# Valley Clean Energy CAC Meeting – Thursday, August 26, 2021
via video/teleconference

## Item 8 – Carbon Neutral Task Group Update

# Item 8 - Carbon Neutral Task Group Update: Charge

Charge: Assist staff and consultants in evaluating feasibility and creating a road map for both carbon-neutral and carbon-free-hour-by-hour power by 2030.[1]

Tasks:

- Support VCE staff's timetable for performing and completing this effort
- Assist in input for and evaluation of model development
- Evaluate different types of power that can be included in model
- Consider impacts of plan on future IRP

EJ component – consider importance of some local resources because of impact on local jobs.

1) Strategic plan reference Goal 2 and Objective 2.5.
** Note: Decarbonization and Grid Innovation (Goal 4) were initially part of the Task Group scope, but the group decided to make that part of a future Task Group due to the volume of work associated with Goal 2 and Objective 2.5.

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# Item 8 - Carbon Neutral Task Group Update: Timeline

**Q1 2021**

- Board approves Strategic Plan (10/8/2020)
- Task Group formed (1/28/21)
- Identify consultants
- Begin defining SOW

**Q2 2021**

- Compile inputs/ assumptions
- Identify eligible technologies
- Finalize consultant selection
- Board approval, if necessary
- Metrics to consider

**Q3 2021**

- Kickoff analysis
- Analyze findings & prepare initial plans
- CAC & Board engagement

**Q4 2021**

- Finalize plans
- Develop final report
- CAC & Board engagement

NOTE: The next IRP will be due no sooner than May 1, 2022, but appears likely to be extended. The CPUC is considering a staff proposal to streamline IRP/RPS filings, which could move the next full IRP filing to 2023 (with new IRPs filed every three years thereafter).

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# Item 8 - Carbon Neutral Task Group Update: Power Source Options

## Renewable Electricity

Includes “biomass, solar thermal, photovoltaic, wind, geothermal, fuel cells using renewable fuels, small hydroelectric generation of 30 megawatts or less, digester gas, municipal solid waste conversion, landfill gas, ocean wave, ocean thermal, or tidal current”, [(Public Resources Code § 25741), Renewables Portfolio Standard (RPS). (Public Utilities Code § 399.11 et seq.)] Renewable electricity is assumed to be free of GHG emissions.

## Carbon Free Electricity

Any electricity that meets the definition of renewable electricity above plus other sources considered zero emission. These zero emission sources now in California include existing large hydro (greater than 30 MW) and existing nuclear. New technologies not now included in the zero-emission category can be added in the future. Carbon Free power uses no fossil fuel generation. See https://focus.senate.ca.gov/sb100/faqs for FAQs on existing large hydro and existing nuclear and their inclusion in SB 100. The percent of the power that must meet RPS is governed by SB 100 (De Leon, 2018) and shall be equal to or greater than 60% for 2030 and beyond. By 2045 all electricity in California is to be Carbon Free.

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# Item 8 - Carbon Neutral Task Group Update: Analysis Time Frames

## Hour by Hour // 24/7

The Carbon Content of the Electricity provided is analyzed on an hour by hour basis. And for our purposes is either Renewable or Carbon Free Electricity each and every hour of the day. (8,760 hrs/yr)

## Carbon Neutral

The net carbon content of the electricity is analyzed over a period of time (usually a year) and the net carbon content is zero. During this period both sources that emit carbon and those that do not can be used, but the net carbon emissions are zero. Net zero can be achieved if zero carbon electricity is overproduced at certain times and that excess zero carbon electricity is demonstrated through available data to displace carbon emitting electricity on the grid at that time. If enough zero carbon electricity is overproduced, the net carbon emissions can be zero.

# Item 8 - Carbon Neutral Task Group Update: Portfolios

**POWER SOURCE**

| | HOUR BY HOUR | CARBON NEUTRAL |
|---|---|---|
| **RENEWABLE** | R/HBH | R/CN |
| **CARBON-FREE** | CF/HBH | CF/CN |

**ANALYSIS TIME FRAME**

"R/HBH/CF/CN": Renewable /Hour by hour/Carbon free/Carbon neutral

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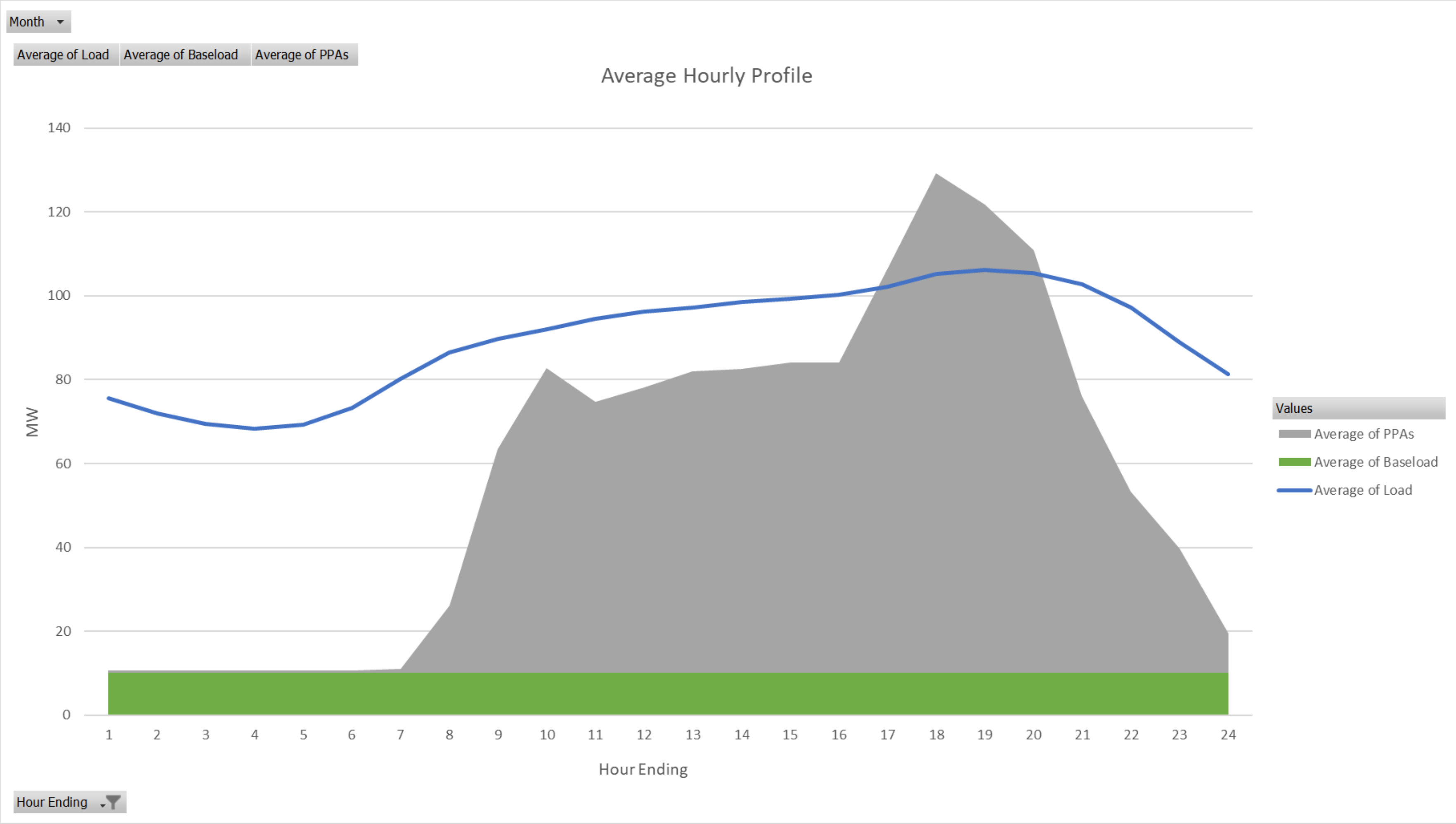
# Item 8 - Carbon Neutral Task Group Update: Portfolio technology diversity will be needed




1) Baseload is an assumed future agreement to satisfy CPUC Order.
2) Contracted PPAs will satisfy a portion of the portfolio but gaps remain that will be addressed in this Task Group study.

