VALLEY CLEAN ENERGY ALLIANCE

Staff Report – Item 8

TO: Community Advisory Committee

FROM: Gordon Samuel, Assistant General Manager & Director of Power Services

SUBJECT: Carbon Neutral by 2030 Draft Report

DATE: January 20, 2022

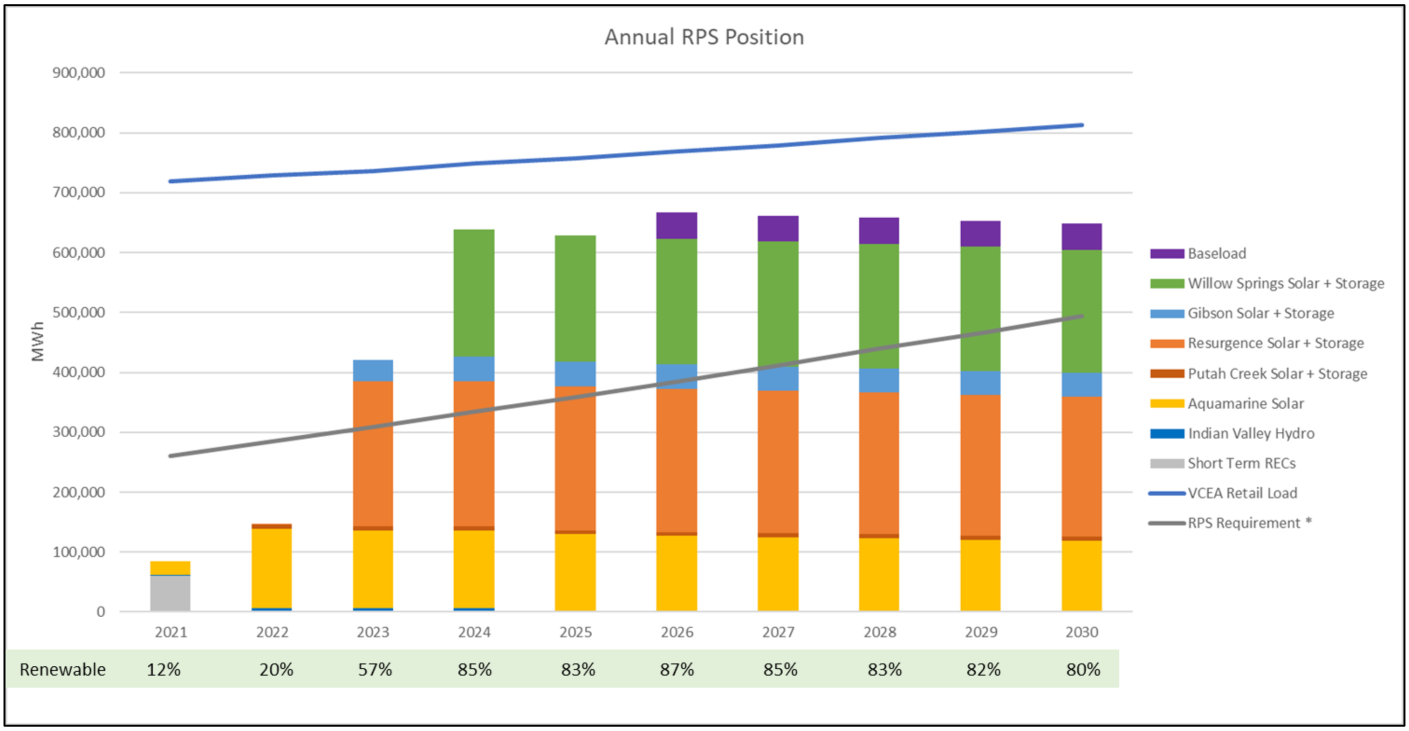
Recommendation
Receive, provide comment and forward Carbon Neutral by 2030 Draft Report to the VCE Board.

Overview
The purpose of this report is to transmit the draft report of the VCE zero-carbon portfolio study to the full CAC. Staff is seeking feedback from the CAC for the final report that will be presented to the Board at their January meeting.

Background
In October 2020, the Board approved VCE's 2021-2023 Strategic Plan which contains goals related to VCE's power resource portfolio as well as decarbonization. The Community Advisory Committee (CAC) formed task groups at the January 2021 meeting and approved the task group "charge" at the February meeting. The initial task group – carbon neutral and decarbonization task group – has been meeting bi-weekly since March. It became apparent very early in the meetings that addressing the carbon neutral topic (specifically Goal 2, Objective 2.5) was going to be more than enough to focus on for 2021 and decided to postpone the decarbonization work (Goal 4) until 2022. The "charge" stated that the task group 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. In order to complete this work an outside consultant was selected from an April 30, 2021 request for proposals (RFP) seeking qualified consultants to explore the feasibility, cost and benefit of pursuing a 100% carbon free portfolio. The consultant, Energeia, was selected to perform the study. The contract with the consultant was approved by the Board on July 8, 2021. Interim updates were provided to the CAC (late August 2021) and to the Board (September 2021).

VCE Current Renewable Portfolio Trajectory
For reference, staff is including VCE's current renewable portfolio and trajectory out to 2030.

Figure 1 - VCE Current Renewable Portfolio Trajectory

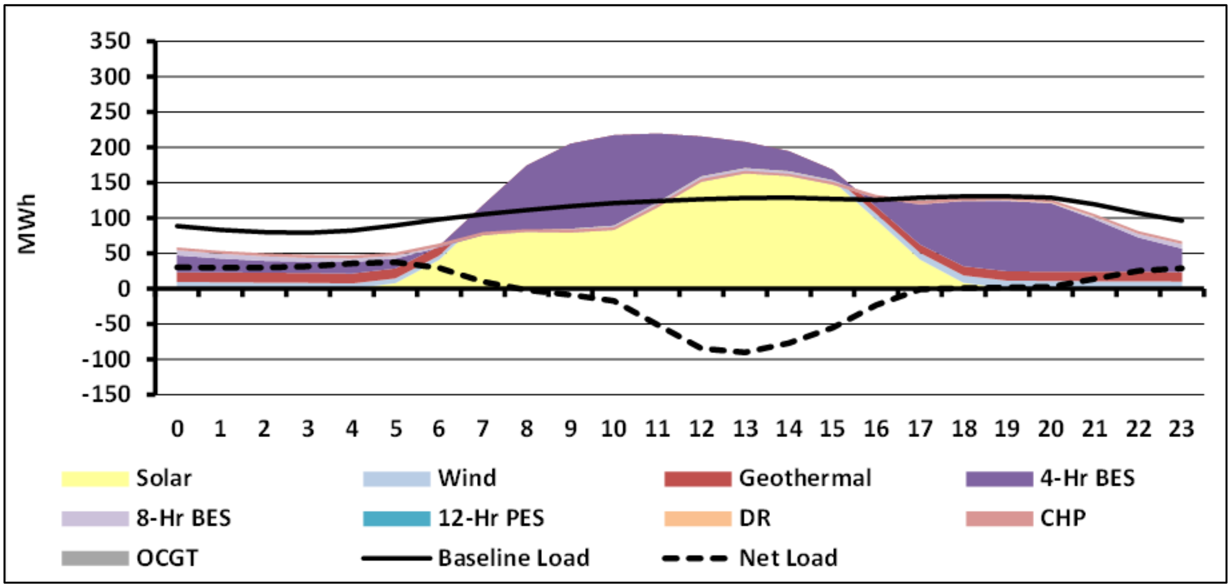


Analysis

The purpose of this effort is to understand what the future resource portfolio would consist of in order to be 100% carbon neutral as well as the be 100% renewable 24x7 (that is, every hour of every day meet VCE's demand with renewable resources). The figures below provide a potential outcome from the draft study to achieve either of these goals.

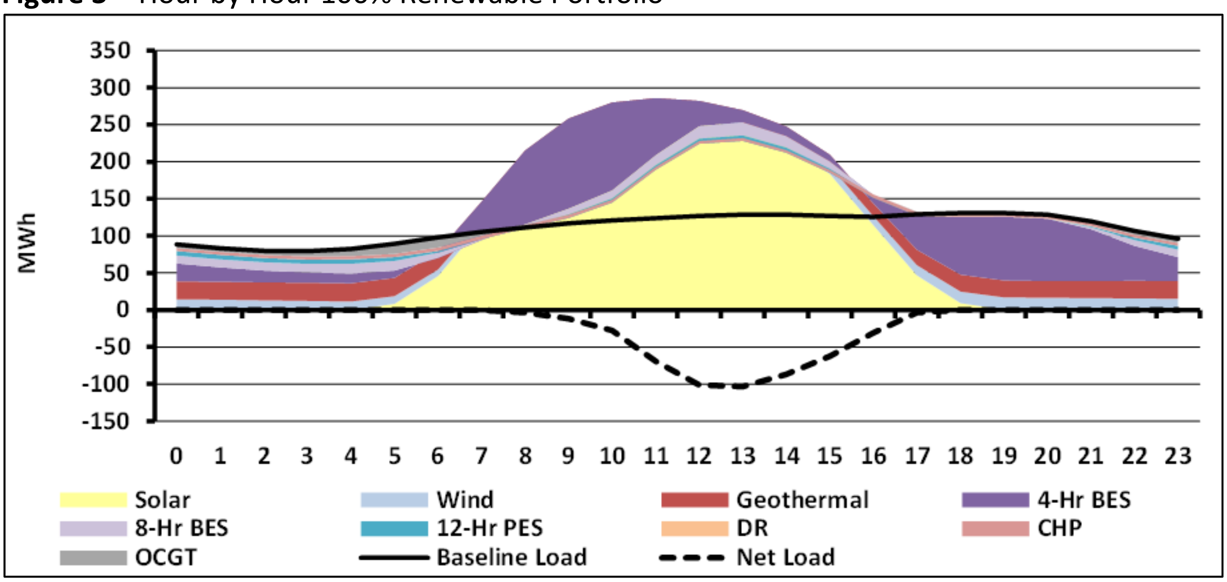
The below graphic is a 100% carbon neutral portfolio meeting VCE's annual demand. That is, over the course of a year the resources generate at least an annual amount that meets or exceeds VCE's annual demand. In this scenario the timing of the resource's generation does not have to match the load.

Figure 2 – 100% Carbon Neutral Portfolio



The below graphic is an hour by hour 100% renewable portfolio for VCE. This portfolio meets or exceeds VCE's load every hour of the year. At a minimum the resource's generation needs to match or exceed the load.

Figure 3 – Hour by Hour 100% Renewable Portfolio



VCE has a stated goal of being 80% renewable by 2030. Either of the portfolios studied goes beyond VCE's current commitment. Resources exist that can satisfy either situation, but there is a significant cost difference between the portfolios. The below table outlines the incremental resources needed – resources above what VCE has contracted for or will be contracting for in the near future to satisfy regulatory mandates (R.20-05-003). The carbon neutral portfolio is approximately 1/3rd the cost of the hour-by-hour portfolio ($17M/yr vs $47m/yr). This would be in addition to the approximate $50-$60M/yr VCE spends on the current power portfolio.

Table 1 – MW Needed for Hour-by-Hour and Carbon Neutral Portfolios

Scenarios	Solar	Wind	Geothermal	Small Hydro	Large Hydro	4-Hour BES	8-Hour BES	12-Hour PES	OCGT
HBH	0.0	39.3	11.3	0.0	0.0	42.3	65.4	10.7	112.3
CN	0.0	26.1	0.0	0.0	0.0	100.0	7.7	0.0	0.0

Above table represents the incremental MWs needed to satisfy the hour by hour (HBH) or the carbon neutral (CN) portfolios.

<u>Sensitivity Analysis</u>

Energeia conducted a sensitivity analysis addressing three risk factors: drought impacts, electric vehicle (EV) penetration, and building electrification (BE). The drought impacts can vary year to year but in severe drought the impact on VCE's annual load can be nearly 10%. EV penetration and BE will be increasing and developing forecasts that accurately reflect this growth will be important in VCE's long range load forecasts. It is not unreasonable to assume a 6% and approximately 20% increase in annual load by 2030 from EV and BE, respectively.

<u>Discussion</u>

At this time, staff is not recommending any policy adjustments. This information, combined with the final report, will act as a foundation that will be used for future discussions with the CAC to formulate a new policy that can be presented to the Board in the first half of 2022.

<u>Attachment</u>

1. Carbon Free Portfolio RFP
2. 100% Carbon Free Portfolio Study (Draft)

Valley Clean Energy Alliance
604 2nd Street, Davis, California 95616
Phone: (530) 446-2750

REQUEST FOR PROPOSALS FOR 100% CARBON FREE PORTFOLIO STUDY

PROPOSALS ARE DUE:
Friday, May 21, 2021 BY 4:00 P.M. (Pacific Daylight Time)
Proposals must be e-mailed in PDF form to Gordon.Samuel@ValleyCleanEnergy.org

Valley Clean Energy Alliance is a Joint Powers Authority consisting of the Cities of Davis, Woodland, and Winters and the County of Yolo.

