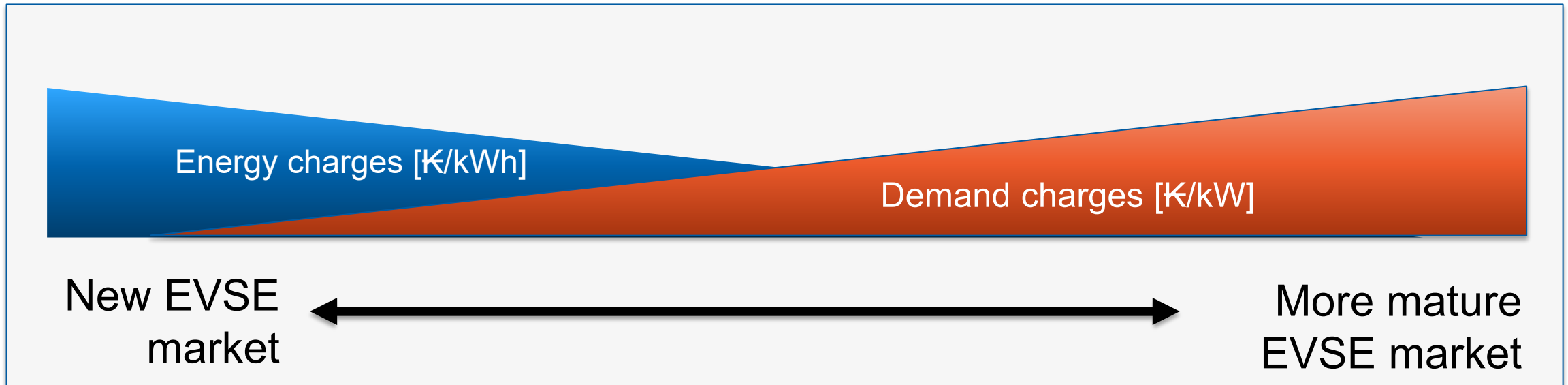


High Utilization DC Fast Charger



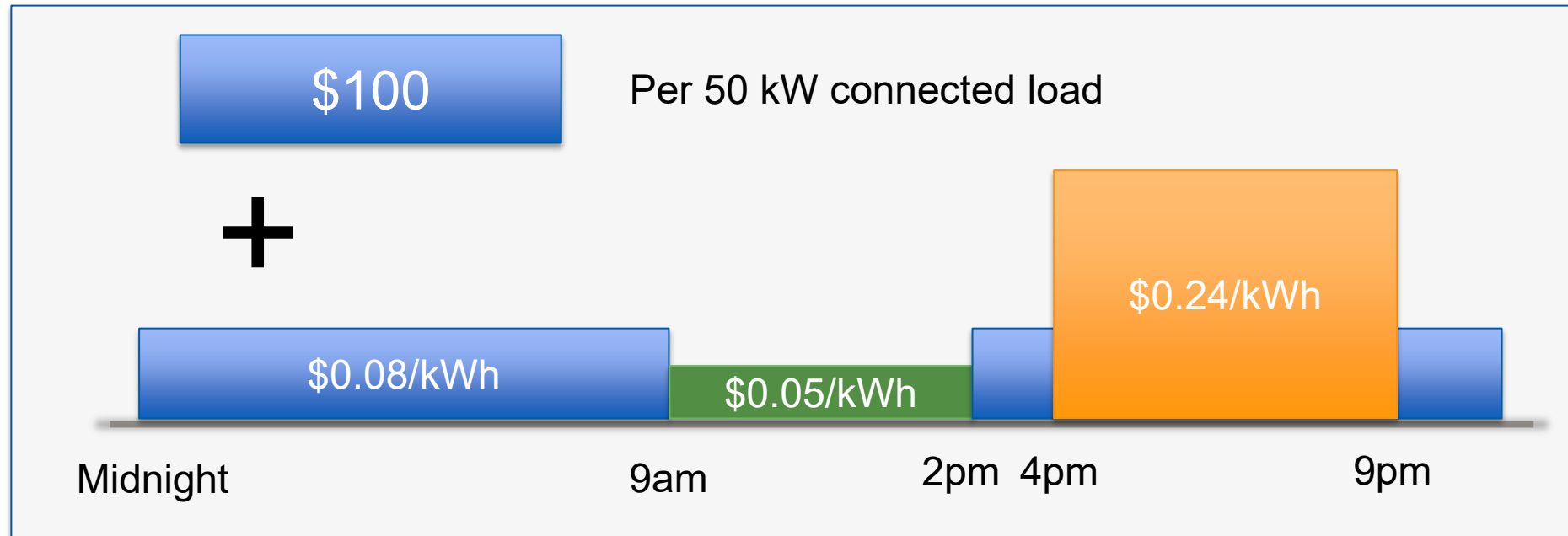
# of 30-minute charges per month	2
Total charging time	60 minutes
Total kWh used	50
Energy rate	\$0.10 per kWh (\$10)
Demand charge	\$4 per kW (\$200)
Total monthly bill	\$210
Equivalent price per kWh	\$4.20