# Item 8 – Carbon Neutral Task Group: Project Scope, Schedule and Status

## Project Schedule and Status

| Task / Sub-Task | Month 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **Project Management** | | | | | | |
| Kick-off | Complete | | | | | |
| Progress updates | Complete | Not started | Not started | Not started | Not started | Not started |
| Weekly project controls | Complete | Not started | Not started | Not started | Not started | Not started |
| **Future Industry Trends** | | | | | | |
| Research future energy trends | In-progress | | | | | |
| Data request | In-progress | | | | | |
| Validate with VCE | In-progress | | | | | |
| **Load Profile Construction** | | | | | | |
| Review load and BTM resource data | In-progress | Not started | | | | |
| Prepare 8,760 and statistical inputs | Not started | Not started | | | | |
| IRP 8,760 forecast | Not started | Not started | | | | |
| Existing and planned 8,760 forecasting | Not started | Not started | | | | |
| Agree key risks and sensitivities | Not started | Not started | | | | |
| Validate with VCE | Not started | Not started | | | | |
| **Resource Cost Estimation** | | | | | | |
| Update resource cost estimates | Not started | Not started | | | | |
| Capital and operating costs by technology | In-progress | Not started | | | | |
| Fuel and carbon mitigation costs | Not started | Not started | | | | |
| Agree key risks and sensitivities | Not started | Not started | | | | |
| Validate with VCE | Not started | Not started | | | | |
| **Resource Portfolio Construction** | | | | | | |
| Configure production cost model | | | Not started | Not started | | |
| Identify least cost 8,760 100% renewables and zero carbon portfolios | | | Not started | Not started | | |
| Identify least cost annual 100% renewables and zero carbon portfolios | | | Not started | Not started | | |
| Minimize scenario costs | | | Not started | Not started | | |
| Consider market interactions | | | Not started | Not started | | |
| Agree key risks and sensitivities | | | Not started | Not started | | |
| Validate with VCE | | | Not started | Not started | | |
| **Risk Analysis** | | | | | | |
| Identify key risks | | | | Not started | Not started | |
| Develop risk mitigations | | | | Not started | Not started | |
| Validate with VCE | | | | Not started | Not started | |
| **Documentation** | | | | | | |
| Draft portfolio study report | | | | | Not started | Not started |
| Develop risk report | | | | | Not started | Not started |
| Revise portfolio study report | | | | | | Not started |
| Develop data pack | | | | | | Not started |

= Complete = In-progress = Not started

- Future Industry Trends research is almost completed
  - Validation with Community Advisory Committee (CAC)
- Sensitivities under consideration
  - EV penetration
  - Building electrification penetration
  - Rooftop solar penetration
  - Weather / climate change
- Data request fulfilment well underway
- Load profile construction commencing
- Resource cost estimate research mid-way