Scope of Services

100% CARBON FREE PORTFOLIO STUDY

I. INTRODUCTION

Valley Clean Energy is seeking a qualified consultant (Contractor) to explore the feasibility, cost and benefit of pursuing a 100% carbon free portfolio. This 100% carbon free portfolio will be developed as an option to be considered as part of VCE's Strategic Plan and in VCE's upcoming Integrated Resource Plan (IRP). It is intended that all elements of the generation portfolio will be renewable and/or carbon free as defined below.

II. BACKGROUND

2.1 Valley Clean Energy Alliance or Valley Clean Energy (VCE), is a joint powers authority providing a state-authorized Community Choice Energy (CCE) program. Participating VCE governments include the City of Davis, the City of Woodland, the City of Winters and the unincorporated areas of Yolo County. PG&E continues to deliver the electricity procured by VCE and to perform billing, metering, and other electric distribution utility functions and services. Customers within the participating jurisdictions have the choice not to participate in the VCE program.

2.2 Since VCE started serving load in June 2018, VCE has added resources under long term contracts and is gradually building up a portfolio of short and long term assets in line with its vision and the demand of its customers. To date, VCE has relied mainly on market purchases of energy, Resource Adequacy (RA), and Renewable Energy Credits (RECs) in order to serve its electric demand and meet regulatory requirements with respect to resource adequacy and renewable energy. Starting in 2021 VCE will increasingly meet electric demand with resources under long term contracts. VCE has contracted for 50 MW of new solar resource (PV – photovoltaic) located in Kings County, CA and a 3 MW PV + 3 MW storage (BESS – battery energy storage system) project in Yolo County, CA to come online before the end of 2021. In 2022, two additional solar + storage power purchase agreements (PPAs) have been executed (90 MW PV + 75 MW BESS in San Bernardino County, CA and 20 MW PV + 6.5 MW BESS in Yolo County, CA). Finally, two other long-term RA capacity contracts have been executed - 7 MW of demand response beginning in the Summer 2021 and another 2.5 MW of stand-alone battery storage by Summer 2022.

III. DETAILED SCOPE OF WORK

The scope of work for this project includes the following:

- Develop a 100% renewable portfolio study report
  - Net zero and 24x7 by 2030
- Develop a 100% carbon free portfolio study report
  - Net zero and 24x7 by 2030
- Use production cost model to simulate generation of existing and future resources

  - o Develop lowest cost resource mix at different renewable/carbon free penetrations levels
- Perform risk analysis of the scenarios/contingencies
  - o Contractor invited to present scenarios/contingencies to consider
- Provide industry trends for renewable resources, large hydro, storage, etc.

3.1 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.

3.2 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.

3.3 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.

3.4 Carbon Neutrality – 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.

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

ANAYLYSIS TIME FRAME

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

IV. PROFESSIONAL SERVICES

The following tasks and are incorporated into the Scope of Work.

4.1 Project Tasks

Contractor shall prepare and provide the following:

4.2 Portfolio Study Reports

The Portfolio Study Report (Report) shall describe at a high level the method used to perform the work. The fundamental algorithmic assumptions and approach must however be logical, consistent and explained in narrative form. The inputs used by the Contractor should align with the inputs provided by VCE. Reports and supporting documents shall be provided in .pdf, WORD, Excel or other commonly used formats.

Potential resources that could be included in the portfolios

- Solar (Front of meter, FOM/Behind the meter, BTM)
- Wind
- Hydro
- Pump Storage

- Geothermal
- Biomass
- Battery Storage (FOM/BTM)
- Nuclear
- Energy Efficiency
- Demand Response
- Demand Management

4.3 Scenario Scope
The Contractor must use a production cost model to simulate the generation of existing and future resources. The results for each scenario must be summarized in the Report to at least include the following: costs, generation of each resource (GWh), market purchases (GWh), demand response deployment, behind the meter deployments, nameplate capacity of new resources, battery configurations (capacity and duration), imports, amount of local generation and CO2 equivalent tons.

The Contractor shall propose and discuss with VCE any viable scenarios based on Contractor's experience and expertise. These proposed scenario submittals will be reviewed by VCE. Each scenario shall include all costs on an annual basis for PPA energy costs, transmission or other delivery costs, fuel costs and any fixed and variable O&M. Contractor shall complete a quantitative evaluation for each scenario. Each scenario, unless otherwise noted, shall be modeled on an hourly basis. The Loss of Load Expectation (LOLE) for each scenario should not exceed one (1) day in ten (10) years.

4.4 Model VCE reference case. Align with the assumptions made for the reference case and identify any differences.
Contractor will solve for the mix of renewable or carbon free resources that results in the lowest cost plan. All loads will be served by assets procured by VCE. VCE will not rely on spot energy purchased from outside resources.

4.5 Risk Analysis
Attempting to achieve a 100% carbon free portfolio entails risks and unknowns, some of which VCE is able to anticipate, and others that may not be obvious. This section lists some of the potential risks that VCE has so far identified. The Contractor shall explain the risk and mitigation for each concern listed below.

It is also anticipated that the list below is likely incomplete, and for that reason the Contractor is expected to address and explain in the Report any additional risks and mitigations that it may be aware of or discover during the course of the study.

4.5.1 Particular attention shall be paid to the capacity and duration of output of any energy storage facilities proposed. There is some concern for instance, that solar sources of supply may not be available or adequate for extended times, during some winter peak conditions. The storage must be capable of covering the deficit.

4.5.2 If large amounts of storage are necessary through the variability of renewable sources, how will it be ensured that storage can be kept sufficiently charged using only the renewables? Would access to a greater amount of renewables, either from the grid or locally connected, be required to charge the storage and maintain a 100% renewable posture? What would be the estimated cost?

For instance, if renewable resources are installed or purchased only in quantities sufficient to serve VCE's peak load, when and how often would it be assumed those resources could be successfully diverted to keep the storage charged to acceptable levels? Would it be necessary to purchase more renewables strictly to serve storage?

4.5.3 There could be a risk in purchasing access to renewables or carbon free in quantities sufficient to ensure the ability to reliably serve load for the full 8760 hours of the year. The risk is having significant excess energy at certain times of the year or day. What would be the best strategy for dealing with this issue? Exporting to the grid? Curtailing the renewable/carbon free energy?

The Contractor shall identify in each scenario evaluated the magnitude in MWs and the risk in annual hours of having significant excess energy.

4.5.4 How will demand response programs be deployed? What is the magnitude, duration (per day/per year), and time of day that these programs are expected to be implemented?

4.6 Discussion of possible future industry trends in renewable resources, carbon free resources and storage

Contractor shall also gather input on trends and emerging technologies that could reach maturity by 2030, and which could help in achieving the 100% renewable or carbon free goal.

The Contractor shall provide in the Report a separate discussion of what is considered to be emerging and future trends in renewable energy, carbon free energy, storage and other potential technologies that could aid in achieving a goal of 100% carbon free portfolio. The discussion should include future factors such as, but not limited to, pricing, capacity factor, efficiency, new inverter technology, operating capabilities, and whatever else the Contractor may consider to be relevant.

The Contractor shall provide in support of this discussion of future trends a survey or summary of pertinent industry sources, referenced as appropriate.

V. PROPOSER MINIMUM QUALIFICATIONS

The proposals submitted in response to this Request for Proposals shall be evaluated for award based on the following criteria and weighting.

Item	Criteria Description	Weighting
	Experience and Qualifications 1. Experience of firm 2. Resumes of staff designated to support this scope 3. CCA/Public Power/Energy experience	**45%**
	Compliance with VCE Sample Contract	**10%**
	Price	**45%**
	Total	**100%**

5.1 Proposal Submittal Requirements

1. Ten pages maximum submitted electronically. Executive Summary with brief description of company including Firm or individual name and contact information, including e-mail and website addresses, year organized, principals with the firm, types of work performed, number of employees.
2. Resumes of key staff that would work on VCE projects.
3. Information on any previous experience or services provided, including CCA experience.
4. Other factors or special considerations you feel would influence the selection of your proposal.
5. List of references and contact information.

5.2 Miscellaneous

1. Additional Information

Scope of Services may be revised upon mutual agreement between the Contractor and VCE.

2. Ownership of Work Products

All notes, documents, and final products in all native formats (e.g., Word, Excel, PowerPoint, databases, handwritten notes) produced in the performance of this agreement shall be the property of VCE and shall not be shared with other entities without permission from VCE staff.

3. Request for Proposal Schedule

VCE anticipates that the process for selection of Carbon Free Portfolio Study and awarding the contract will be according to the following tentative schedule.

5.3 Schedule

Milestone Description	Date
Issue RFP	4/30/2021
Return NDA	5/12/2021
Responses due	5/21/2021
Consultant selection	6/17/2021
Study work	Q3 2021
Final report complete	Q4 2021

5.4 Instructions to Proposers

1. Time and Manner of Submission

The Proposal shall be submitted electronically to and received by VCE's office no later than 4:00 p.m. (PDT) on Friday, May 21, 2021.

Submit to:

Gordon Samuel, Assistant General Manager
Email: gordon.samuel@ValleyCleanEnergy.org

- Each proposal shall include the full business legal name, DBA, and address and shall be signed by an authorized official of the company. The name of each person signing the proposal shall be typed or printed below the signature.
- All proposals submitted become the property of VCE.

2. Explanations to Proposers

All requests, questions or other communications regarding this RFP shall be made in writing to VCE via email. **Address all communications to Gordon Samuel (gordon.samuel@valleycleanenergy.org)**. To ensure that written requests are received and answered in a timely manner, email correspondence is required.

VCE will not be bound by any oral interpretation of the Request for Proposal, which may be made by any of its representatives or employees, unless such interpretations are subsequently issued in the form of an addendum to this Request for Proposal.

3. Withdrawal or Modification of Proposals

Proposals may be modified or withdrawn only by an electronic request received by VCE prior to the Request for Proposal due date.

4. Revisions and Supplements

Addenda: If it becomes necessary to revise or supplement any part of this Request for Proposal an addendum will be provided.

5. Proposal Evaluation and Selection Process

The proposals submitted shall be evaluated for award based on the criteria described in the "Proposal Evaluation Criteria" section of this Request for Proposal.

VCE may request additional information from any or all Proposers after the initial evaluation of the proposals to clarify terms and conditions.

Based on VCE's review of the proposals received, a "short listed" group of Proposers may be selected. The "short listed' firms may be required to make verbal presentations of their qualification to VCE. If a presentation is determined to be required, the presentation will be considered in the overall technical rating.

The contract will be awarded to the best-qualified Proposer, after price and other factors have been considered, provided that the proposal is reasonable and is in the best interests of VCE to accept it.

The right is reserved, as the interest of VCE may require, to reject any or all proposals and to waive any irregularity in the proposals received.

Within fourteen (14) calendar days after notice of award, the successful Proposer shall deliver to VCE the required insurance certificates as per section 3.10 of the sample contract and the signed copies of the contract. The contract forms will be forwarded to the Proposer with the award notification.

6. Duration of Contract

This contract shall be for one year, subject to approval by VCE's Board of Directors of the corresponding annual budget, unless otherwise mutually agreed upon in writing.

The Budget is subject to the approval of VCE's Board of Directors.

7. Qualifications of Proposers

VCE expressly reserves the right to reject any proposal if it determines that the business and technical organization, financial and other resources, or experience of the Proposer, compared to the work proposed justifies such rejection.

8. Proposal Preparation Costs

The costs of developing proposals are entirely the responsibility of the Proposer and shall not be charged in any manner to VCE.

9. Conflicts

If conflicts exist between the contract and the other elements of this Request for Proposal, the contract prevails. If conflict exists within the contract itself, the Terms and Conditions govern, followed by Scope of Services. If conflict exists between the contract and applicable Federal or State law, rule, regulation, order, or code; the law, rule, regulation, order, or code shall control. Varying levels of control between the Terms and Conditions, drawings and documents, laws, rules, regulations, orders, or codes are not deemed conflicts, and the most stringent requirement(s) shall control.

10. Manner and Time of Payment

At completion of the scope, Contractor shall submit an invoice for the lump sum of the work performed.

11. Subcontractors

The Proposers must describe in their proposals the areas that they anticipate subcontracting to specialty firms. Identify the firms and describe how Proposer will manage these subcontracts.

Contractor will pay subcontractors in a timely manner.

Nothing contained in the Contract shall create any contractual relation between any subcontractor and VCE.

12. Notice Related to Proprietary/Confidential Data

Proposers are advised that the California Public Records Act (the "Act", Government Code §§ 6250 et seq.) provides that any person may inspect or be provided a copy of any identifiable public record or document that is not exempted from disclosure by the express provisions of the Act. Each Proposer shall clearly identify any information within its submission that it intends to ask VCE to withhold as exempt under the Act. Any information contained in a Proposer's submission which the Proposer believes qualifies for exemption from public disclosure as "proprietary" or "confidential" must be identified as such at the time of first submission of the Proposer's response to this RFP. A failure to identify information contained in a Proposer's submission to this RFP as "proprietary" or "confidential" shall constitute a waiver of Proposer's right to object to the release of such information upon request under the Act. VCE favors full and open disclosure of all such records. VCE will not expend public funds defending claims for access to, inspection of, or to be provided copies of any such records.

13. Contract

VCE's standard contract is included as Attachment A - *Sample* Contract of this Request for Proposal. VCE may reject proposals that contain exceptions to the Terms and Conditions included in the sample contract.

5.5 Performance Requirements

Performance Requirements/Acceptance Criteria

a. All Milestones shall be completed in accordance with approved schedule.

b. Deliverable items must be complete, legible, comprehensible, and satisfy all requirements set forth in the scope of work.

5.6 Reference Documents

VCE will provide reference documents to aid in the preparation of RFP responses after execution of the non-disclosure agreement (NDA) – a sample NDA is attached as Attachment B.

5.7 Resource and Submittal Requirements

Contractor shall provide all resources required to complete the work described herein, including but not limited to skills, services, supervision, tools, documents, information, labor, materials, equipment, computing capability, transportation, and any other necessary item or expense to fulfill the work requirements.

5.8 Project Cost

Contractor shall provide a not to exceed lump sum price. If VCE modifies the scope and additional study work needs to be performed, Contractor shall provide a change order price before initiating the work.

ATTACHMENT A - *SAMPLE* CONTRACT

A *SAMPLE* CONTRACT IS ATTACHED HERETO.

SAMPLE CONTRACT INTENTIONALLY REMOVED

ATTACHMENT B – SAMPLE NON-DISCLOSURE AGREEMENT

A SAMPLE NON-DISCLOSURE AGREEMENT IS ATTACHED HERETO.

SAMPLE NON-DISCLOSURE AGREEMENT INTENTIONALLY REMOVED energeia-usa.com

100% Carbon Free Portfolio Study

DRAFT Report

Prepared for Valley Clean Energy

14 January 2022

ENERGEIA

Executive Summary

In 2018, the California Governor issued Executive Order B-55-18[1] to Achieve Carbon Neutrality, which set a zero carbon goal by no later than 2045, and negative emissions thereafter, and the State Legislature passed Senate Bill No. 100[2], requiring all electricity consumed in California to be 100% carbon neutral by 2045.

Since then, a growing number of California utilities have set more ambitious targets, including the Sacramento Municipal Utilities District (SMUD), whose Board approved[3] a net zero carbon generation target by 2030, and the Los Angeles Department of Water and Power (LADWP), whose Board approved[4] a net zero target by 2035.

Valley Clean Energy (VCE) is in the process of reviewing its decarbonization pathways and engaged Energeia to analyse the feasibility, costs and benefits of pursuing renewable and carbon-free portfolios on an hour-by-hour and annual carbon neutral basis by 2030 to inform its Strategic Plan and Integrated Resource Plan (IRP).

Scope and Approach

Energeia's approach to delivering the scope of work involved the following main workstreams:

- **Stakeholder Engagement** – Energeia meet with VCE throughout the project to discuss the scope and approach for each of the technical workstreams, our initial findings, conclusions and recommendations and to agree material for discussion with the Consumer Advisory Committee (CAC).
- **Resource Requirements** – Energeia developed an estimate of the annual and hour-by-hour resource gap in 2030 based on VCE's IRP, updated to include newly contracted resources, as well as resources required since then due to changes in regulations.
- **Desktop Review of Technology Options and Costs** – Energeia undertook comprehensive desktop research of technology trends to identify the most prospective zero carbon fuels, generation and storage technologies, which were vetted and validated by VCE and the CAC.
- **Modelling Resource Portfolios** – Energeia configured its zero carbon resource portfolio optimization model with information from VCE's IRP, the results of the technology costs research to identify least cost resource mixes capable of meeting VCE's forecasted 2030 demand under the four scenarios.
- **Risk Assessment and Sensitivity Analysis** – Energeia agreed key demand and supply risks associated with the four scenarios with VCE and the CAC, and then modelled their potential impact on the portfolio mix and net costs.
- **Implementation Considerations and Pathways** – Based on the results of the portfolio optimization modelling, including the sensitivity analysis, Energeia developed recommendations regarding key implementation considerations and practical pathways for achieving the identified optimised portfolios.

Following completion of each of the above workstreams, Energeia documented the project scope, approach, technical methodologies, results and key recommendations in this report.

VCE's Resource Requirement by Hour in 2030

Figure ES1 shows Energeia's estimate of VCE's average net resource requirements in 2030 by hour and month.[5] VCE demand is expected to be met by existing and planned contracts from 9:00 to 15:00, and additional resources are needed to address the remaining load during other hours of the day, depending on the month.

[1] State of California (2018), *Executive Order B-55-18 To Achieve Carbon Neutrality*

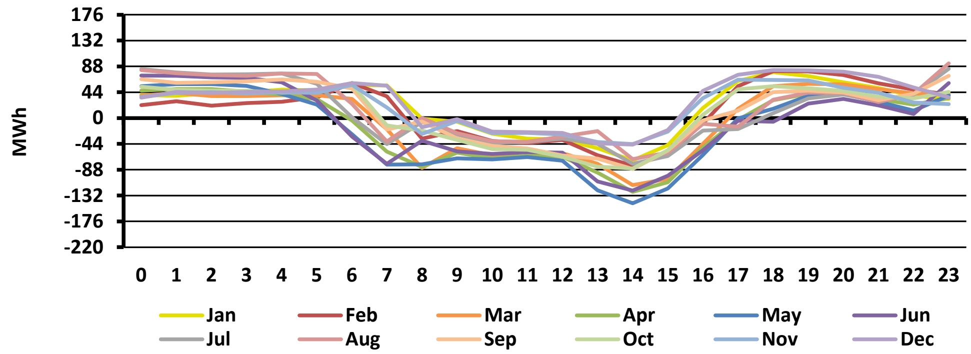
[2] State of California – Legislative Information (2018), *Senate Bill No. 100*

[3] SMUD (2021), *Our 2030 Clean Energy Vision*

[4] Mayor of LA (2021), *Targets – Renewable Energy*

[5] Energeia modelled all hours of the year, i.e. 8,760 hours per year. Hourly average results are shown here as easier to visualize.

Figure ES1 – 2030 Average Hourly Net Requirements by Month



Source: VCE (2020); Note: Hour of the Day (Military Time)

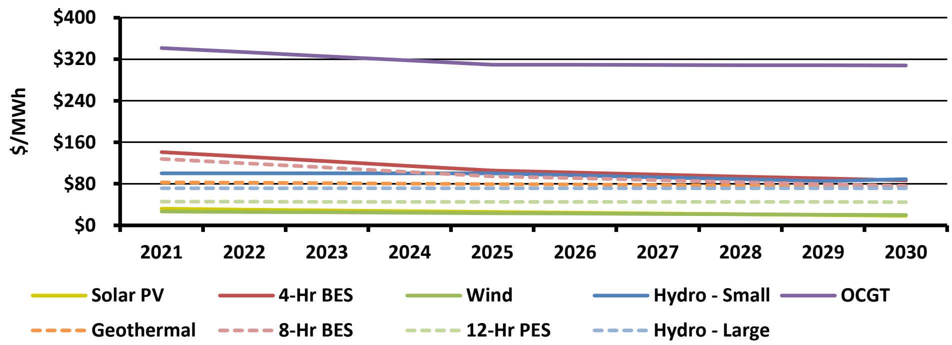
It is important to note that the resource gaps may be met by zero carbon fuelled generation, renewable energy generation and/or storage technologies capable of shifting VCE's excess generation into the periods of deficit.

Future Zero Carbon Resource Options and Costs

Energeia's comprehensive desktop research of zero carbon fuel, renewable and storage technologies identified green hydrogen and renewable natural gas[6] fuelled combustion, solar PV, onshore wind, geothermal, pumped hydro and lithium battery storage as the most prospective resources for 2030 portfolio construction.

Figure ES2 shows Energeia's forecast of levelized cost of resources by type over time, which draws from a range of authoritative public domain sources. Energeia notes that levelized costs can be misleading, as they do not reflect the shape of the renewable energy resource, nor the flexibility value of dispatchable resources.[9]

Figure ES2 – Forecasted Levelized Cost of Energy for Resources Considered in Portfolio Construction ($/MWh)



Source: NREL (2020), EIA (2021), IEA (2010); Note: OCGT = Open Cycle Gas Turbine, PES = Pumped Energy Storage, BES = Battery Energy Storage, gas turbine capacity factor of 50% assumed

Whether or not a given resource forms part of a least cost portfolio of zero carbon resources in 2030 depends on the hour-by-hour resource gap, as well as the relative costs of competing resource options.

Resource Portfolio Optimization

Energeia identified four least cost portfolios to meet the forecast resource gap in 2030, which varied by carbon balancing period and resourcing constraints, per VCE's specifications. The carbon balancing constraints were hour-by-hour (HBH) and (annual) carbon neutral (CN). The resource constraints were Carbon-Free (100% carbon free, incl. large hydro) and Renewable (excludes large hydro).

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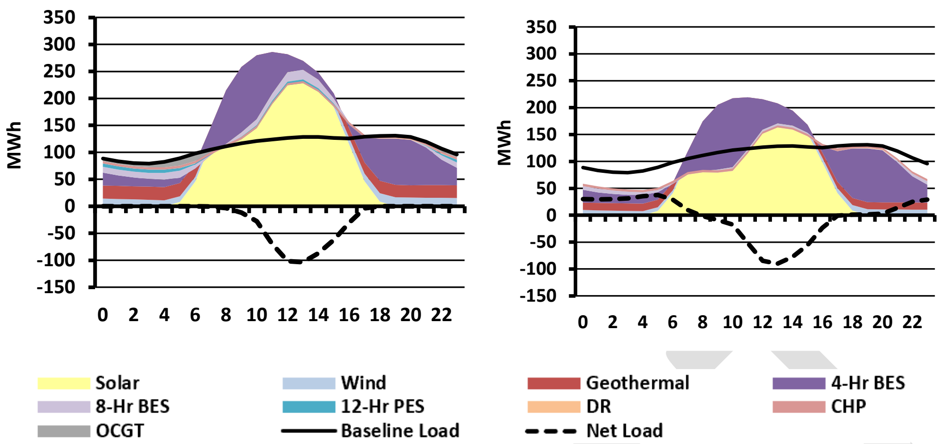
[6] Energeia considered both renewable natural gas and green hydrogen as fuel for thermal generation, but research and analysis revealed green hydrogen will be the lower cost fuel by 2030.

[9] Levelized storage costs are exclusive of energy costs or associated losses, which were included in the portfolio optimization modelling.

Figure ES3 shows the resulting average hourly profiles (including existing and planned resources) for the HBH and CN scenarios against VCE's gross (Baseline) load.[10] The modelling shows the expected least cost approach to meeting HBH and CN average daily demand in 2030 is primarily via solar PV and 4-hour lithium-ion storage, complemented by geothermal, wind and a wider mix of resources to meet demand before 6:00 and after 17:00.[11]

Figure ES3 – 2030 Hour-by-Hour (left) and Carbon Neutral (right) Average Day Profiles



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

The estimated incremental costs of the four portfolios are shown below on an annualized basis by cost category. Resource costs are broken out from CAISO net costs, with HBH scenarios showing a net payment for excess resources and CN scenarios showing a net cost overall.

Table ES1 – Proposed Portfolio Total Costs ($M/Yr)

Scenarios	Power Source	Resources	CAISO	Net
HBH	Carbon Free	$46.5	-$3.9	$42.6
HBH	Renewable	$46.5	-$3.9	$42.6
CN	Carbon Free	$16.5	$0.5	$17.0
CN	Renewable	$16.5	$0.5	$17.0

Source: Energeia research and analysis; Note: RA = Resource Adequacy, AS = Ancillary Services, FRA = Flexible Resource Adequacy

These results show that, given the inputs and assumptions set out above and in the report, the estimated incremental annual cost for VCE to meet demand with zero carbon resources every hour of the day is 250% greater at $42.6m than the cost of being carbon neutral on an annual basis at $17.0m.

Sensitivity and Risk Analysis

Energeia, VCE and the CAC discussed and agreed a wide range of potential risks and issues that could materially impact on VCE's ability to achieve the target resource portfolios at the estimated net cost. These were then refined over the course of multiple discussions into seven key risks, which were then modelled.

The effects of the seven agreed sensitivities on portfolio costs are shown in Figure ES4.

Energeia's analysis found that further constraining the HBH scenario to exclude green hydrogen powered OCGT resources, and to not rely on selling excess energy to the CAISO, increased costs by $13m per year.[12]

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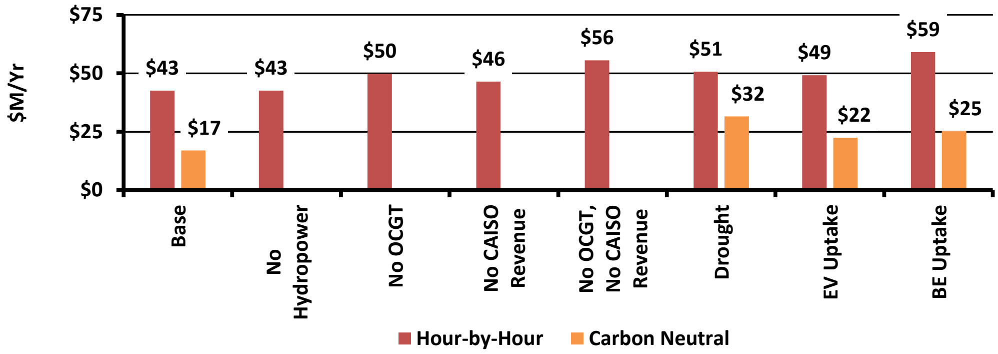
[10] Only two portfolio mixes are shown because large hydro was not part of the most economical resource mix for either scenario.

[11] Energeia notes that other portfolios could be the same or lower cost due to the complexity of this type of portfolio analysis and the limitations of non-linear programming techniques. However, we have tested these results multiple times to help mitigate this risk.

[12] These risk factors do not apply to the CN scenario.

On the demand side, Energeia's modelling found annual HBH costs go up the most due to Building Electrification (BE), while CN costs go up the most as a result of drought. However, each of the demand side risk factors resulted in a significant increase in annual incremental portfolio costs.

Figure ES4 – Hour-by-Hour and Carbon Neutral Net Portfolio Costs



Source: Energeia modelling

Portfolio optimization is a complex interplay of resource costs and shape, and hourly net shortfalls, however, in general these results reflect the relative increase in energy under each of the analyzed demand side risk factors.

Portfolio Implementation Considerations

Based on the results of our least cost portfolio optimization analysis, including assessment of the impact of seven key risk factors, Energeia developed the following key recommendations regarding implementing the identified least cost portfolios:

- **Focus on No Regrets Opportunities** – Resources present in both portfolios, including wind, 4-hour and 8-hour lithium-ion storage could be purchased initially allowing VCE to head in the direction of carbon neutrality under the CN scenario, and potentially change to the HBH scenario in the future.
- **Consider Deferring Lithium-ion Projects** – Lithium-ion battery storage systems are expected to decline significantly over the next decade. VCE should therefore consider delaying storage contracts, and/or requesting that storage embedded in future renewables projects to be built closer to 2030.
- **Benefit from Co-location** – Regarding resource placement, co-locating batteries at solar or wind sites, if possible, may minimize revenue lost to curtailment, which is expected to increase in California over the next 10 years. Battery asset timing should therefore consider curtailment and future cost declines.
- **Address Key Risk Factors** – Developing programs to increase the efficiency of agriculture pumping load, and to increase the flexibility of transportation and building electrification loads, could help reduce the associated impact on portfolio costs.

It is important to evaluate these recommendations over time, as key risk factors could change due to unforeseen changes in policy, regulation, technology, market and industry conditions.

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Disclaimer

While all due care has been taken in the preparation of this report, in reaching its conclusions Energeia has relied upon information and guidance from Valley Clean Energy, and other publicly available information. To the extent these reliances have been made, Energeia does not guarantee nor warrant the accuracy of this report. Furthermore, neither Energeia nor its Directors or employees will accept liability for any losses related to this report arising from these reliances. While this report may be made available to the public, no third party should use or rely on the report for any purpose.

For further information, please contact:

Energeia USA
132 E St. #310
Davis, CA 95616
T: (530) 312-6127
E: energeia@energeia-usa.com W: www.energeia-usa.com

1. Background

In 2018, the California Governor issued Executive Order B-55-18[13] to Achieve Carbon Neutrality, which set a zero carbon goal by no later than 2045, and negative emissions thereafter, and the State Legislature passed Senate Bill No. 100[14], requiring all electricity consumed in California to be 100% carbon neutral by 2045.

Since then, a growing number of California utilities have set more ambitious targets, including the Sacramento Municipal Utilities District (SMUD), whose Board approved[15] a net zero carbon generation target by 2030, and the Los Angeles Department of Water and Power (LADWP), whose Board approved[16] a net zero target by 2035.

California community choice aggregators (CCAs) are increasingly setting carbon and/or renewable targets above those of state minimum levels, including San Jose Clean Energy's goal of carbon neutrality by 2030, [18] Peninsula Clean Energy's goal of 100% renewable energy on a 24/7 basis by 2025[20] and finally, Marin Clean Energy's goal of 85% renewable by 2029.[21]

Currently, VCE has multiple long-term contracts for solar, storage, geothermal and demand response, which are forecasted to serve approximately 35.8% of VCE's 2030 load, leaving 528 GWh p.a. to be served by CAISO purchases. This is consistent with California state targets for CCAs.

Valley Clean Energy (VCE) is in the process of reviewing its decarbonization pathways and engaged Energeia to analyse the feasibility, costs and benefits of pursuing renewable and carbon-free portfolios on an hour-by-hour and annual carbon neutral basis by 2030 to inform its Strategic Plan and Integrated Resource Plan (IRP).

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[13] State of California (2018), *Executive Order B-55-18 To Achieve Carbon Neutrality*

[14] State of California – Legislative Information (2018), *Senate Bill No. 100*

[15] SMUD (2021), *Our 2030 Clean Energy Vision*

[16] Mayor of LA (2021), *Targets – Renewable Energy*

[18] City of San Jose (2021), *City of San Jose to Pledge Carbon Neutrality by 2030*

[20] Peninsula Clean Energy (2021), *Our Path to 24/7 Renewable Power by 2025*

[21] Marin Clean Energy (2022), *MCE Operational Integrated Resource Plan*

2. Scope and Approach

This section summarizes Energeia's scope of work and the approach adopted to deliver it.

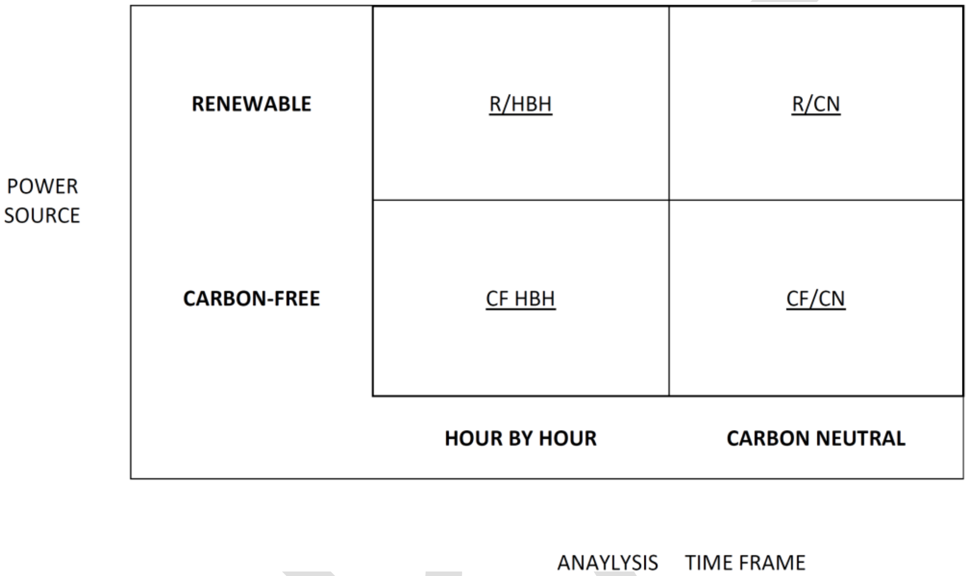
2.1. Scope

Valley Clean Energy engaged Energeia to explore:

- The feasibility, costs and benefits of pursuing renewable or carbon free portfolios under two scenarios, Carbon Neutral (CN) and Hour-by-Hour (HBH), by 2030 and;
- The impact of key risks forecasted to potentially drive increases in portfolio costs.

A diagram of the scenarios assessed is shown in Figure 1.

Figure 1 – Portfolios Assessed in the Following Study



Source: VCE (2021)

The HBH analysis requires VCE's demand to be met by zero carbon generation every hour of the year, while the CN timeframe requires VCE's annual renewable generation to equal VCE's annual demand.

The power source analysis defines renewable electricity to include biomass, solar thermal, photovoltaic, wind, geothermal, fuel cells using renewable fuels, small hydroelectric generation (<= 30 MW), digester gas, municipal solid waste conversion, landfill gas, ocean wave, ocean thermal, or tidal current, and carbon free electricity to include any generation source that meets the definition of renewable plus other sources considered zero emission such as large hydro (> 30 MW) and existing nuclear.

Additional refinements to the scope were developed over the course of the engagement in consultation with VCE and the CAC, including the consideration of green hydrogen and renewable natural gas fuelled Combined Cycle Gas Turbines (CCGTs).

2.2. Approach

Energeia's approach to delivering the scope of work involved the following main workstreams:

- **Stakeholder Engagement** – Energeia meet with VCE throughout the project to discuss the scope and approach for each of the technical workstreams, our initial findings, conclusions and recommendations and to agree material for discussion with the Consumer Advisory Committee (CAC).
- **Resource Requirements** – Energeia developed an estimate of the annual and hour-by-hour resource gap in 2030 based on VCE's IRP, updated to include newly contracted resources, as well as resources required since then due to changes in regulations.

- **Desktop Review of Technology Options and Costs** – Energeia undertook comprehensive desktop research of technology trends to identify the most prospective zero carbon fuels, generation and storage technologies, which were vetted and validated by VCE and the CAC.
- **Modelling Resource Portfolios** – Energeia configured its zero carbon resource portfolio optimization model with information from VCE's IRP, the results of the technology costs research to identify least cost resource mixes capable of meeting VCE's forecasted 2030 demand under the four scenarios.
- **Risk Assessment and Sensitivity Analysis** – Energeia agreed key demand and supply risks associated with the four scenarios with VCE and the CAC, and then modelled their potential impact on the portfolio mix and net costs.
- **Implementation Considerations and Pathways** – Based on the results of the portfolio optimization modelling, including the sensitivity analysis, Energeia developed recommendations regarding key implementation considerations and practical pathways for achieving the identified optimised portfolios.

Following completion of the above workstreams, Energeia documented the project scope, approach, technical methodologies, results and key recommendations in this report.

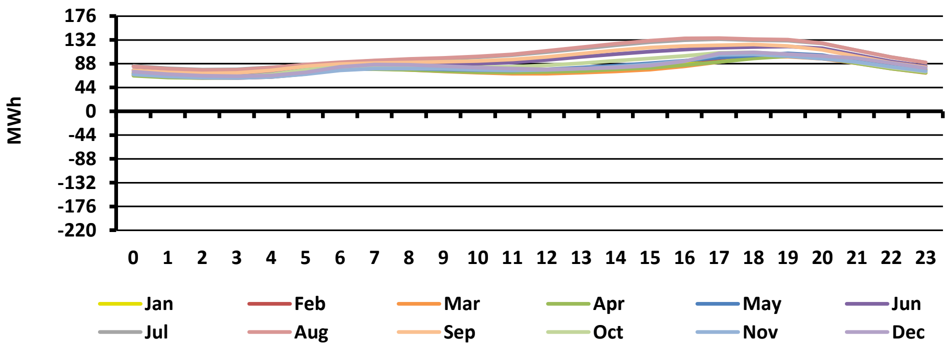
3. VCE's Resource Requirements by Hour in 2030

This section describes the development of the forecast VCE resource requirements by hour in 2030. We developed our estimates by taking VCE's forecast loads from their latest Integrated Resource Plan (IRP), including Behind-the-Meter (BTM) resources, and updated their forecast resources by adding any new resources acquired since the IRP was issued, or planned to be required due to changes in regulations.

3.1. Load Net of Behind-the-Meter Resources

Figure 2 and Figure 3 shows daily averages by month and were generated using VCE's forecast demand net of BTM resources. In 2020, VCE's hourly load varies by 74 MW, with a minimum hourly load of 61 MW in November and a maximum of 135 MW in August. Additionally, a very slight 'duck curve'[22] can be seen peaking around 17:00 during the most sun-intensive months, June through September.

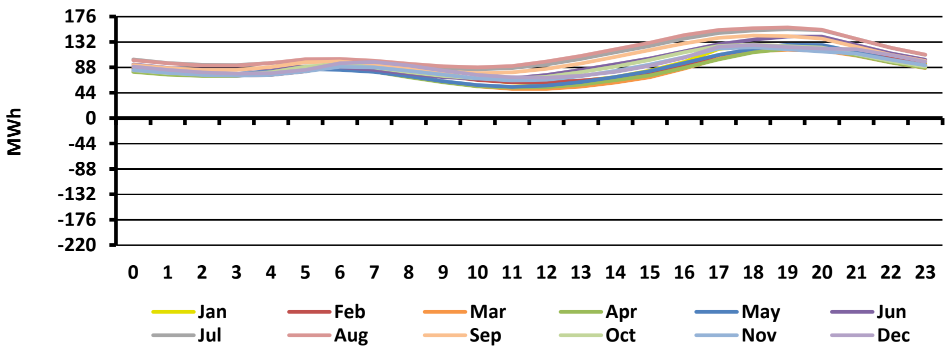
Figure 2 – 2020 Average Load Including DER



Source: VCE (2020)

VCE's forecast hourly demand in 2030 experiences varies by ~106 MW on average, which is 44% greater than the range in 2020. In 2030, the minimum hourly load occurs in March rather than November and is 51 MW, while the maximum hourly load remains in August and increases to 157 MW. An expected increase in BTM solar PV uptake over the next decade drives a more prominent duck curve in all months of 2030.

Figure 3 – 2030 Average Load Including DER



Source: VCE (2020)

Resource generation curves scaled to VCE's existing PPAs were applied to the demand curves shown above to understand the shape of the outstanding load. These resource profiles were taken from VCE's IRP assumptions.

[22] The Duck Curve refers to the impact of solar PV generation on the net load shape, which increasingly looks like a duck in profile.

3.2. Baseline Resource Assumptions

The Power Purchase Agreement (PPA) values presented in *Appendix A – Existing Power Purchase Agreements* were provided by VCE, they include all current PPAs, as well as expected PPAs required to meet changes in regulatory requirements since the IRP was completed, including geothermal and long duration storage portfolio requirements.

VCE currently contracts a total of 401 MW of renewable generation, and its portfolio has the following resources:

- Solar PV, 235 MW
- Hydroelectric, 2.9 MW
- Geothermal, 15 MW
- Combined Heat and Power (CHP), 8 MW
- Short Duration Storage (4-hour), 123 MW
- Long Duration Storage (8-hour) 5 MW, and
- Demand Response, 7 MW.

As a result of changes in portfolio requirements regulated by the California Energy Commission (CEC), VCE is also expecting to need to contract the following additional resources by 2026:

- Long Duration Storage (8-hour) 15 MW, and
- Geothermal, 5 MW.

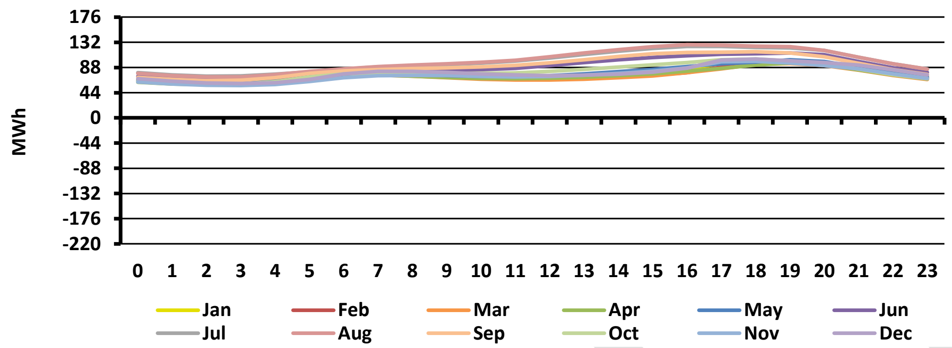
The above resources represent the Baseline resources assumed in place by 2030.

3.3. Hourly Resource Requirements

Resource load shapes provided in VCE's IRP were scaled to their available capacity in a given year to determine net hourly resource requirements. An annual degradation factor of 0.5%[23] and a system round trip efficiency of 86%[2] were assumed when calculating expected battery storage output, and a solar panel annual degradation factor of 0.5%[24] was assumed when calculating expected solar PV output.

Figure 4 shows average net load requirements by hour and month in 2020, which is almost identical to the 2020 average load including DER as the only existing PPA in 2020 provided 2.9 MW of hydroelectric generation.

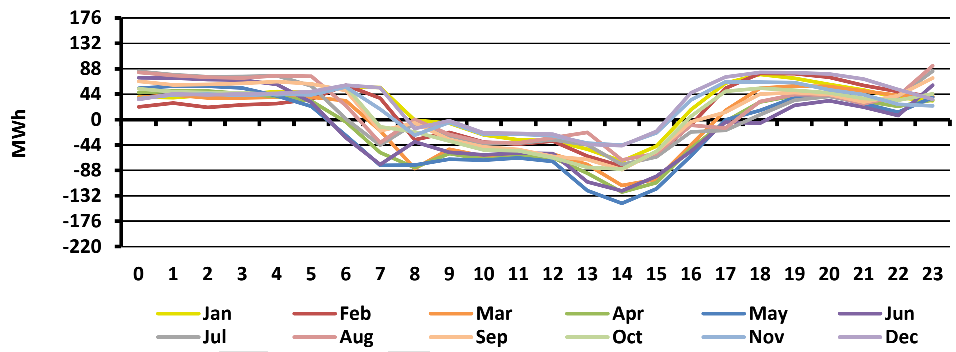
Figure 4 – Average Hourly Net Requirements by Month Including PPAs (2020)



Source: VCE (2020)

VCE's 2030 average net load requirements by hour and month are shown in Figure 5. There is a significant difference in this chart compared to 2030 as nearly all the PPAs listed in will be online in 2030. From 7:00 to 16:00, VCE is forecasted to have excess generation of 50 MWh on average, and during other hours, VCE will need to contract more resources.

Figure 5 – Average Hourly Net Requirements by Month Including PPAs (2030)



Source: VCE (2020)

[23] DOE (2019), *Energy Storage Technology and Cost Characterization Report*

[24] NREL (2018), *STAT FAQs Part 2: Lifetime of PV Panels*

4. Future Resource Costs

Energeia conducted a comprehensive review of zero carbon fuels, renewable generation and storage technology trends to ensure the list of potential resources in VCE's portfolios included the most prospective resources.

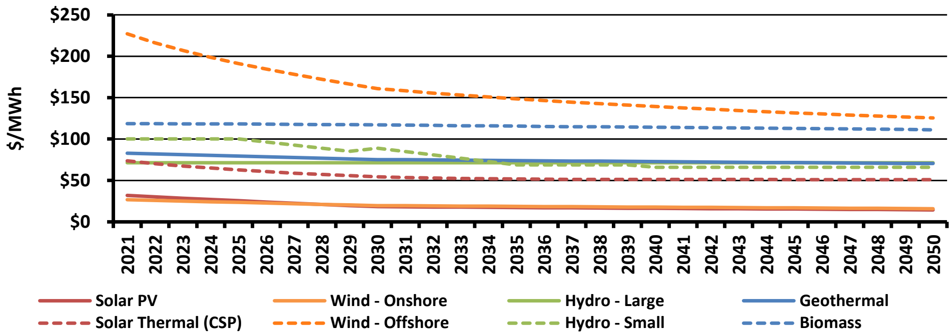
Appendix B – Technology Findings reports the detailed findings from our research, and the following subsections cover the present and forecasted levelized cost of energy (LCOE) values for the key technologies and fuels considered as potential resources for 2030. LCOE values are assumed to include each resource's capital expenditure (capex), fixed operational expenditure (opex), variable opex and fuel cost, if any.

4.1. Key Future Carbon-Free and Renewable Technologies

The LOCE costs presented in Figure 6 are from NREL's 2020 Annual Technology Baseline report. A key trend to highlight is the relatively constant costs for all technologies except for offshore wind. This reflects the trend of falling technology costs to be offset by the development of increasingly lower quality renewable resources.

Of the two solar resources presented, only solar PV was taken forward as a potential resource for VCE's portfolios due to the relative immaturity of solar thermal. Similarly, only onshore wind was considered in portfolio development. Both small and large hydro power technologies were considered in portfolio development, and biomass was not considered due to its relatively higher cost and alternative consideration of zero carbon fuels.

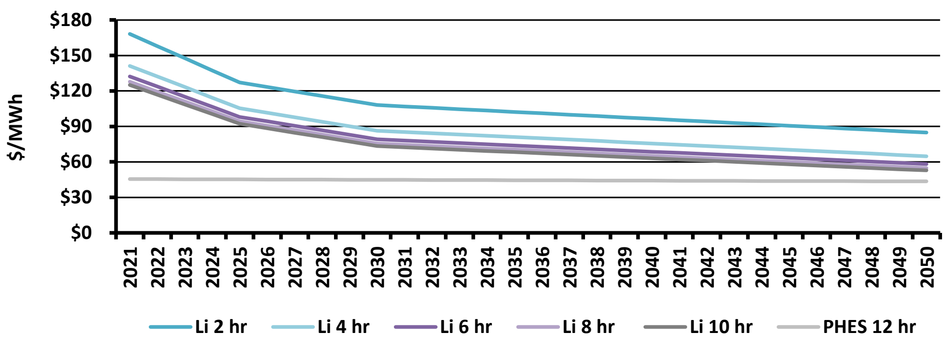
Figure 6 – Forecast Levelized Cost of Renewable Electricity Generation Technology



Source: NREL (2020); Note: CSP = Concentrated Solar Power, Hydro – Large is for hydropower projects > 30 MW and Hydro – Small is for hydropower projects <= 30 MW

NREL forecasted prices for storage technologies are shown in Figure 7 on a Levelized Cost of Storage (LCOS) basis, assuming lifetimes of 10 and 20 years for Li-ion energy storage and pumped energy storage, respectively. Both long and short duration Li-ion energy storage prices are expected to fall by ~50% over the next decade before experiencing a smaller rate of decline while pumped energy storage prices are expected to remain essentially constant through 2050. Both 4-hour (short duration) and 8-hour (long duration) Li-ion battery storage and 12-hour pumped energy storage were considered as potential resources during portfolio construction.

Figure 7 – Forecast Levelized Cost of Storage Technology

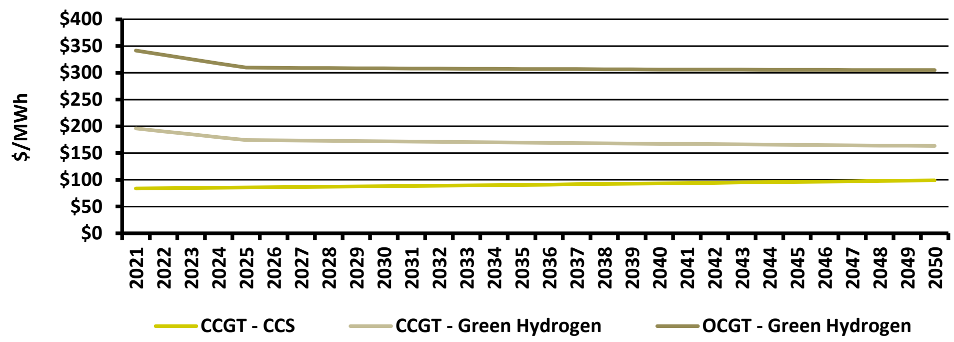


Source: NREL (2020), Energeia modelling; Note: Li = Lithium, PHES = Pumped Hydro Energy Storage

Energeia's forecast LCOE values for the zero carbon thermal technologies presented in Figure 8 were developed using a bottom-up approach. Capex, opex, CCS and fuel prices for combined cycle gas turbines (CCGT) and open cycle gas turbines (OCGT) were gathered from the EIA and IEA sources. Energeia modelled green hydrogen fuel prices on a bottom-up basis using public domain sources for solar PV renewable energy projects, electrolyzer, gas storage and gas transport costs.

Energeia's research and modelling found that LCOEs for zero carbon OCGT and CCGT configurations are expected to fall by 11.2% and 10.3%, respectively, over the 2020 to 2025 period, mainly driven by decline in green hydrogen costs. Post 2025, LCOEs are projected to change only marginally, rate of cost reduction is expected to slow significantly.

Figure 8 – Forecast Levelized Cost of Thermal Electricity Generation Technology Costs



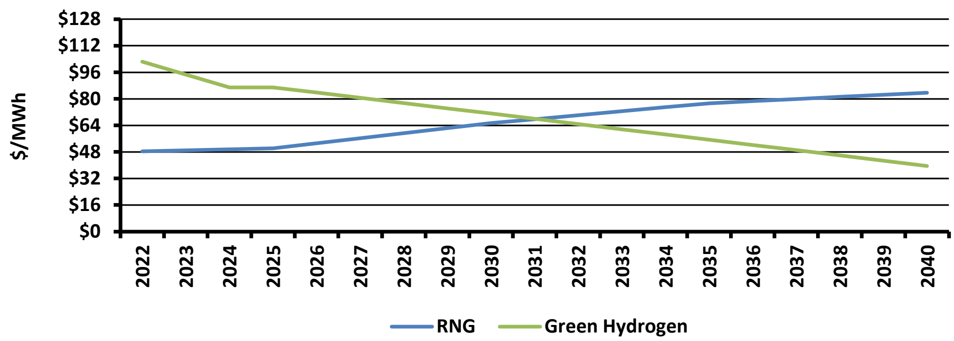
Source: EIA (2021), IEA (2010), Energeia modelling; Note: CCGT = Continuous Cycle Gas Turbine, OCGT = Open Cycle Gas Turbine, CCS = Carbon Capture and Sequestration

Despite having a forecast higher LCOE in 2030, Energeia only included OCGT technology as a potential technology during portfolio construction because combined cycle plants are unlikely to be able to achieve the dispatch levels required to make them economic due to the zero marginal cost of renewable generation. This decision was vetted with VCE and the CAC.

4.2. Zero Carbon Fuel Price Forecasts

Both renewable natural gas (RNG) and green hydrogen were considered as zero carbon fuels for the above thermal electricity generation technology. RNG prices were gathered from the public domain, and Energeia's method for modelling green hydrogen prices was summarised in the preceding section. Green hydrogen was selected because it is forecasted to be the more economical option after 2031, as shown in Figure 9.

Figure 9 – Forecast Renewable Fuel Prices



Source: ICF (2019), Energeia modelling; Note: RNG = Renewable Natural Gas

It is important to note that the above prices are exclusive of any government incentives.

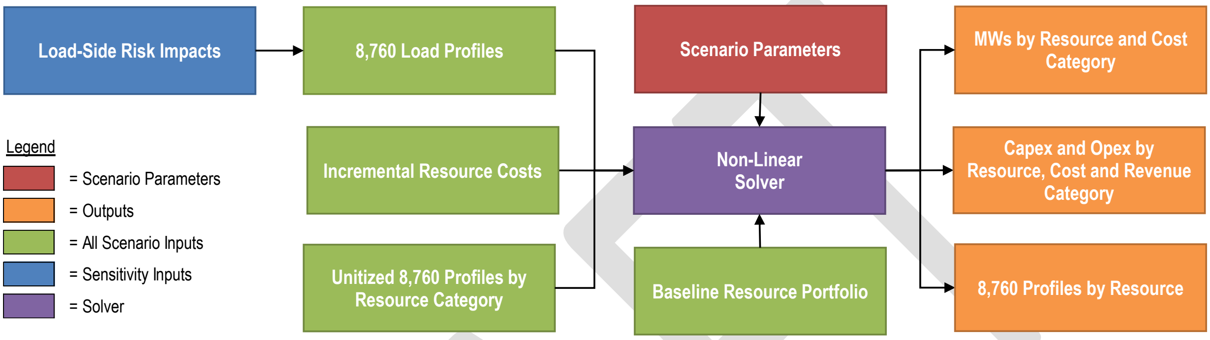
5. Optimized Carbon-Free and Renewable Portfolios

This section discusses the portfolio optimization methodology Energeia used along with optimized portfolio results, including resource mix, costs, revenues and net costs.

5.1. Portfolio Optimization Model

A diagram of the portfolio optimization tool used to determine least cost resource portfolios is shown in Figure 10. Energeia configured the tool by loading in VCE's 2030 hourly demand profiles, 2030 baseline capacity by resource type, 2030 costs by potential resource type, hourly (i.e. '8760') profiles by resource type. The tool was then parameterized for each portfolio scenario, including sensitivity scenarios, and a least cost portfolio mix was identified using a non-linear solver, which ensured the solution met all conditions, including resource adequacy.

Figure 10 – Schematic of Portfolio Optimization Tool



Source: Energeia

The final step was to generate the incremental resource capacities (MWs) by resource type, incremental resource costs by resource type and total 8,760 electricity profiles by resource.

5.2. Least Cost Resource Portfolios

Table 1 shows the results of Energeia's modelling of least cost incremental resource mixes for VCE in 2030 by scenario.

Under both the HBH and CN scenarios, there is no variation between the carbon free and renewable resource mixes as large hydropower (> 30 MW) generation is not included in the least cost solution for either portfolio. Additionally, neither portfolios include additional solar generation, which is not unexpected due to the relatively poor alignment of solar PV generation with forecast resource requirements.

Table 1 – Proposed Resource Capacities (MW)

Scenarios	Power Source	Solar	Wind	Geo thermal	Small Hydro	Large Hydro	4-Hr BES	8-Hr BES	12-Hr PES	OCGT
HBH	Carbon Free	0	39.3	11.3	0	0	42.3	65.4	10.7	112.3
HBH	Renewable	0	39.3	11.3	0	0	42.3	65.4	10.7	112.3
CN	Carbon Free	0	26.1	0	0	0	100.0	7.7	0	0
CN	Renewable	0	26.1	0	0	0	100.0	7.7	0	0

Source: Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

The least cost resource mix for the HBH scenario features wind, geothermal, 4-hour BES, 8-hour BES, 12-Hr PES and green hydrogen fuelled OCGT generation. It should be noted OCGT generation is only used in the HBH scenario to ensure all demand is met on an hourly basis. The modelling shows it is cheaper in this capacity than oversizing renewable energy capacity or investing in additional storage resources.

The least cost CN resource mix is much simpler in composition with only three incremental resource types required: wind, 4-hr BES and 8-hr BES, with 4-hour BES making up almost all of the storage resource. This is also unsurprising given the annual carbon balancing requirement is much less restrictive than the HBH scenario.

5.3. Portfolio Cost by Resource Type

Total estimated annual resource costs by resource category in 2030 are shown in Table 2.

Annual cost calculations used an assumed Weighted Average Cost of Capital (WACC) of 6% and the lifetime of all resources was assumed to be 20 years except for BES resources, which were assumed to have a 10-year lifetime. 8-hr and 4-hr BES resources are the highest cost across both HBH and CN portfolios, which is a reflection of their relative size in MW terms.

Ultimately, Energeia's modelling shows that meeting every hour of demand with renewable generation in 2030 is expected to cost nearly three times more in resources alone than being carbon neutral on an annual basis for VCE. However, it is important to note that costs could turn out to be significantly different to expectations.

Table 2 – Proposed Resource Costs ($M/Yr)

Scenarios	Power Source	Solar	Wind	Geo thermal	Small Hydro	Large Hydro	4-Hr BES	8-Hr BES	12-Hr PES	OCGT	Total $M/Yr
HBH	Carbon Free	$0.00	$3.30	$7.30	$0.00	$0.00	$5.30	$14.40	$3.30	$12.90	$46.50
HBH	Renewable	$0.00	$3.30	$7.30	$0.00	$0.00	$5.30	$14.40	$3.30	$12.90	$46.50
CN	Carbon Free	$0.00	$2.20	$0.00	$0.00	$0.00	$12.70	$1.70	$0.00	$0.00	$16.50
CN	Renewable	$0.00	$2.20	$0.00	$0.00	$0.00	$12.70	$1.70	$0.00	$0.00	$16.50

Source: Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

Net portfolio costs, which include resource cost, resource adequacy (RA), ancillary services (AS), flexible resource adequacy (FRA) and CAISO imports/exports are shown in Table 3.

Energeia's portfolio optimization modelling assumed an RA requirement of 115% of peak, an AS requirement of 105% of peak[25] and an FRA requirement[26] of 100% of nameplate solar PV generation.

Under all scenarios, no additional RA, AS, or FRA costs were as incurred, as requirements were able to be met by the portfolio itself. Regarding CAISO import/export costs, the HBH portfolio exported $3.9m of energy, while the CN portfolio incurred $0.5m of net imports, suggesting CAISO energy purchases almost exactly balance energy exports.

Portfolio net costs were $42.6m and $17.0m for the HBH and CN portfolios, respectively.

Table 3 – Proposed Portfolio Total Costs ($M/Yr)

Scenarios	Power Source	Resources	RA/AS/FRA	CAISO	Net
HBH	Carbon Free	$46.50	$0.00	($3.90)	$42.60
HBH	Renewable	$46.50	$0.00	($3.90)	$42.60
CN	Carbon Free	$16.50	$0.00	$0.50	$17.00
CN	Renewable	$16.50	$0.00	$0.50	$17.00

Source: Energeia research and analysis; Note: RA = Resource Adequacy, AS = Ancillary Services, FRA = Flexible Resource Adequacy

5.4. Portfolio Load and Resource Profiles

The following subsection visualize the daily average and peak day (August) hourly load, generation and net load of the proposed HBH and CN portfolios. The graphics include the baseline as well as incremental resources.

[25] This represents a maximum level of regulating capacity, actual AS requirements are likely to be lower throughout the year.

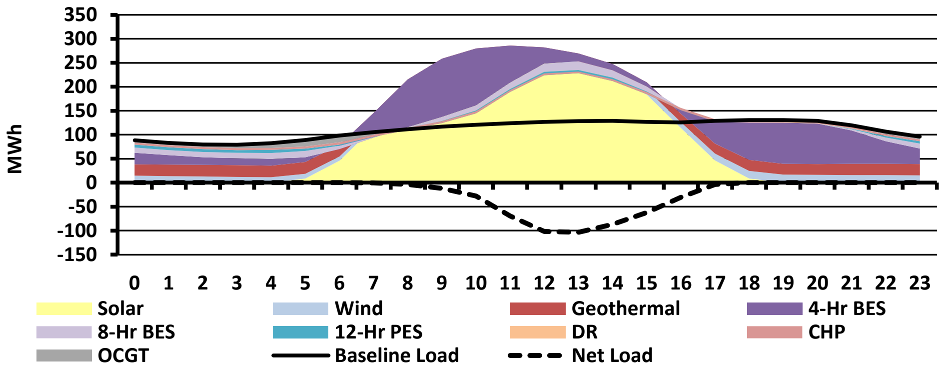
[26] Energeia is anticipating solar PV to drive flexible RA requirements in 2030 based on similar work we have done.

5.4.1. Hour-by-Hour Scenario

The 2030 HBH average day profile shown in Figure 11 shows solar PV generation meets all customer demand from 7:00 to 16:00. In the morning before 7:00, all portfolio resources including storage are used to meet demand with very little OCGT generation, while the evening load is met primarily with 4-hr BES.

The negative Net Load from 9:00 to 17:00, mainly driven by excess solar generation, suggests the average 2030 day has ~45 MWh to export to CAISO. This reflects oversizing of renewable generation resources in order to be able meet demand each hour of the year using zero carbon resources at least cost.

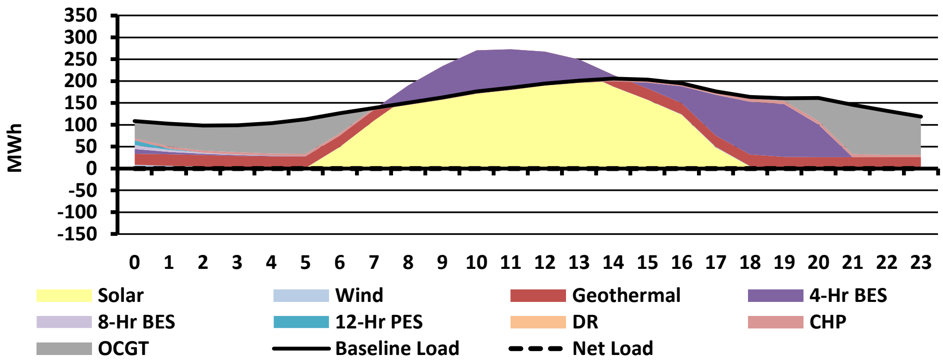
Figure 11 – 2030 Hour-by-Hour Average Day Profile



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

Figure 12 shows the HBH peak day profile, and the key item to note here is net load during every hour is zero due to the assets being sized to meet the peak day. Demand is met primarily with a much smaller range of resources compared to the average day. Only 3.0% of daily average load is met using OCGT generation whereas 21.2% of the peak day base load is met by OCGT generation.

Figure 12 – 2030 Hour-by-Hour Peak Day Profile



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

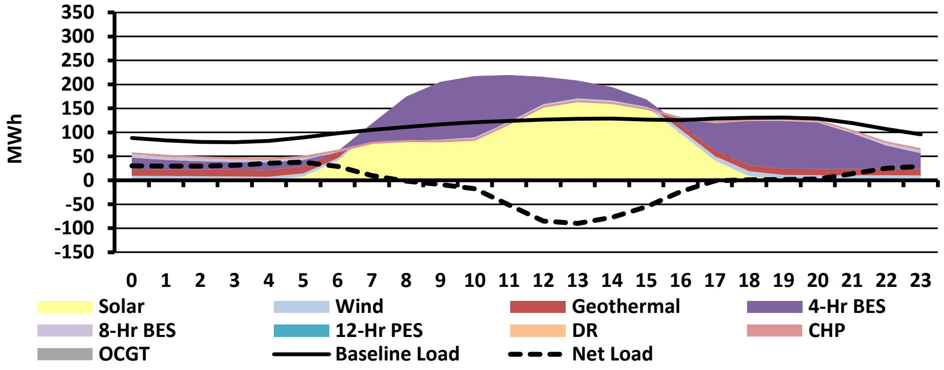
It is worth noting that there is less 8-hour and 12-hour generation during the peak day than on the average day due to the lack of excess solar PV during the days surrounding the peak day.

5.4.2. Carbon Neutral Scenario

The 2030 CN average day profile, displayed in Figure 13, shows the main resources used to meet demand are solar and 4-hr BES, with solar PV meeting 66.8% and 4-hr BES meeting 23.4% of load on average, respectively.

Under the CN scenario, there is no requirement to meet demand with zero carbon generation every hour, and on average VCE will be procuring CAISO resources during the 9pm to 6am period, which can be seen in the gap between the solid baseline load and resource stack. On average, 305 MWh of electricity will need to be procured, amounting to 11.5% of average energy consumption.

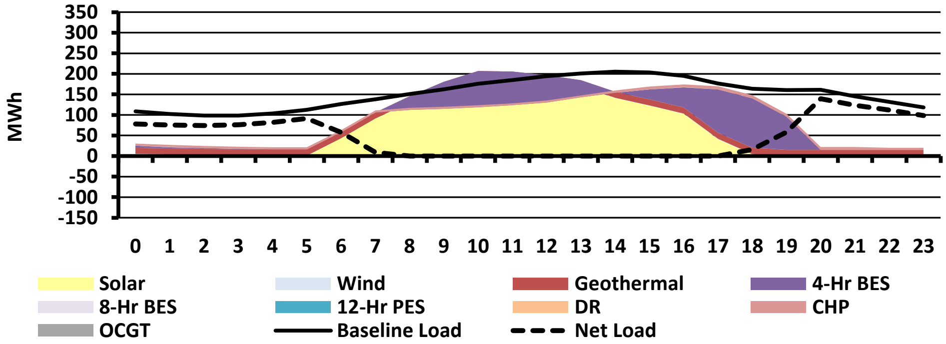
Figure 13 – 2030 Carbon Neutral Average Day Profile



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

The CN portfolio's peak day profile is also dominated by solar and 4-hr BES as shown in Figure 14. However, the resource gap is significantly higher, with 1.1 GWh or approximately 30.1% of load needing to be procured from CAISO on the peak day.

Figure 14 – 2030 Carbon Neutral Peak Day Profile



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

The above analysis highlights the large role that CAISO will need to play under the CN scenarios. If other utilities are also planning on meeting their zero carbon targets using CAISO resources, it is likely to impact on the cost of resources, which was out of scope for this study. CAISO resource costs are therefore potentially higher than estimated in this study as a result – depending on the level of CAISO reliance by other jurisdictions in 2030.

6. Risk Analysis

The following section discusses the key risks Energeia assessed as part of this study and estimated their impacts on portfolio net cost. Supply risks included excluding hydropower and green hydrogen availability, and CAISO revenue. Demand side risks included drought and higher than expected EV and BE uptake rates.

6.1. Key Risks

Energeia identified a range of potential risks to the cost and feasibility of the identified least cost resource portfolios, which we then vetted with VCE and the CAC, who also added to the list. A final list of seven key risks were agreed to be taken forward for quantitative analysis based on their expected materiality.

6.1.1. Green Hydrogen Powered OCGTs are Unavailable or Higher Cost

This risk assessment evaluated the HBH portfolio excluding OCGT fuelled by green hydrogen as the technology is still in development stages with Siemens[27] and GE[28] aiming to run their gas turbines on 100% hydrogen by 2030. Thus, there is a possibility this technology may not be available for VCE to incorporate in its 2030 resource portfolios. There is also a risk that the forecast cost of green hydrogen does not decline as anticipated.

6.1.2. CAISO Prices Are Higher and/or Lower than Expected

Both HBH and CN portfolios were assessed assuming that excess generation could not be sold in the CAISO wholesale market. This risk was evaluated due to the potential impact of other Community Choice Aggregators (CCAs), Publiclly Owned Utilities (PONs) and Investor Owned Utilities (IOUs) also trying to sell their excess renewable electricity and buy shortfalls from the market, which is likely to reduce the value of the former and increase the cost of the latter. There is also the risk that VCE stakeholders will require more self-reliance.

6.1.3. Drought Conditions Increase in Frequency and Magnitude

Two potential effects of drought on VCE's portfolio cost and feasibility were raised:

- Limited availability to hydroelectric power generation, and
- increased agriculture load due to pumping ground water to meet irrigation needs.

As Table 2 showed, hydropower is not part of a least cost portfolio under any scenario, and the proposed resource mixes will therefore not be affected by limited availability of hydropower during a drought.

The effect of drought on agriculture load was evaluated using VCE's hourly (8,760) agriculture loads from 2019, 2020 and 2030, where 2019 was used as the baseline year and 2020 was used as the drought year. Energeia developed a forecast 2030 under drought conditions by first calculating growth factors at the hourly level equal to 2020 load / 2019 load, then multiplying the hourly growth factors by VCE's forecasted hourly 2030 load in its IRP. The total additional annual load amounts to 57.4 GWh.

Figure 15 shows, on average, the daily added load from drought would only make up 5.4% of total load or 157 kWh, while Figure 16 shows the additional load would have a very significant impact on the peak day, constituting 58.1% of total load or 3.09 MWh – more than doubling consumption. Additionally, the peak day with added drought load is in May and driven by the high volumes of water required for crop irrigation in the Spring.

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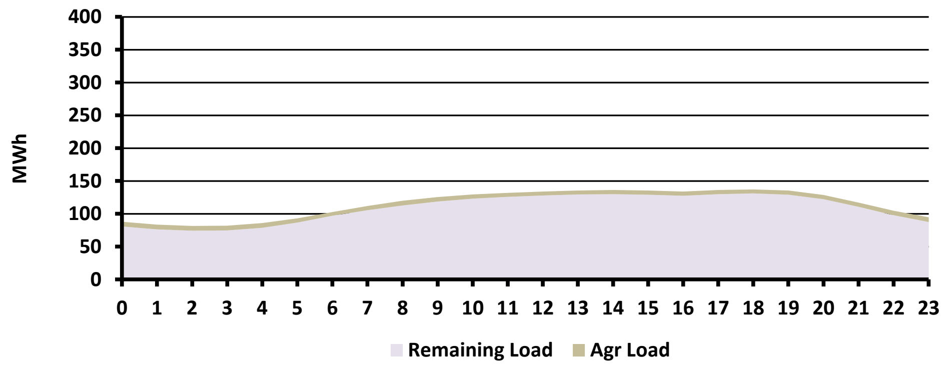
[27] Siemens (2021), *Zero Emission Hydrogen Turbine Center*

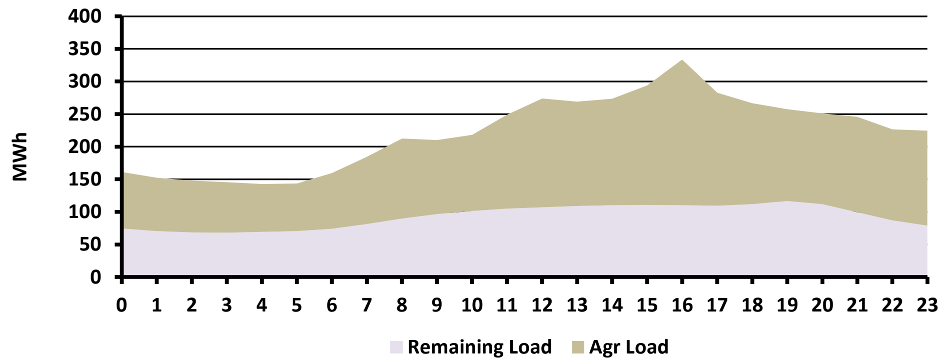
[28] General Electric (2020), *The Power Couple: Renewable + Gas Can Drive Decarbonization with Greater Speed*

Figure 15 – Forecast Added Daily Average Load from Drought (2030)



Source: SMUD (2021), Energeia modelling; Note: Agr = Agriculture

Figure 16 – Forecast Added Peak Day Load from Drought (2030)



Source: SMUD (2021), Energeia modelling; Note: Agr = Agriculture

6.1.4. Higher than Expected Electric Vehicle Uptake

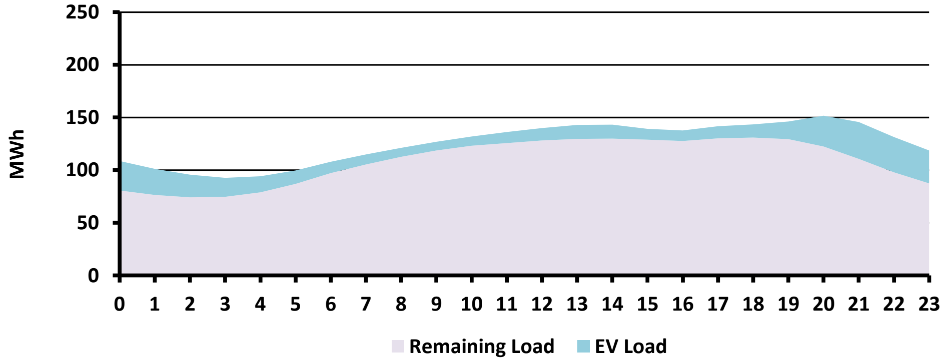
Energeia modelled EV uptake in VCE's service area by configuring its EV uptake model using public domain inputs such as vehicle miles travelled, EV fuel efficiency, EV model availability, current vehicle stock, fuel prices and vehicle tech prices.

Energeia's EV uptake modelling forecast EV stock in 2030 to be 15,423. Assuming an average annual consumption of 2.5 MWh p.a. for passenger and light duty vehicles, Energeia estimate total additional annual load from EVs to be 38.5 GWh in 2030, which was scaled on an hourly basis using the IRP EV load shape.

The resulting average day and peak day load profiles are shown in Figure 17 and Figure 18, respectively. EV loads are not forecasted to change significantly between VCE's peak and average day, as EV load sums to 392 MWh during the peak day and 405 MWh on an average day. Relative to total load, peak day EV load is 9.8% and average day EV load is 13.4% of total energy consumed.

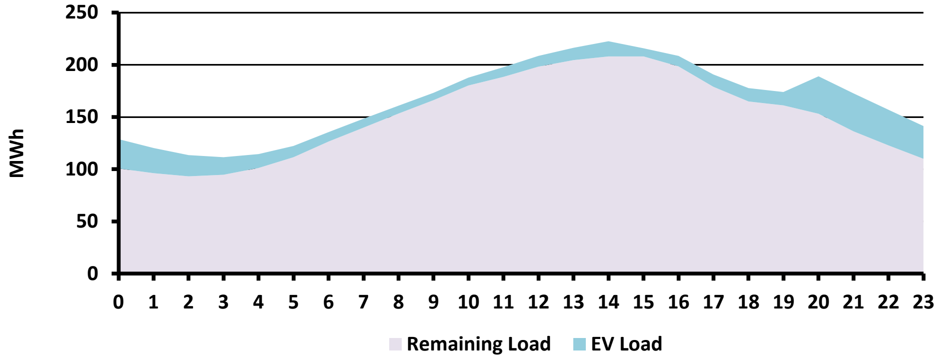
It is worth noting that EV load is not forecast to impact on the timing of the peak day, which remains in August.

Figure 17 – Forecast Added Daily Average Load from EV Adoption (2030)



Source: VCE (2020), Energeia research and modelling

Figure 18 – Forecast Added Peak Day Load from EV Adoption (2030)



Source: VCE (2020), Energeia research and modelling

6.1.5. Higher than Expected Building Electrification Uptake

As all-electric construction becomes common and the potential for a ban on new gas appliances increases, VCE's building electrification uptake is predicted to increase significantly and impact 2030 demand forecasts. Currently, SMUD expect 80% of buildings in its service territory to be all-electric by 2040 and 33 municipalities in California including Davis have introduced building codes requiring or encouraging all-electric construction.[29]

Energeia estimated the potential BE impact on load in 2030 by configuring our building electrification model, which models the impact of space heating, water heating and cooking end uses in residential and non-residential buildings. Appliance lifetimes, energy efficiency and hourly (8760) consumption values used in the analysis reflect the latest available figures in the public domain. Gas appliance market shares were calculated using the updated 2019 Residential Appliance Saturation Study and census data and appliance load shapes are based on US DOE load shape estimates for Sacramento under the 2010 Building Technologies Program.

Energeia's modelling assumed 100% of new customers and end of life replacements to be electric from 2023 onwards. This assumption reflects a scenario whereby new gas appliances are banned from 2023, even on a replacement basis. It is therefore a conservative estimate of the potential impact of building electrification, actual impacts on cost are likely to be lower, and should be assessed in more detail in future work.

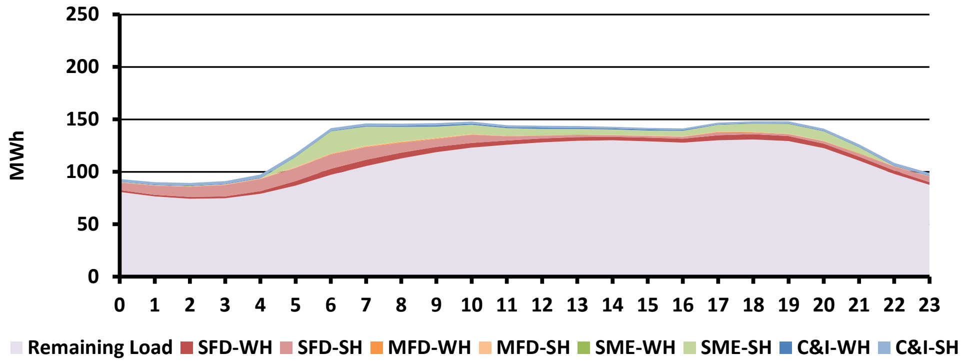
Average daily and peak day building electrification load profiles are show in Figure 19 and Figure 20, respectively.

On average, up to 474.3 MW of demand could added from BE by 2030, which is 15.4% of the total load. During the 2030 peak day, up to 2.7 GWh of additional demand could added from BE, which is 51.9% of the total load.

[29] Green Tech Media (2020), *This California Utility Is Now Measuring Building Electrification in "Avoided Carbon"*

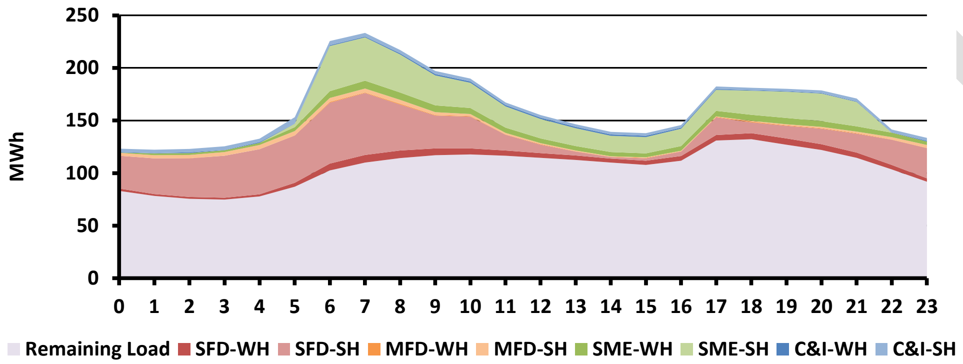
Throughout the entire year, up to 173.1 GWh could be added from BE, with the largest contributions coming from residential and small business space heating.

Figure 19 – Forecast Maximum Potential Daily Average Load from Building Electrification (2030)



Source: US DOE - Open EI (2010), Energeia research and modelling; Note: SFD = Single Family Dwelling, MFD = Multi Family Dwelling, SME = Small and Medium Enterprises, C&I = Commercial and Industrial, SH = Space Heating, WH = Water Heating

Figure 20 – Forecast Maximum Potential Peak Day Load from Building Electrification (2030)



Source: US DOE - Open EI (2010), Energeia research and modelling; Note: SFD = Single Family Dwelling, MFD = Multi Family Dwelling, SME = Small and Medium Enterprises, C&I = Commercial and Industrial, SH = Space Heating, WH = Water Heating

Finally, high levels of BE load on the peak day would significantly change the shape of the curve, giving it a double peak and shifting the annual peak from August in summer to December in winter.

6.2. Portfolio Cost Impacts

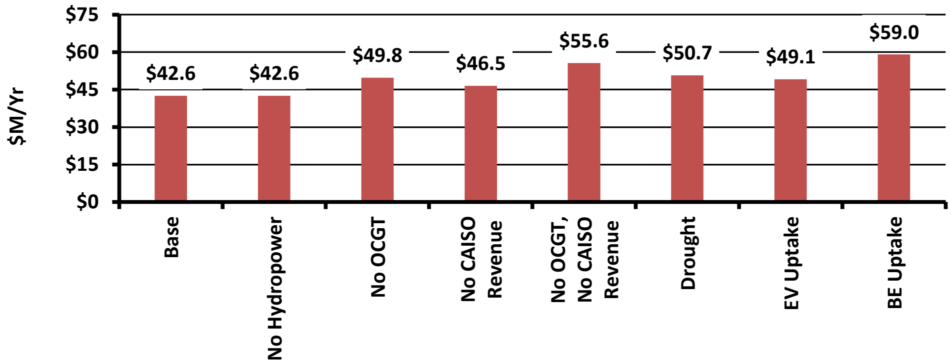
The results of Energeia's modelling of the net portfolio cost of each risk adjusted HBH and CN portfolio are shown Figure 21 and Figure 22, respectively. Detailed views of the associated resource mixes and total costs by portfolio are reported in Appendix C – Detailed Portfolio Results.

Energeia's modelling of key risks found that each risk factor increased annual costs, however the impact depended on the portfolio scenario.

Excluding hydropower from the HBH scenario did not impact costs because the least cost portfolio does not include hydropower. Removing the green hydrogen powered OCGT, on the other hand, increased HBH costs by $7.2m p.a. or 17.0% over the least cost portfolio. Removing CAISO revenue increased costs by $3.9m, or 9.2%. Excluding both CAISO revenue and OCGT generation increased costs by $13m, which is 30.6% higher, but lower than the sum of each risk individually. In terms of demand side risks, drought increased annual costs by $8.1m or 19%, higher EV uptake increased costs by $6.5m or 15% and, finally, higher BE uptake increased costs by $16.4m or 38.4%.

Portfolio optimization of the range of resources considered as part of this study is complex, and it is therefore difficult to pick apart how each demand side risk factor is driving portfolio costs. However, the main driver of HBH cost differentials across demand side risk factors appears to be total annual energy impacts. Changes in system peak demand, or the hourly shape of the impact, appear to exert a lesser impact on portfolios costs.

Figure 21 – Hour-by-Hour Portfolio Cost Impacts



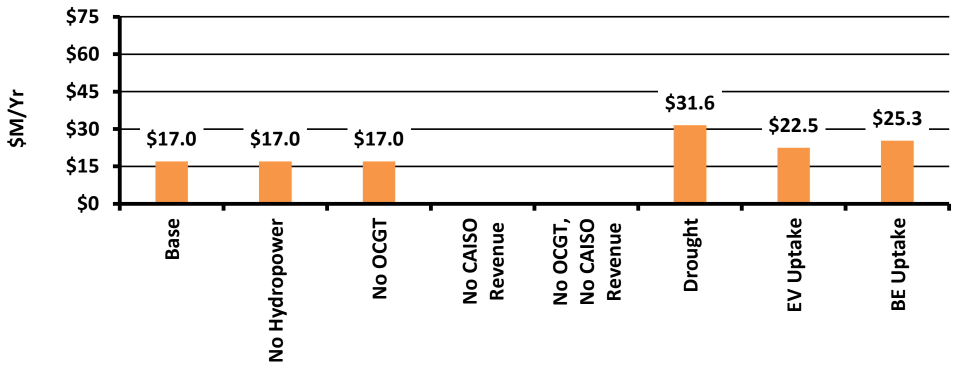
Source: Energeia modelling

The impact of supply side risk factors on CN portfolio costs is nil as the least cost CN portfolio does not include hydropower or OCGT generation. CAISO revenue was not assessed as a risk factor as it was considered a core element of this scenario. Energeia recommends that the risk of CAISO costs being significant different to today's levels be explored in a future piece of work, as we consider it to be potentially material.

Regarding the impact of demand side risks, they range from 32% to 86% higher than the least cost portfolio. The drought-impacted portfolio is the highest cost impact at $14.6 or 86% higher, followed by the BE-impacted portfolio at $8.3m or 49% higher cost. The EV-impacted portfolio was the lowest cost impact at $5.5m or 32% higher than the least cost portfolio.

The impact of risk factors on CN portfolio costs are higher in percentage terms than the impact of risk factors on HBH portfolio costs due to the use of latter's use of excess generation. The CN portfolios also appear to be more sensitive to the impacts of the risk factor on the shape of demand, as drought increases costs more than BE uptake, despite the latter risk factors larger impact on annual energy consumption.

Figure 22 – Carbon Neutral Portfolio Cost Impacts



Source: Energeia modelling

7. Portfolio Implementation Considerations

Based on the results of our least cost portfolio optimization analysis, including assessment of the impact of seven key risk factors, Energeia developed the following key recommendations regarding implementing the identified least cost portfolios:

- **Focus on no regrets opportunities** – Resources present in both portfolios, including wind, 4-hour and 8-hour lithium-ion storage could be purchased initially allowing VCE to head in the direction of carbon neutrality under the CN scenario, and potentially change to the HBH scenario in the future.
- **Consider deferring lithium-ion projects** – Lithium-ion battery storage systems are expected to decline significantly over the next decade. VCE should therefore consider delaying storage contracts, and/or requesting that storage embedded in future renewables projects to be built closer to 2030.
- **Benefit from co-location –** Regarding resource placement, co-locating batteries at solar or wind sites, if possible, may minimize revenue lost to curtailment, which is expected to increase in California over the next 10 years. Battery asset timing should therefore consider curtailment and future cost declines.
- **Address key risk factors –** Developing programs to increase the efficiency of agriculture pumping load, and to increase the flexibility of transportation and building electrification loads, could help reduce the associated impact on portfolio costs.

It is important to evaluate these recommendations over time, as key risk factors could change due to unforeseen changes in policy, regulation, technology, market and industry conditions.

Appendix A – Existing Power Purchase Agreements

Table A1 lists VCEs current and planned resource contracts.

Table A1 – Valley Clean Energy's Current and Planned Resource Contracts

Name of Counter Party	Project Name	Project Technology	Hydro (MW)	Solar (MW)	Storage (MW)	DR (MW)	Geo-thermal (MW)	VCE Allocation	Project Start Year	Project Start Month	PPA Term (Years)
California Joint Powers Authority	Indian Valley Short Term PPA	Hydroelectric Generation	2.9	0	0	0	0	100%	2020	May	5
Aquamarine Westside LLC	PPA	AC Solar PV	0	50	0	0	0	100%	2021	Oct	15
Putah Creek Solar Farms LLC	Renewable PPA	AC Solar PV	0	3	3 (4-hrs)	0	0	100%	2022(?)	Jan	20
VESI 10 LLC	Tierra Buena Energy Storage	Lithium (RAR Attributes)	0	0	2.5 (4-hrs)	0	0	100%	2022	June	10
Leapfrog Power Inc.	Resource Adequacy Agreement	Demand Response (RAR Attributes)	0	0	0	7	0	100%	2021	June	10
Gibson Renewables LLC	Renewable PPA	Solar PV, Lithium Battery Storage	0	20	6.5 (4-hrs)	0	0	100%	2023	Oct	20
Resurgence Solar I, LLC	Renewable PPA	Solar PV AC Coupled w/ Li-Ion Storage	0	90	75 (4-hrs)	0	0	100%	2023	Jan	20
Willow Springs Solar 3 LLC	Willow Springs Solar 3	Solar + Storage	0	72	36 (4-hrs)	0	0	100%	2024	Jan	15
TBA	TBA	Geothermal	0	0	0	0	15	100%	2026	TBA	20
TBA	TBA	Long-Duration Storage	0		5 (8-hrs)	0	0	100%	2026	TBA	15

Source: VCE (2021)

Appendix B – Technology Findings

The following tables (Table B1 and B2) summarize findings from Energeia's comprehensive desktop research of zero carbon energy generation and storage technologies. Each table provides descriptions, advantages, disadvantages, availability and potential breakthroughs by technology. Capacity factors are reported for generation technologies, and roundtrip losses are reported for storage technologies.

Table B1 – Key Future Zero Carbon Generation Technologies

Name	Category	Capacity Factor	Description	Advantages	Disadvantages	Availability	Potential Breakthroughs
Onshore Wind	Wind	51%	A windmill is used to turn a turbine to generate electricity on land	• Mature technology • Relatively low $/kWh capex • Relatively constant generation	• Community resistance • Limited resource availability	• Commercially available • 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 • Relatively low $/kWh capex • Relatively constant generation	• Community resistance • Limited resource availability	• Commercially available • Limited to areas of high wind resource • Limited to coast areas	• Larger turbines increasing efficiency and reducing costs
Single Axis Solar PV	Solar	30-35%	Photovoltaic (PV) panels on a single axis tracking system are used to generate electricity	• Mature technology • Relatively low $/kWh capex	• Strongly seasonal • Limited resource availability	• Commercially available • 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 • Firm capacity • Relatively low $/kWh	• Strongly seasonal • Limited resource availability • Relatively immature	• Commercially available • Limited to areas of high solar resource • 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 • Firm capacity • Mature technology	• Limited resource availability • Relatively high $/kWh capex	• Commercially available • Limited to areas of high geothermal resource	
Ocean Tidal	Tidal	20-35%	Tidal energy is used to drive an electric generator	• Predictable resource • Complementary generation profile	• Requires tidal estuary • Relatively expensive per kWh • Immature technology	• