CLEAN POWER

11AM-12PM

BEACH WOMEN IN ENGINEERING

CONFERENCE 2022

CLEAN POWER

Moderator

DARR HASHEMPOUR

President and Founder
DH Green Energy

BEACH WOMEN IN ENGINEERING CONFERENCE 2022

CLEAN POWER
Speakers

SUSAN BRENNAN
President and CEO,
Romeo Power

DANA CABBELL
Director Integrated System Strategy,
Southern California Edison

BEACH WOMEN IN ENGINEERING

CONFERENCE 2022

ROMEO POWER

Tech Track: Clean Power

CSULB BEACH Women in Engineering Conference

April 8, 2022

Agenda

BACKGROUND

TODAY

ROMEO POWER AT-A-GLANCE

WHAT I'VE LEARNED

INSIGHTS FROM EXPERIENCE

ENGINEERING OPPORTUNITIES

Q&A

ROMEO POWER

BACKGROUND

ROMEO POWER

EDUCATION

- Bachelor’s degree in Microbiology from the University of Illinois
- Moved to Texas to conduct research for MD Anderson Hospital and Chemical Research for Hoechst-Celanese
- Master’s degree in Business Administration from the University of Nebraska at Omaha

ROMEO
POWER

TRANSITION TO AUTOMOTIVE

MOVED TO IOWA

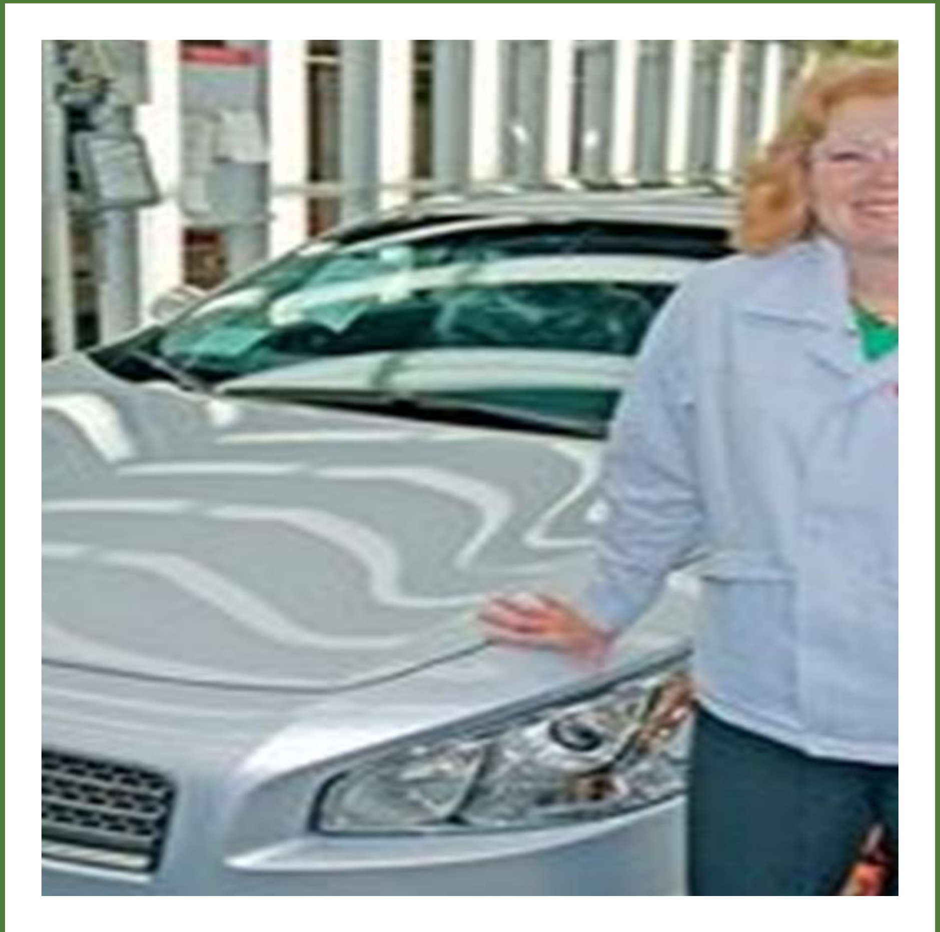
ACCEPTED JOB WITH DOUGLAS AND LOAMSON

CONTINUED MBA WITH THOUGHTS OF PHD

COMPLETED MBA AT UNIVERSITY OF NEBRASKA

BECAME PLANT MANAGER IN KANSAS CITY, MO

Ford



FORD

Factory Manager in Wayne, MI - Moved several times within Ford

- Plant Manager
- Director of Manufacturing for multiple assembly plants
- Director of Global Manufacturing Strategy

NISSAN

After years of restructuring, I moved to Tennessee

- Vice President of Manufacturing for Nissan's Smyrna and Decherd Tennessee plants.

ROMEO POWER


TODAY

After 30 years in the auto and energy industries, restructuring, growing, launching, and bringing in new technology…

I am now in Los Angeles working for Romeo Power where I plan on applying my years of manufacturing experience while learning and leading an energy technology company


Wayne
New York
Sunnyvale
Omaha
Red Oak
Champaign
St. Louis
Kansas City
Smyrna
Los Angeles
Houston
Corpus Christi

ROMEO POWER AT-A-GLANCE

ABOUT US

Romeo Power is on a mission to power the world's transition to electrification.

Romeo Power was founded in 2016 by a team of former Tesla and SpaceX engineers with a vision to create an electrified world where all have access to clean energy. Since then, we've laser-focused our collective engineering, entrepreneurial and networking skills to push high-density battery technology to its peak, to serve a market with a need for cleaner energy solutions now, and at scale: heavy-duty commercial vehicle fleets.

Together, we are Romeo Power. This is our bold vision to create an electrically powered world.

GOALS

At Romeo Power, we're not just in the business of delivering electrification solutions for complex commercial vehicle applications. We want to change the way people live. We have a bold vision to create a world where energy poverty no longer exists.

2016

Romeo Power Founded

2017

Vernon Manufacturing Plant Opened

2019

Heritage Environmental Partnership established

2020

Romeo Power Goes Public Through SPAC Merger

2021

Susan joins Romeo as CEO

2022

New Manufacturing Facility opening in Cypress, CA

MILESTONES

ROMEO POWER IN NUMBERS

~7

GWh Capabilities produced at 220,000 sqft Cypress facility

11

Worldwide Issued Patents & Patent Applications

100+

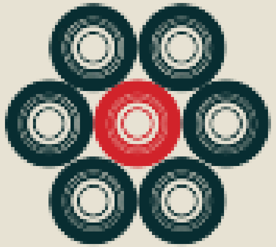
Engineering Professionals

325+

Growing Workforce

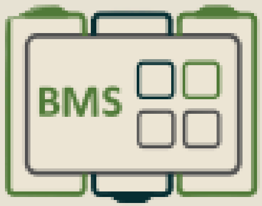
ROMEO POWER

What Makes Our Product Different



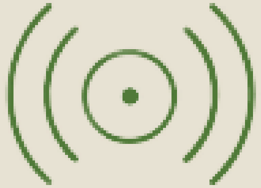
Single Cell Fault Tolerance

Through robust cell validation and safety testing, Romeo Power selects optimal cells and incorporates design features to mitigate thermal propagation.



Battery Management System

Algorithms detect faults to maintain safe operating conditions for the battery system. Combined hardware and software methods provide necessary controls for safe and long-term performance.



Sensing

Accurate monitoring devices at all levels (cell, module, pack and system) constantly measure voltage, current and key temperature locations for reporting to the battery management system.

What Makes Romeo Different

Powered by Nature - For far too long, we've taken from nature without replenishing. Now, here we are. We see and feel the effects and it's time for real change.

Curiosity is key to achieving our goal. It spurs innovation. It empowers us to find new ways to approach seemingly unyielding challenges. We embrace the tough questions because they're necessary to drive transformation. We have an opportunity to make universal energy a thing of the future.


WHAT
I'VE
LEARNED

Make career changes when the decision is "Low on Risk and High on Reward"

The possibilities are endless so don't close the door on anything

Take care of yourself

Build and maintain networks

Be a Lifetime Learner


INSIGHT FROM
EXPERIENCE

IS THIS REALITY?

Insight from Experience

Nourish Your Network

Don't lose connections with the people who have supported your journey along the way. Be agnostic to industry or role, you never know when a connection might be

Build a Brand

Use social media to have a brand and point of view and own it. Don't rely on your company's social media brand – make what they offer your own.

Give Back

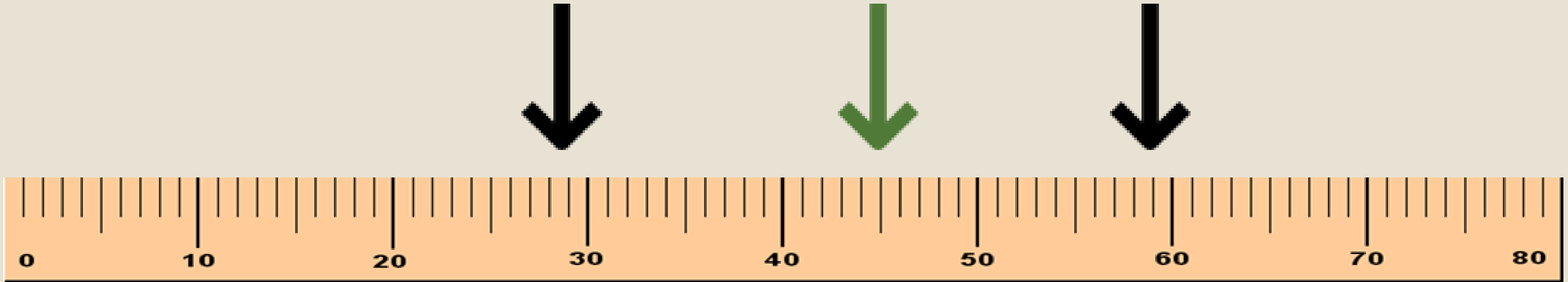
Mentor, speak, role model – the generation behind us can lose ground in the workplace if they don't understand many things that they enjoy today are hard to win and easy to

Don't Stay Stuck

Life is too short. Don't stay stuck somewhere – either in a job or mentally.

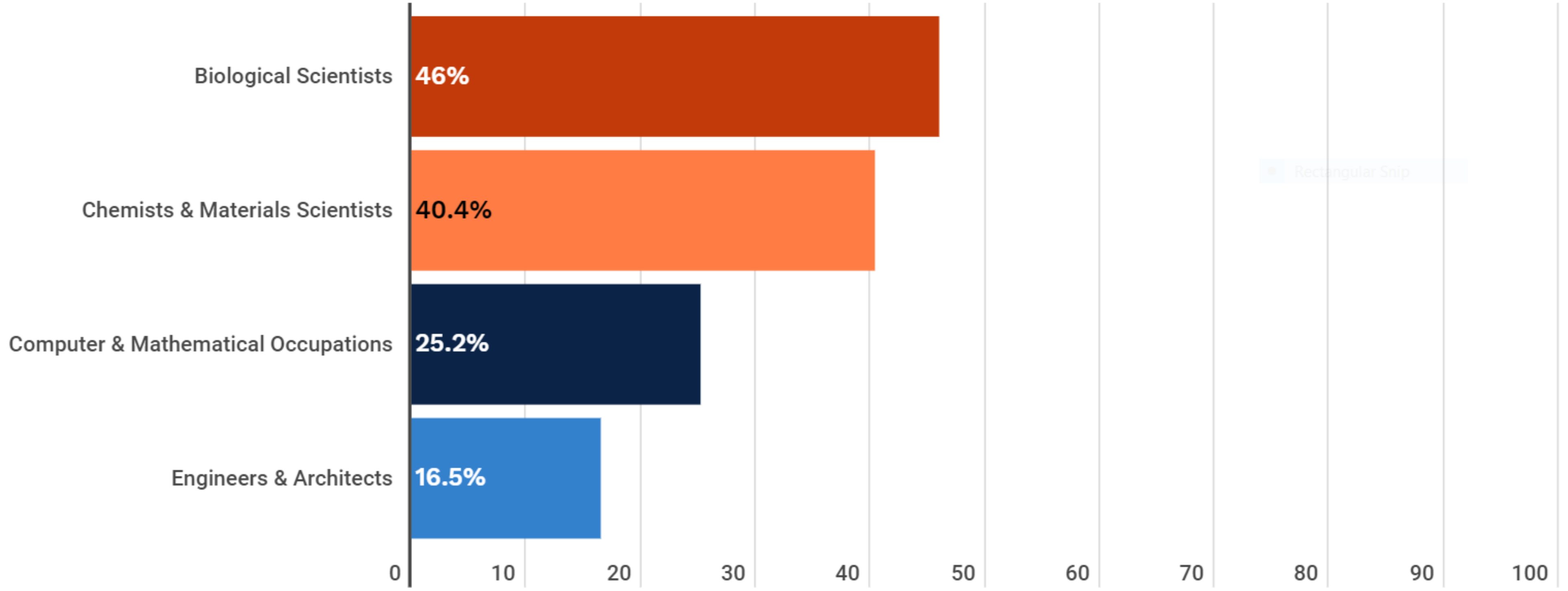
Insight from Experience

- Make sure you do what you love
- Other people are very good at spending your time
- Make sure you are focused on your goals and that they are clear to you
- Know your worth – and make sure those around you do, too
- Re-clarify your goals annually and then act



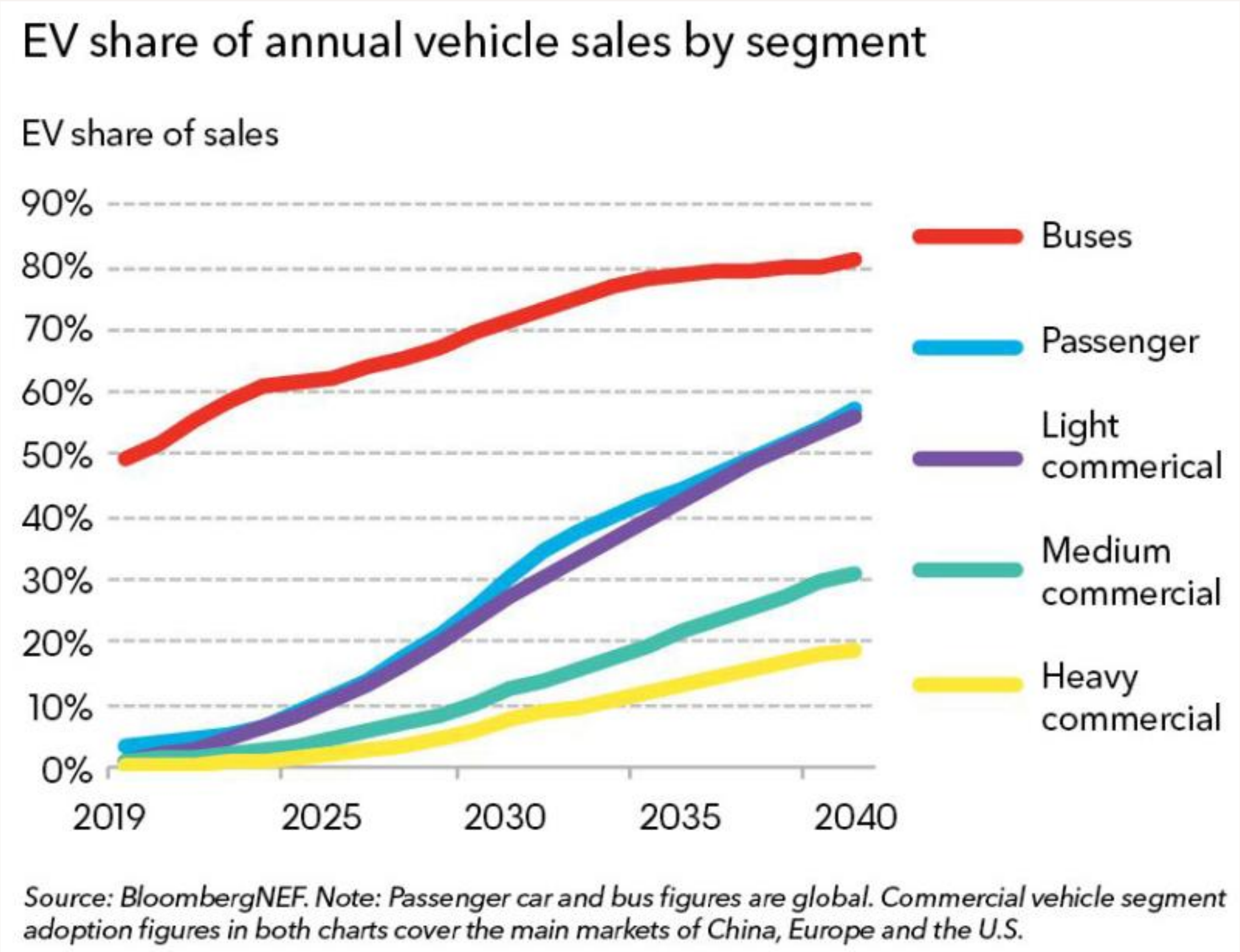
ENGINEERING OPPORTUNITIES

Women in STEM Occupations



SOURCE: U.S. Bureau of Labor Statistics, "Employed persons by detailed occupation, sex, race, and Hispanic or Latino ethnicity," Labor Force Statistics from the Current Population Survey, Table 11, 2020.

ELECTRIFICATION IS THE FUTURE



Opportunities for Engineers at Romeo Power

Our end-to-end engineering capabilities include cell science, mechanical, thermal, electrical, firmware systems and stress.

Battery Safety

Develop the new core technology of Romeo Power, make design improvements to all battery programs, and push our technology further for the next generation vehicles.

Battery Systems Applications Engineer

Anchor to create the technical bridge between the customers, external stakeholders and internal engineering teams to develop Electric/Hybrid Vehicle Battery Systems.

Mechanical Engineering - Packs

Ownership of component and/or system delivery from conception, design, manufacturing readiness, assembly and production launch through the EVT, DVT and PVT design and validation loops.

Electronic Design Engineer

Design and develop digital and analog electronics for the next generation battery management system of Romeo Power.

ROMEO POWER

Thank you

Q&A

Clean Power Panel – Transition to a Clean Power Grid

Women in Engineering Conference

April 9, 2022

Dana Cabbell, P.E.

Director, Integrated System Strategy

Southern California Edison

Dana Cabbell, P.E.
Director, Southern California Edison

Education

- ❖ BSEE, Cal Poly – San Luis Obispo
- ❖ Registered Professional Engineer, Electrical

Career Path

Southern California Edison

- ❖ Summer Intern – 3 summers
- ❖ Full-time upon Graduation -- Power System Planning Engineer to Director

Current Responsibility

Integrated System Planning:

- ❖ **Designs executable system strategies** that transform the electric system to proactively achieve SCE's strategic objectives
- ❖ Anticipate system needs through **comprehensive power system planning and analysis** and drive innovative activities informed by the analyses

SCE's Transmission System is Part of the Western Interconnection and Operated by the California Independent System Operator (CAISO)

One of three Investor Owned Utilities (IOUs) operated by the CAISO

CAISO at a Glance

50,300 MW peak demand

Over 30 million customers

CAISO oversees the operation of the bulk electric power system by managing the flow of electricity across transmission lines, serving 80 percent of California and a small part of Nevada (VEA)

SCE at a Glance

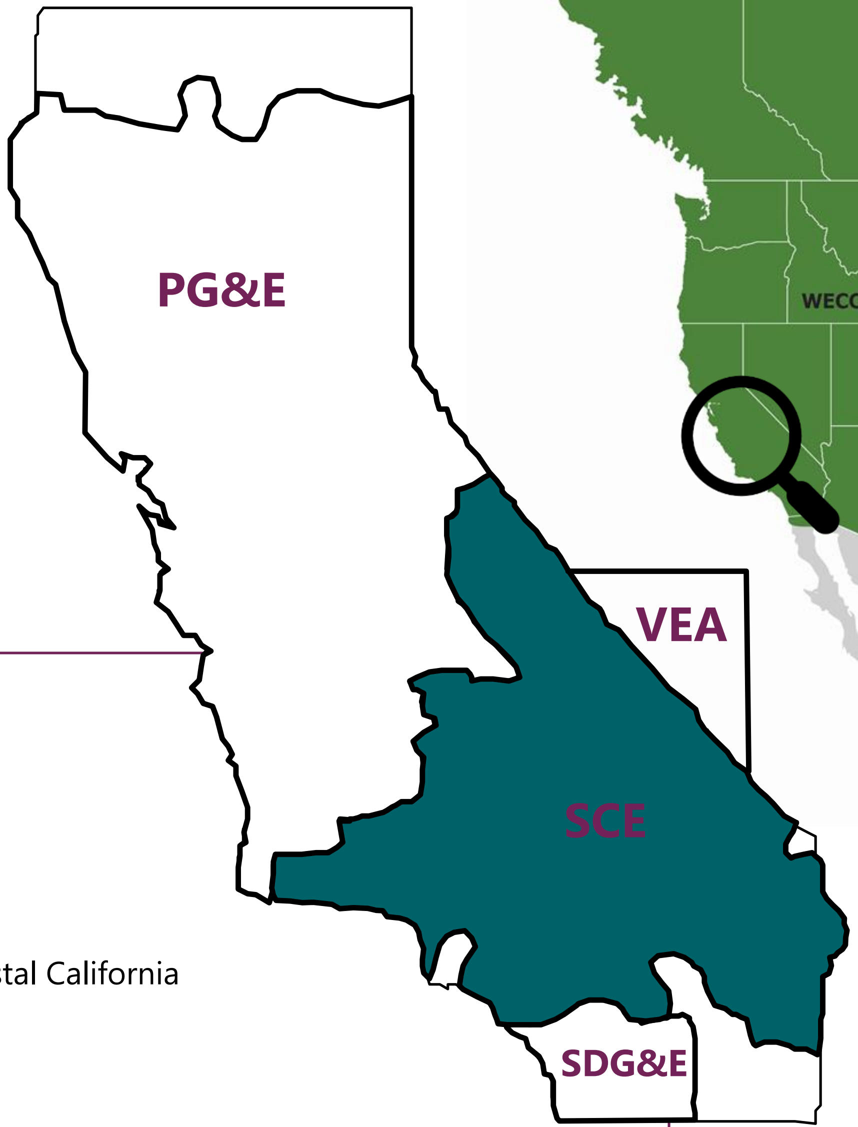
23,800 MW peak demand

5 million customer accounts
(serving 15 million residents)

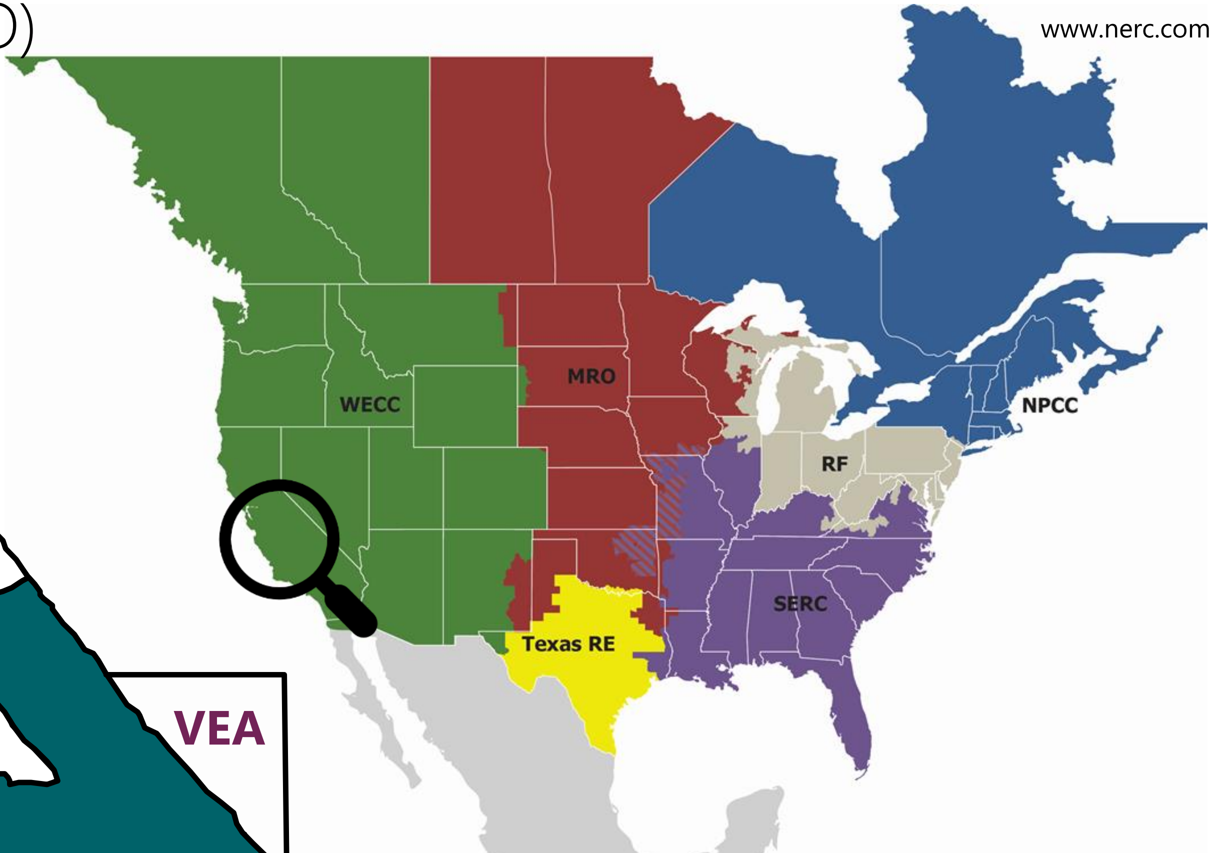
50,000+ square miles
service area across southern, central and coastal California

118,000 miles
of SCE distribution and transmission lines

43% carbon-free power in 2020
SCE's estimated delivered power mix from owned gen and third-party power procurements



www.nerc.com



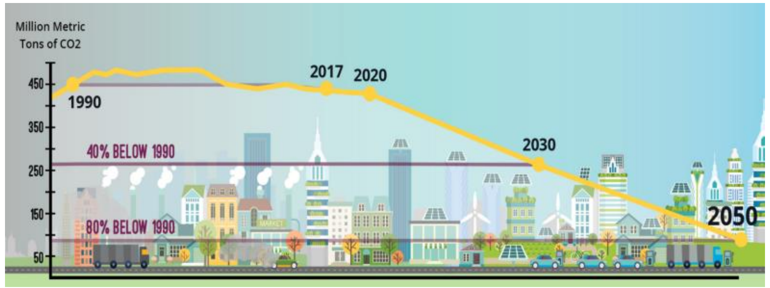
Eastern Interconnection
MRO – Midwest Reliability Organization
NPCC – Northeast Power Coordinating Council
RF – Reliability First
SERC – SERC Reliability Corporation

Western Interconnection
WECC – Western Electricity Coordinating Council

ERCOT Interconnection
TRE – Texas Reliability Entity

SCE's Perspectives to Achieve CA State Policy & Decarbonization Goals

California's climate-change goals include a 40% reduction in absolute greenhouse gas (GHG) emissions from 1990 levels by 2030, and 80% by 2050, as well as net-zero GHG emissions economy-wide by 2045



SCE is required by law to meet the following retail sales requirements for the power it delivers to customers:

- ✓ By 2020 – **33%** of power from Renewables Portfolio Standard (RPS)-eligible resources *(requirement met)*
- ❑ By 2030 – **60%** of power from RPS-eligible resources
- ❑ By 2045 – **100%** carbon-free power

Weblinks are provided below as a pre-read to the course, which outline SCE's perspectives to transform the industry towards a clean energy future and achieve decarbonization goals:

2020 Sustainability Report

Clean Power and Electrification Pathway
An integrated blueprint for California to reduce GHG emissions and air pollutants by 2030.

Pathway 2045
A data-driven analysis of the steps that California must take to meet 2045 goals, which identified 5 key actions for affordably achieving carbon neutrality.

Reimagining the Grid
An assessment of the grid changes needed to support GHG reduction goals, while adapting to evolving customer and climate-change driven needs.

Mind the Gap
An assessment of policy changes and additions needed to ensure California meets its GHG emissions reductions targets by 2030 in anticipation of its goal to decarbonize by 2045.

SCE'S PATHWAY 2045 OUTLINES FIVE ACTIONS CALIFORNIA CAN TAKE TO AFFORDABLY ACHIEVE ECONOMYWIDE CARBON NEUTRALITY

Decarbonize Electricity
100% of retail sales powered with carbon-free electricity

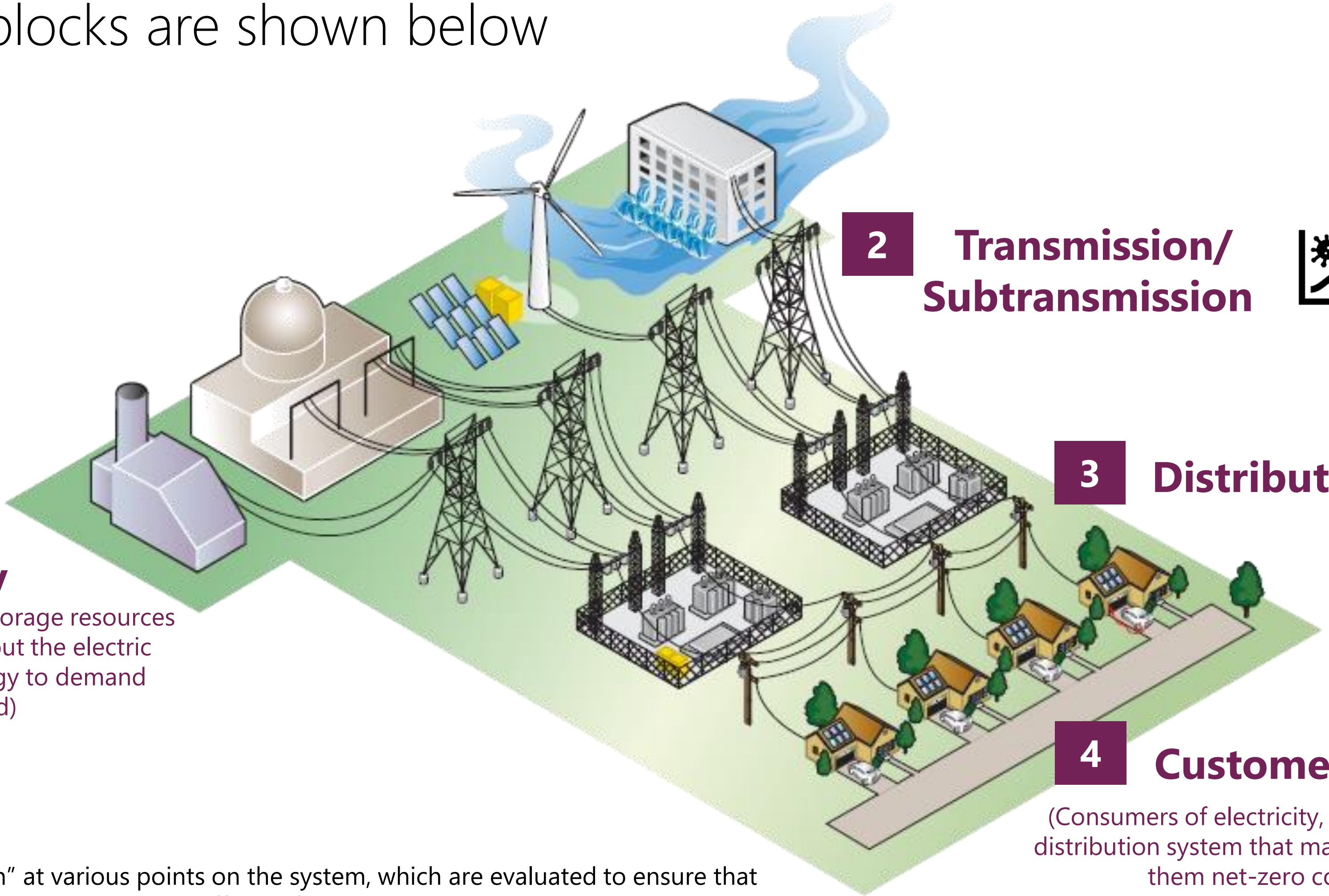
Electrify Transportation
Including three-quarters of light-duty vehicles, two-thirds of medium-duty vehicles and one-third of heavy-duty vehicles

Electrify Buildings
70% of space and water heating electrified in the built environment

Low-Carbon Fuels
Applications that are not viable for electrification to use low-carbon fuels

Carbon Sinks
Remaining carbon to be sequestered to reach carbon neutrality

The electric system is an interconnected network for supplying and delivering electricity from energy resources to consumers.
Its major building blocks are shown below



1

Supply

(includes generation and storage resources interconnected throughout the electric system that supply energy to demand when needed)

2 Transmission/ Subtransmission

3 Distribution

4 Customer

(Consumers of electricity, namely loads, typically served by the distribution system that may also have on-site resources, making them net-zero consumers or net-producers)

Hourly load profiles as “seen” at various points on the system, which are evaluated to ensure that grid infrastructure can always support the net effects of loads and generation both upstream and downstream. Profiles may be at the individual equipment level (i.e. circuit or transformer) or an aggregation of multiple facilities (i.e. a transmission corridor).

The future grid is becoming more complex with challenges that are changing the way we plan and operate the system

CUSTOMER

- Supporting **large adoption of DERs**[1] on distribution systems
- **Higher usage and load density** largely due to electrification
- **More end-uses that are sensitive to power quality** (e.g., power electronics)
- Overall, **increased reliance on electricity**

SUPPLY

- **Integrating very high levels of renewables** (intermittent and far from load centers)
- **Ensuring Resource Adequacy** with an evolving mix of resources
- Maintaining grid stability and resilience under **lower levels of inertia** with conventional generation retirements

CLIMATE

- Direct impacts to **performance of grid assets** from climate risks such as extreme temperatures, wildfires, and floods
- Climate-driven changes in **customer needs and electric service continuity**

1. Distributed Energy Resources.

Enabling **customer** programs & adoption of Distributed Energy Resources

Energy for What's Ahead℠

SOUTHERN CALIFORNIA EDISON®

What are Distributed Energy Resources (DER)?

Distributed Generation (Non-renewable)	**Distributed Generation** (Renewable)	**Energy Storage**	**Energy Efficiency**	**Demand Response**	**Plug-in Electric Vehicles**
					
On-premise generation resources such as diesel generators, fuel cells, combined heat & power, microturbines	Distributed generation from renewable sources—photovoltaic solar (PV), wind, geothermal, biomass	Devices that store electrical energy locally for use during peak periods or as backup	Any service or device that allows for reduced energy use while providing the same service	Technology that enables utility or third-party to control energy usage during peak demand and high pricing periods	Vehicles that can plug in and store energy in their battery

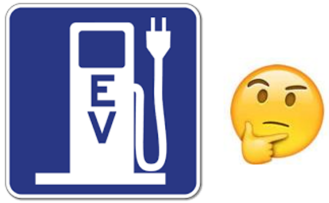
Transportation Electrification (TE)

Electric vehicle (EV) adoption is increasing in multiple sectors and there are load and grid infrastructure impacts with supporting from pilot to scale, especially Medium and Heavy-Duty (MD/HD) fleets. Grid planning activities include:

Customer Engagement and Education

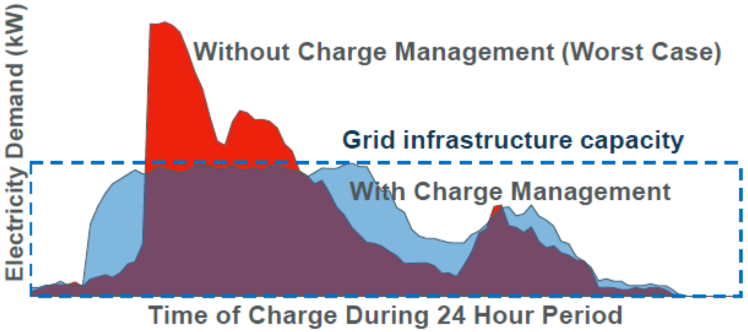
- Minimizing grid impact through customer engagement

"Right sizing"

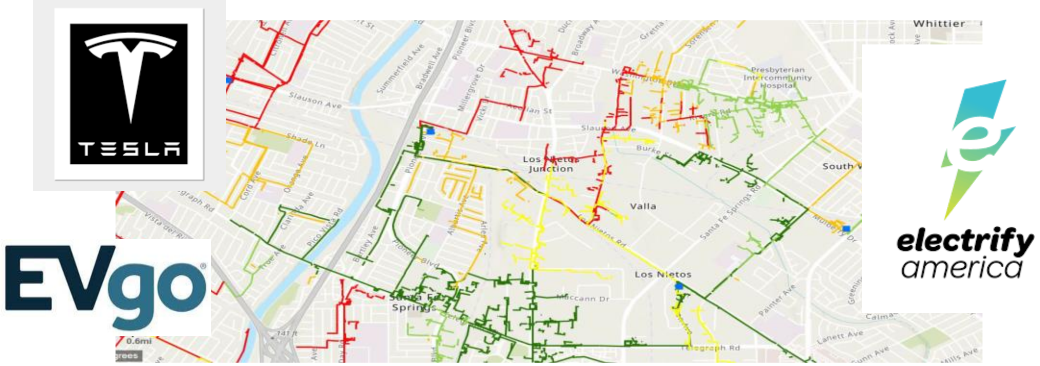


Level 2 or DCFC?

"Flatten the curve"

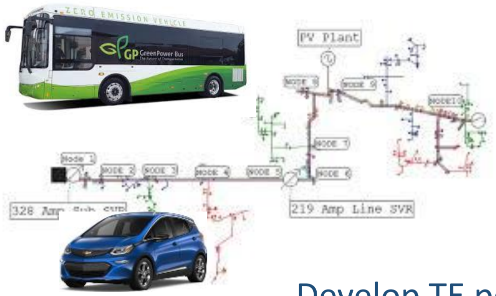


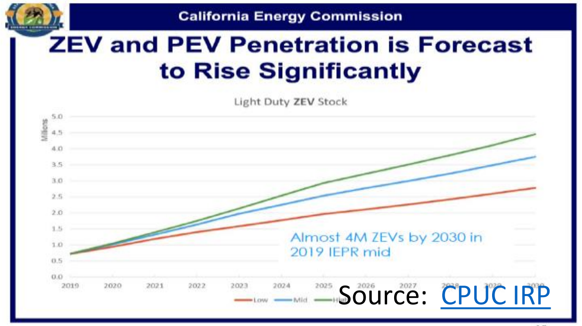
- Partnering with customers/regulators on optimal location siting



Forecasting and Grid Infrastructure Planning

- Improving locational TE forecasting accuracy and incorporating into existing planning processes





Source: CPUC IRP

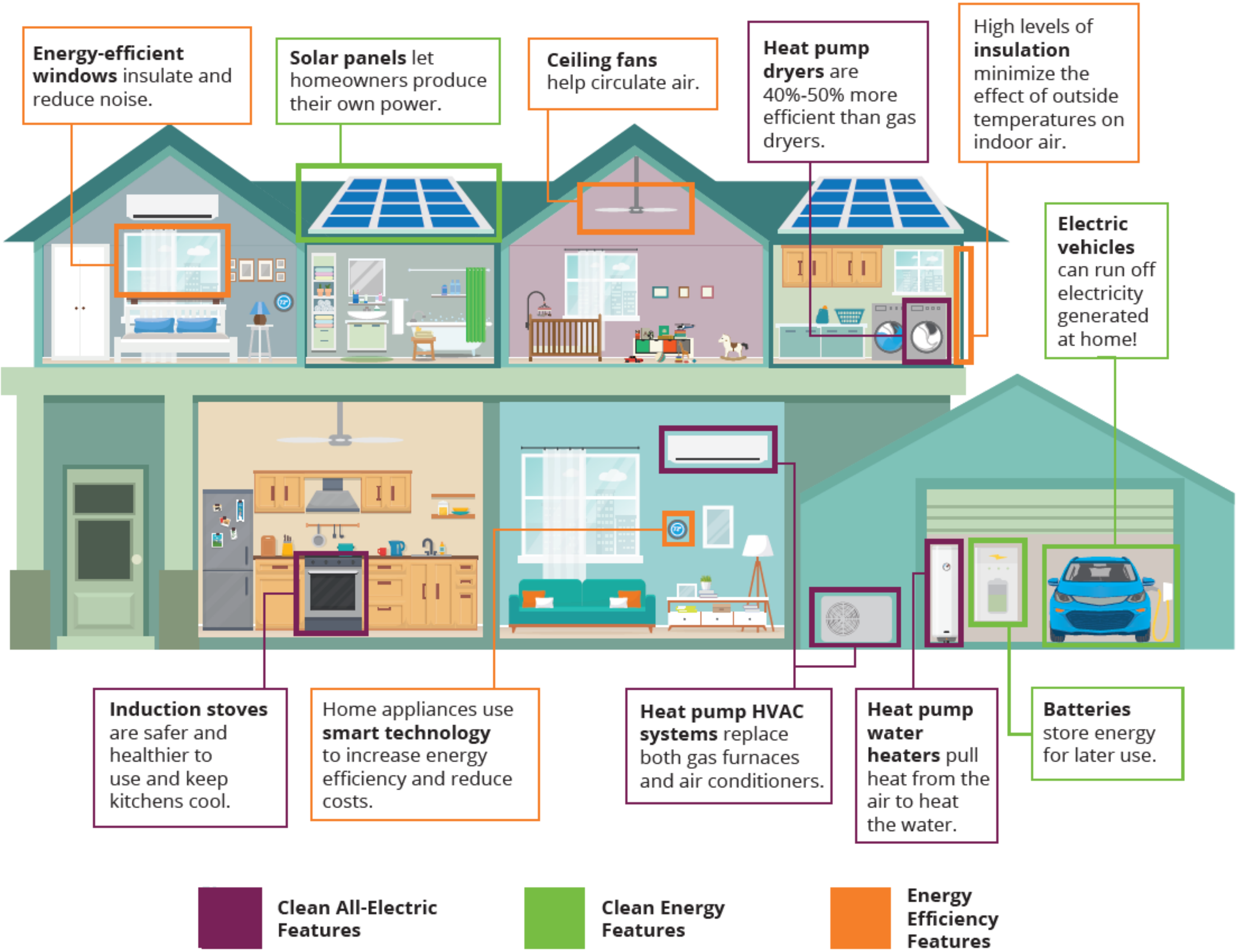
Develop TE policy/customer data process to improve both system-level and circuit-level TE forecast

- Refining our understanding of grid infrastructure needs to inform regulatory policy

- Streamlining licensing and environmental review process for new grid infrastructure required to support (i.e. substations)

Building Electrification (BE) is common across decarbonization strategies and will result in greater electrical demands

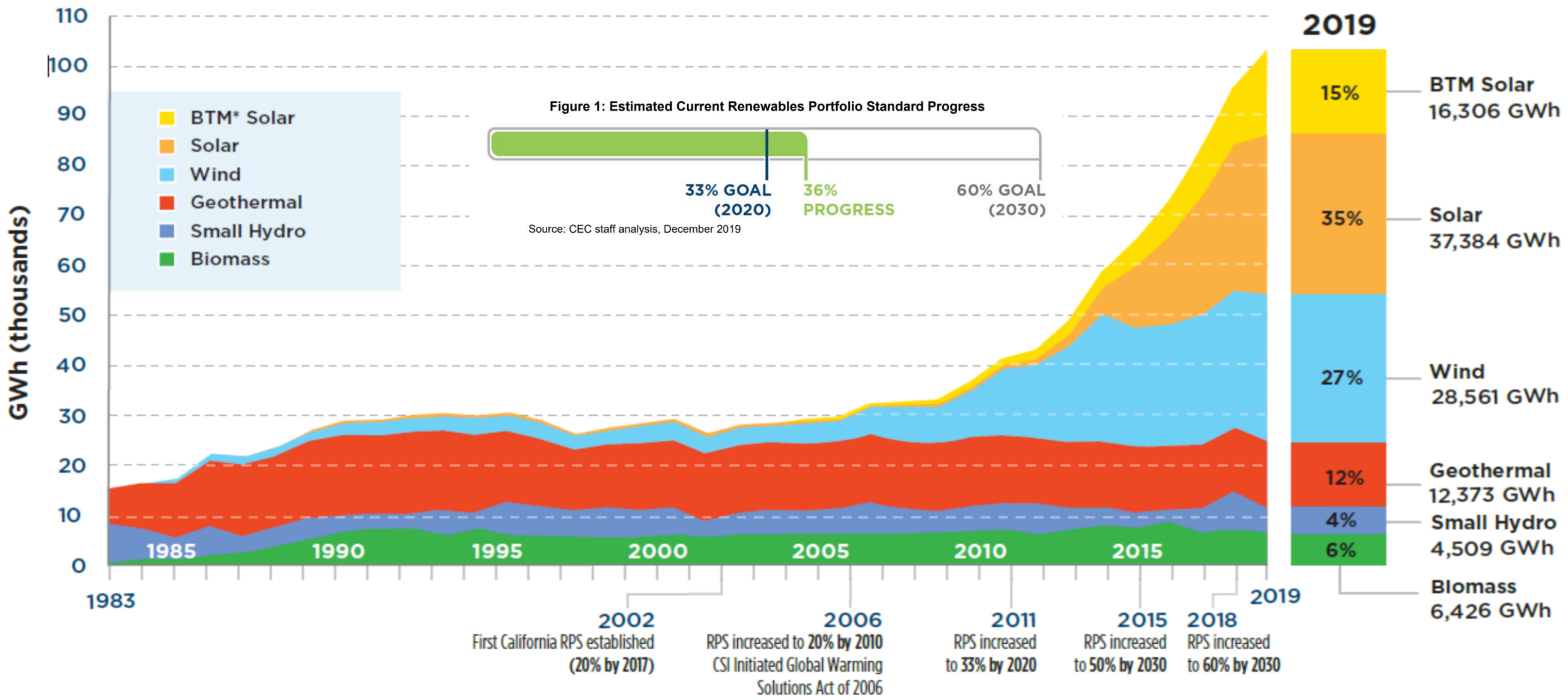
BE involves substituting gas end-uses at the end of their useful life with high efficiency electric end-uses, such as heat pump technologies, as well as in newly constructed buildings



Source: Edison.com

Transitioning **supply** and integrating renewables

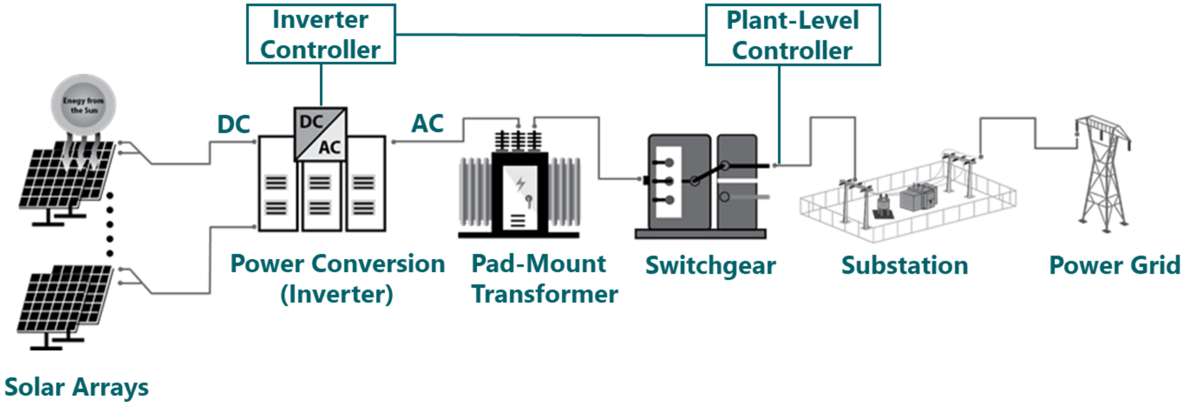
Figure 6: Total Renewable Generation Serving California Load by Resource Type



Source: CEC staff analysis, December 2019

Integrating Inverter-Based Resources (IBR)

Operating Challenges		
Short circuit duty and contribution	Erroneous frequency tripping	**Momentary cessation**
Plant controller ramp rate interactions	Phase lock loop synchronization issues	DC reverse current tripping
Instantaneous voltage tripping	Low short-circuit strength networks	**System inertia**

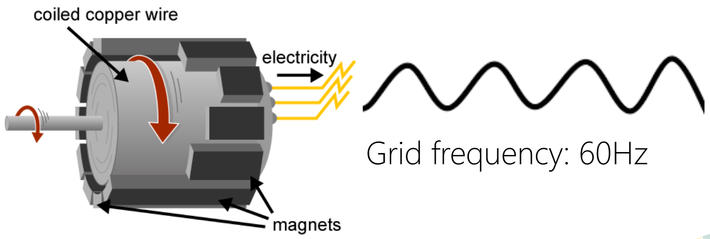


Ongoing Efforts to Address

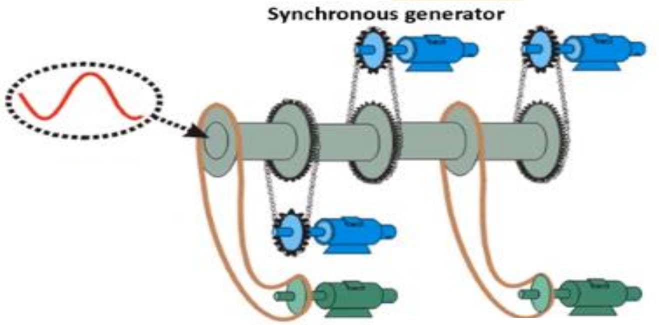
- Development of standards and performance requirements (differentiation between distribution and BPS-interconnection operational needs
  - IEEE 1547 for DERs
  - IEEE P2800 for bulk-power interconnections
- **NERC Modeling, Verification, and Assessment of BPS grid disturbances involving solar PV reduction**
- Reliability Guidelines
  - BPS-Connected IBR Performance: *to guide inverter manufacturers and Generator Owners*
  - Improvements to Interconnection Requirements for BPS-Connected IBRs: *to guide utilities*
- Fast Frequency Response Concepts and BPS Reliability Needs

In today's grid, synchronous generators' inertia acts as a shock absorber to changes in frequency

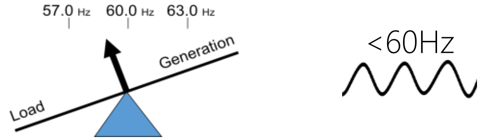
Synchronous generators have a rotating mass that spins at a frequency proportional to the AC electrical power being generated for the grid, 60Hz



Asynchronous generators such as inverter-based resources lack rotating parts. They connect to the grid either completely or partially through a power electronic converter interface. **Software installed in the power conversion system governs inverter behavior**



0 **Following a grid disruption** (e.g., line trip, generator drops offline), grid frequency drops since demand > supply

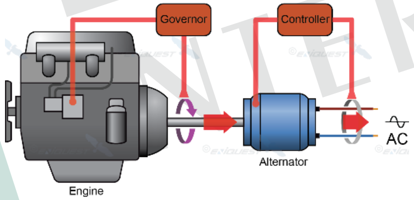


HISTORICAL GRID SUPPLY
Primarily synchronous generation

FUTURE GRID SUPPLY
Primarily asynchronous generation

1A Because of their rotational inertia,[1] synchronous generators (SG) **continue spinning and generating energy for ~3-5 seconds** after the disruption, and this "stored energy" **temporarily makes up for the under-supply**

1B This action slows down the generators but **provides time for the governor in the SG to detect the imbalance and respond** by speeding up the generator to balance supply / demand



1C A central control system (AGC) run by the grid operator then takes over to assure recovery

1D Normal grid frequency restored

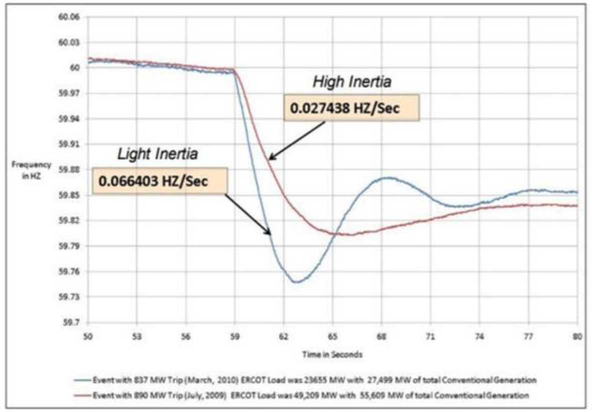
60Hz

2A If the frequency falls below a specific level, portion of customer load is shed to balance remaining load and protect grid equipment

2B Large-scale **generators slow down beyond operating threshold and trip offline**, DERs also trip offline known as under-frequency tripping.

2C This **can have a domino effect leading to system collapse**

In Southwest 2011 blackout, when SCE disconnected from the SDG&E system, the resulting drop in frequency caused a blackout



Source: NERC Frequency Response Initiative Report, 2012

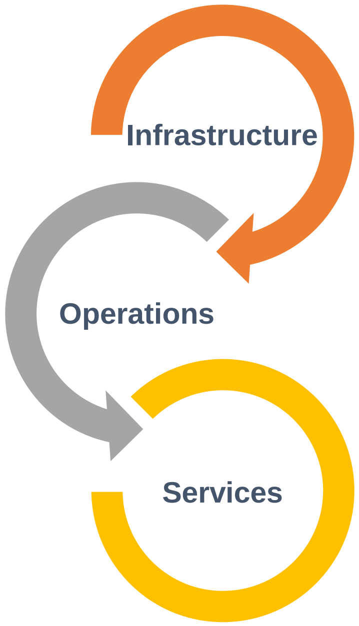
Source: NERC. 1. In synchronous machines, there is a direct electromagnetic coupling between the machine and the power system enabling the machine to contribute to system inertia (measured in MW-sec)

Planning for Climate Change

Identify infrastructure, operations, & services with the greatest risk to climate hazards 10 to 50 years in the future with proposed mitigation options to solve identified risks, starting with a **vulnerability assessment** & prioritization approach

Climate Hazards

- **Temperature**
- **Sea-Level Rise**
- **Wildfire**
- **Precipitation**
- **Cascading Impacts**



How might climate change affect us?

Exposure → Potential Impact ← Sensitivity

Potential Impact + Adaptive Capacity → Vulnerability

How might we manage these effects

Undertake **adaptation** to reduce vulnerability and **enhance climate resilience**

System Level Vulnerability Assessment

Transmission → Sub-Transmission → Distribution

System sensitivities are tailored towards system reliability & safety

Reduced Line Capacity	Sea Level Rise Flood Impact	Fresh Water Flood Impact	Wildfire Impact

System adaptive capacities to be studied

Outage Contingencies	System Resilience & Redundancies	WECC-approved Operating Load

Mitigation strategies will be developed for climate exposure risks

Near-Term (2030)	**Mid-Term (2050)**	Long-Term (2070)

List of Acronyms

A	Amps (current)
AC	Alternating Current
ADMS	Advanced Distribution Management System
AGC	Automatic Generation Control
BE	Building Electrification
BPS	Bulk Power System
BTM	Behind the Meter
CA	California
CAISO	California Independent System Operator
CEC	California Energy Commission
CPUC	California Public Utilities Commission
DC	Direct Current
DCFC	Direct Current Fast Charging
DER	Distributed Energy Resources
DERMS	Distributed Energy Resources Management System
DIDF	Distribution Investment Deferral Framework
DR	Demand Response
DSM	Demand Side Management
EE	Energy Efficiency
ES	Energy Storage
EV	Electric Vehicle
FAN	Field Area Network
FERC	Federal Energy Regulatory Commission
GHG	Greenhouse Gas
GIP	Generation Interconnection Process
GW	Gigawatt
GWh	Gigawatt-hour
HD	Heavy-Duty (vehicles)
Hz	Hertz
IBR	Inverter-Based Resources
ICA	Integration Capacity Analysis
IEEE	Institute of Electrical and Electronics Engineers
IEPR	Integrated Energy Policy Report
IOU	Investor-Owned Utility
IT/OT	Information Technology/Operational Technology
kV	Kilovolt
LOLE	Loss of Load Expectation
MD	Medium-Duty (vehicles)
MW	Megawatt
MWh	Megawatt-hour
NEM	Net Energy Metering
NERC	North American Electric Reliability Corporation
PEV	Plug-in Electric Vehicles
PG&E	Pacific Gas and Electric
PRM	Planning Reserve Margin
pu	Per Unit
PV	Photovoltaic (solar)
RA	Resource Adequacy
Re-MAT	Renewable Market Adjusting Tariff
RES-BCT	Renewable Energy Self-Generation Bill Credit Transfer
RPS	Renewable Portfolio Standard
SCADA	Supervisory Control and Data Acquisition
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SG	Synchronous Generation
SLG	Single-Line-to-Ground (fault)
T&D	Transmission and Distribution
TE	Transportation Electrification
TOT	Transmission Owner Tariff
TOU	Time of Use
VAR	Volt-Ampere Reactive
VEA	Valley Electric Association
VNM	Virtual Net Metering
WAN	Wide Area Network
WDAT	Wholesale Distribution Access Tariff
WECC	Western Electric Coordinating Council
ZEV	Zero Emission Vehicles

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https://bit.ly/BWIE-S6

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