ENERGEIA

# Item 8 – Carbon Neutral Task Group: Key Future Zero Carbon Generation Technologies

| Name | Category | Fuel Type | Description | Energy Efficiency | Advantages | Disadvantages | Availability | Potential Breakthroughs |
|---|---|---|---|---|---|---|---|---|
| **Thermal Generation Technologies** | | | | | | | | |
| Combined Cycle Turbine (CCGT) | Combustion | Hydrogen / Renewable Methane / Methane + CCS | Generates power via combustion in a combustion turbine followed by a steam turbine to use waste heat | 50-60% | • Higher efficiency than OCGT<br>• Mature technology<br>• Fuel flexible<br>• Provides intertia | • Higher capex than OCGT<br>• Emissions from combustion<br>• Less flexible than OCGT | • Limited availability of hydrogen or renewable methane<br>• Pilot projects only | • Higher temp combustion turbine |
| Open Cycle Turbine (OCGT) | Combustion | Hydrogen / Renewable Methane / Methane + CCS | Generates power via combustion in a gas turbine | 30-40% | • Higher ramp rate than CCGT<br>• Mature technology<br>• Fuel flexible<br>• Provides intertia<br>• Lower capex than CCGT | • Lower efficiency than CCGT<br>• Emissions from combustion<br>• Less flexible than a OCGT | • Limited availability of hydrogen or renewable methane<br>• Pilot projects only | • Higher temp combustion turbine |
| Carbon Capture and Sequestration (CCS) | Combustion | Coal / Methane | Captures and stores CO2 from coal or methane combustion to prevent it from enterring the atmosphere | 80% | • Allows use of relatively low cost methane and coal fuel | • Unproven technology<br>• Generates waste stream | • Commercially available<br>• Pilot projects only | • New electrochemical process converts CO2 through a mineralization approach and produces green hydrogen. |
| Small Modular Reactor | Fission | Uranium | Generates heat from fission, used to drive steam turbine | 33-37% | • Smaller (<300 MW) than conventional nuclear (<1,600 MW)<br>• Lower and more stable fuel costs compared to methane | • Relatively immature technology<br>• Potential community resistence | • Pilot projects only | • None identified |
| Pebble Bed Reactor | Fission | Uranium | Generates heat from fission, used to drive steam turbine | Up to 50% | • Smaller (<300 MW) than conventional nuclear (<1,600 MW)<br>• Lower and more stable fuel costs compared to methane<br>• Fuel pebbles touted as inherently safe | • Relatively immature technology<br>• Potential community resistence | • Pilot projects only | • None identified |
| Proton Exchange Membrane Fuel Cell (PEMFC) | Chemical | Hydrogen | Fuel cell generates electricity and water using hydrogen | 30-50% | • Higher ramp rate than SOFC<br>• Maturing technology | • Lower efficiency than SOFC<br>• Most only run on hydrogen | • Limited availability of hydrogen<br>• Pilot projects only | • DOE targetting higer efficiencies and increased fuel stack hours |
| Solid Oxide Fuel Cell (SOFC) | Chemical | Hydrogen / Renewable Methane | Fuel cell generates electricity and water using hydrogen or methane | 63-81% | • Higher efficiency than PEMFC | • Lower efficiency than SOFC<br>• Immature technology<br>• Less flexible than SOFC | • Limited availability of hydrogen<br>• Pilot projects only | • DOE targetting higer efficiencies and increased fuel stack hours |

- CAC feedback: Are we missing any technologies, or does any of the key information need to be updated?

# Item 8 – Carbon Neutral Task Group: Key Future Renewable Energy Technologies

| Name | Category | Capacity Factor | Description | Advantages | Disadvantages | Availability | Potential Breakthroughs |
|---|---|---|---|---|---|---|---|
| **Generation Technologies** | | | | | | | |
| Onshore Wind | Wind | 51% | A windmill is used to turn a turbine to generate electricity on land | • Mature technology<br>• Relatively low $/kWh capex<br>• Relatively constant generation | • Community resistance<br>• Limited resource availability | • Commercially available<br>• Limited to areas of high wind resource | • Larger turbines increasing efficiency and reducing costs |
| Offshore Wind | Wind | 40-50% | Floating windmills are used to generate electricity in the ocean | • Mature technology<br>• Relatively low $/kWh capex<br>• Relatively constant generation | • Community resistance<br>• Limited resource availability | • Commercially available<br>• Limited to areas of high wind resource<br>• Limited to coast areas | • Larger turbines increasing efficiency and reducing costs |
| Single Axis Solar PV | Solar | 30-35% | Photo-voltaic(PV) panels on a single axis tracking system are used to generate electricity | • Mature technology<br>• Relatively low $/kWh capex | • Strongly seasonal<br>• Limited resource availability | • Commercially available<br>• Limited to areas of high solar resource | • Solar technology increasing efficiency and lowering costs |
| Concentrated Solar Power (CSP) | Solar | 25% | Mirrors are used to concentrate solar energy on a working fluid, which is used to transfer heat to a steam turbine | • Includes storage<br>• Firm capacity<br>• Relatively low $/kWh | • Strongly seasonal<br>• Limited resource availability<br>• Relatively immature | • Commercially available<br>• Limited to areas of high solar resource<br>• Pilot scale | • High temp steam turbines can reduce costs |
| Geothermal | Geothermal | 72% | Underground geothermal energy is used to drive a steam turbine | • Relatively high capacity factor<br>• Firm capacity<br>• Mature technology | • Limited resource availability<br>• Relatively high $/kWh capex | • Commercially available<br>• Limited to areas of high geothermal resource | |
| Ocean Tidal | Tidal | 20-35% | Tidal energy is used to drive an electric generator | • Predictable resource<br>• Complementary generation profile | • Requires tidal estuary<br>• Relatively expensive per kWh<br>• Immature technology | • Commercially available<br>• Limited to coastal areas<br>• Limited to tidal areas | |
| Ocean Wave | Wave | 25-32% | Wave energy is used to drive an electric generator | • Predictable resource<br>• Complementary generation profile | • Requires coast access<br>• Relatively expensive per kWh<br>• Immature technology | • Commercially available<br>• Limited to coastal areas | |
| Run-of-River Hydro | Hydropower | 40-80% | Water flow is used to drive an electric generator | • Relatively low $/kWh capex<br>• Firm capacity | • Community resistence<br>• Subject to rainfall | • Commercially available<br>• Limited to areas of high hydro potential | |
| Reservoir Hydro | Hydropower | 35-43% | Water is stored in dams and then released to drive an electric generator | • Relatively low $/kWh capex<br>• Includes storage<br>• Firm capacity | • Community resistance<br>• Subject to rainfall<br>• Subject to other uses, e.g. fish | • Commercially available<br>• Limited to areas of high hydro potential | |
| Waste-to-Energy | Waste | 70% | Methane is captured from waste and used to drive a combustion turbine | • Relatively low $/kWh cost<br>• Methane reduction boost<br>• Firm capacity | • Local emissions from combustion | • Commercially available<br>• Limited to areas with significant waste streams | |
| Biomass | Biomass | 50-60% | Methane is capured from biomass or biomass is burned directly to drive a combustion turbine | • Firm capacity | • Local emissions from combustion | • Commercially available<br>• Limited to areas with significant biomass streams | • Improvements in bio-digester technology increases efficiency and reduces cost |

- CAC feedback: Are we missing any technologies, or does any of the key information need to be updated?

# Item 8 – Carbon Neutral Task Group: Key Future Storage Technologies

| Name | Cycle Time | Description | Round-trip Losses | Advantages | Disadvanages | Availability | Potential Breakthroughs |
|---|---|---|---|---|---|---|---|
| **Storage Technologies** | | | | | | | |
| Capacitors | Seconds | Capacitors used to rapidly charge and discharge small amounts of electricity directly | 5% | • Fastest response of any technology<br>• Mature technology | • Relatively expensive per kWh<br>• Unable to store significant energy<br>• 10-20% losses per day | • Widely available | |
| Flywheels | Seconds | Uses a flywheel to rapidly charge and discharge relatively small amounts of electricity using an electric generator | 5%-50% | • Relative fast response times<br>• Mature technology | • Relatively large footprint<br>• Relatively expensive per kWh<br>• 20-50% losses over 2 hours | • Widely available | |
| Battery | Hours | Electrochemical reactions are used to store and discharge electricity directly | 10% | • Relatively responsive<br>• Relatively low losses<br>• Mature technology | • Relatively high cost per kWh<br>• Thermal runaway | • Widely available | • Metal air and liquid metal formulations may improve cost effectiveness |
| Flow | Hours | Stores electricity in two chemicals, which can be stored indefinitely | 40% | • No standing losses if turned off<br>• Relatively safe | • Unproven technology<br>• High parasitic losses while on<br>• Relatively high $/kWh | • Commercially available<br>• Pilot scale | |
| CSP | Hours | Stores energy as heat in working fluid, which is then used to drive a heat recovery-based steam generator | 1% | • Very low round trip losses<br>• Can be coupled with CSP<br>• Relatively low $/kWh capex | • Unproven technology<br>• Safety of high operating temp | • Commercially available<br>• Pilot scale | • High temp steam turbine technology could increase efficiency, lower $/kWh |
| Hydrogen-Compression | Hours | Uses steel or carbon fiber based receiving vessels to store relatively small amounts of hydrogen | 53% | • Mature technology<br>• Relatively compact footprint<br>• Relatively low $/kWh capex | • Amount of space required<br>• High round trip losses | • Widely available | • Material science could reduce cost |
| Hydrogen-Salt Cavern | Weeks | Uses air compressors to store large amounts of hydrogen in salt caverns | 42-55% | • Relatively low cost per kWh<br>• Mature technology | • Requires access to a salt cavern<br>• High losses<br>• Relatively slow response | • Limited availability of salt caverns | |
| Compressed Air Energy Storage (CAES) | Weeks | CAES stores electricity in underground formations including salt caverns and an expander to drive a turbine generator | 42-55% | • Relatively low $/kWh capex<br>• Mature technology | • Requires access to a salt cavern<br>• High losses<br>• Relatively slow response | • Limited availability of salt caverns | • Isobaric systems potentially reduce volume by 77% |
| Hydrogen-Organics | Months | Uses chemical processes to store hydrogen, typically as amonia or methanol | 59-89% | • Mature technology<br>• Relatively high energy density | • Storage of volatile chemicals<br>• Relatively high losses<br>• Relatively high $/kWh | • Widely available | • High potential for cost reduction |
| Pumped Hydro | Months | Pumps water into reservoirs for later use to drive water turbine generators | 80% | • Mature technology<br>• Relatively low $/kWh capex<br>• Relatively low standing losses | • Requires access to reservior<br>• Scale required<br>• Relatively slow response | • Limited availability of reserviors | |

- CAC feedback: Are we missing any technologies, or does any of the key information need to be updated?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**Item 9 – Discussion on possibility of restructuring CAC**

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# Item 9 – Discussion: possibility of restructuring CAC

**Option 1: No Change**

- 12 Seats (3 seats from each of the 4 jurisdictions)
- Reappoint / Appoint from current applicant pool for Davis and Winters Class 3 seats
- Continue to actively advertise and solicit applicants to fill 2 vacancies: Woodland and unincorporated Yolo County

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# Item 9 – Discussion: possibility of restructuring CAC

**<u>Option 2:</u> Addition of Member-at-Large appointment**

- 12 Seats (3 seats from each of the 4 jurisdictions)
- Allows temporary appointment of Member-at-Large for vacancies greater than 90 days
- Includes 1 reappointment, 1 appointment, and continued recruitment for vacancies (unincorp. Yolo and Woodland)
- Member-at-Large:
  - A) is an applicant(s) from jurisdictions that have filled all available seats for their respective jurisdiction;
  - B) would be appointed for 1 year term and limited to 1 per jurisdiction; and,
  - C) would participate in task group and committee meetings as voting members until the 1 year term or the Class term expired.
- Member-at-Large terms limited to 1 per jurisdiction, i.e. maximum of 4 seats for each jurisdiction to prevent majority representation

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# Item 9 – Discussion: possibility of restructuring CAC

**<u>Option 3:</u> Modified Structure**

- 8 seats (2 seats from each of the 4 jurisdictions), staggered terms
- Creation of 1 alternate from each jurisdiction (like Board structure)
- Alternates would be allowed to act in the absence of their jurisdiction seat: voting rights at CAC meetings. May participate in task groups and CAC meetings (without voting rights)
- Continue to actively advertise and solicit applicants to fill 2 vacancies: Woodland and unincorporated Yolo County
- Before adoption and implementation of Option 3, Option 1 in the interim
- Strategy for implementation development with Staff and CAC Ad Hoc Committee for future consideration

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