# of 30-minute charges per month	200
Total charging time	6,000 minutes
Total kWh used	5,000
Energy rate	\$0.10 per kWh (\$500)
Demand charge	\$4 per kW (\$200)
Total monthly bill	\$700
Equivalent price per kWh	\$0.12



- Avoid demand charges while market is young, instead use volumetric energy charges
- As market matures, demand charges scale up and energy charges scale down
- Market maturity can be tracked based on EVSE utilization rates

EVSE Utilization	Energy Charge	Demand Charge
< 15%	\$0.25/kWh	\$0/kW
15–30%	\$0.20/kWh	\$1.25/kW
30–45%	\$0.15/kWh	\$2.50/kW
45–60%	\$0.10/kWh	\$3.75/kW
> 60%	\$0.05/kWh	\$5/kW



- ✓ Combination of **fixed charges** (based on connected load) and **time-of-use energy charges**
- ✓ No demand charges
- ✓ Time-of-use energy charge is matched so system conditions support cost recovery
- ✓ Tariffs are stable throughout year

Co-locating EVSE with Existing Load

- Some EVSE may be located next to existing commercial customer load (e.g., a shopping center)
- If demand charge, leads to relatively smaller incremental demand charge
- If energy charge, EVSE only pays for electricity used and shares smaller portion of other fixed bill charges



Walmart.com

Discussion Questions

Discuss the primary tariff design considerations for:

- **Low-utilization public EVSE**
- **High-utilization public EVSE**

Discuss these questions:

1. In what kinds of locations would you expect to see your EVSE?
2. What business models might be best suited for your EVSE?
3. What are the tariff design issues for your EVSE?
4. What types of tariff designs and/or subsidies might be appropriate for your EVSE?

Retail Customer Charges for Public EVSE



Tool: Price per 100 km by Fuel Type in Lao PDR Advanced Energy Partnership for Asia

NREL has created a tool to compare the cost to operate a vehicle per 100 km for the Lao PDR

- The user can change the price of the fuel and vehicle model
- The tool will then calculate the price to operate the vehicle per 100 km

The values shown for Lao PDR are for demonstration purposes only and are not intended to be the basis of any investment, policy, or regulatory decisions. The results are based on data available at the time of analysis, and results could be different if new data become available and are incorporated.

Table 1: Average Fuel Prices

Fuel Prices	Price	Metric
Electricity (Residential Rate) ¹	348.00	Lao Kip/kWh
Electricity (EVSE Providers) ²	780.00	Lao Kip/kWh
Diesel ⁴	7,900.00	Lao Kip/liter
Gasoline ³	8,890.00	Lao Kip/liter

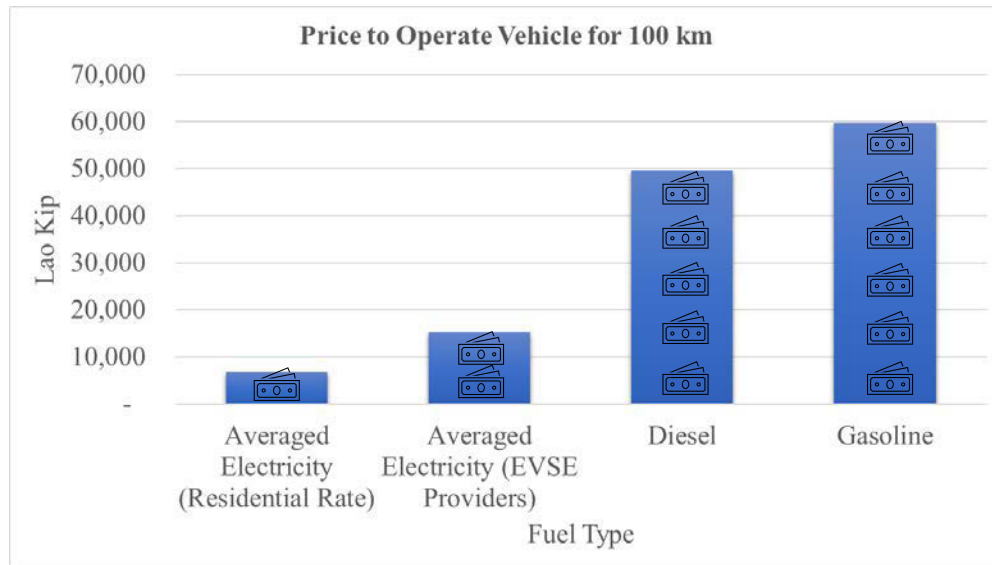
Table 2: Fuel Efficiency per 100 Kilometers:

Liters or kWh per 100 km	Fuel Efficiency	Metric
Electric (2020 BYD e6) 5	19.5	Average kWh/100 km
Gasoline (2019 Nissan Versa) ⁷	6.7	Average Lge/100 km
Diesel (2019 Chevrolet Cruze) ⁸	6.3	Average Lge/100 km

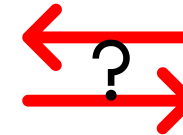
Table 3: Calculated Fuel Price per 100 Kilometers

Fuel	Price	Metric
Averaged Electricity (Residential Rate)	6,786	Lao Kip/100 km
Averaged Electricity (EVSE Providers)	15,210	Lao Kip/100 km
Diesel	49,557	Lao Kip/100 km
Gasoline	59,751	Lao Kip/100 km

1. Thythavy, Siphachanh. "Re: Draft Agenda for Lao EV webinar May 22." Message to Nate Lee. 13 May 2020. Email.
 2. National Renewable Energy Laboratory, United States Agency for International Development. (15 June 2020). Inception Report (Concept Note): Electric Vehicle Charging Infrastructure Business Model and Tariff Design Support to Lao PDR
 3. Thythavy, Siphachanh. "Re: Draft Agenda for Lao EV webinar May 22." Message to Nate Lee. 13 May 2020. Email.
 4. Thythavy, Siphachanh. "Re: Draft Agenda for Lao EV webinar May 22." Message to Nate Lee. 13 May 2020. Email.
 5. <https://afdc.energy.gov/calc/>. 29 kWh per 100 miles City or 36 kWh per 100 miles Highway. Average of 32.5 kWh per 100 miles.
 6. https://en.byd.com/wp-content/uploads/2017/06/e6_cutsheet.pdf
 7. <https://afdc.energy.gov/calc/>. 31 miles per gallon City or 39 miles per gallon Highway. Average of 35 miles per gallon.
 8. <https://afdc.energy.gov/calc/>. 30 miles per gallon City or 45 miles per gallon Highway. Average of 37.5 miles per gallon.



Dennis Schroeder, NREL



Warren Gretz, NREL

Graph based on "Price per 100 km" tool, sources available on previous slide

- Using electricity to power a vehicle is 3 to 8 times more affordable than gasoline or diesel
- There is ample room for EVSE owners to recover costs within their EVSE rate while remaining competitive with gasoline and diesel prices

The values shown for Lao PDR are for demonstration purposes only and are not intended to be the basis of any investment, policy, or regulatory decisions. The results are based on data available at the time of analysis, and results could be different if new data become available and are incorporated.

- Options for privately owned EVSE

Pricing Structure	Payment Models	Payment Collection Methods
<ul style="list-style-type: none">• Free (with limitations)• Flat fee (per session)• Per kWh• Per minute or hour of charging time• Combination (time + kWh)	<ul style="list-style-type: none">• Pay per session• Monthly subscription	<ul style="list-style-type: none">• Mobile app• Credit card processor• RFID reader (smart card or phone)• Access code

The pricing structures for public EVSE often vary by network. Most networks require customers to create an account and link their credit card to facilitate automatic payments during charging sessions.

Examples of Pricing Structures for Public EVSE



- By kWh consumed during session



- Tesla
- By kWh or by the minute (varies)



- Member & nonmember pricing
- By the hour or minute (varies)



- Monthly membership for unlimited charging
- Or priced per session (varies for L2 & DCFC)

Government Role in Setting Private EVSE Retail Customer Charges

OPTION 1: FULL MARKET COMPETITION

Government allows private sector to set customer charge



Private sector competition may reduce costs

OPTION 2: SET MAXIMUM CUSTOMER CHARGE

Government sets maximum customer charge



Private sector can compete to reduce charges below maximum

OPTION 3: SET CUSTOMER CHARGE

Government sets customer charge



All private EVSE has the same price

Establishing Customer-Facing Charges

Consumer-facing EVSE charges (options 2 or 3) may entail some combination of these or other considerations

Energy Rate for EVSE Providers
(charged by Electric Utility)

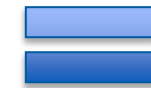
Considerations

Potential Rate for Public EVSE Users
(charged by EVSE providers)

\$/KWh



- What are socially acceptable charge levels for a jurisdiction?
- How much does the private sector or utility need to recover costs?
- How much should the private sector be allowed to profit from resale of electricity?
- Do different EVSE types (DC or level 2) and/or locations (capitol or village), utilization rates (low or high) have different costs?
- Other relevant considerations?



Discussion Questions

1. What should the role of your government be in setting privately owned public EVSE tariffs?
2. Should private EVSE owners be allowed resell electricity to customers (EV drivers) for a profit?
3. What pricing *structures* and *models* for privately owned EVSE may be applicable or are of interest to your jurisdiction?

Thank You!

Questions?



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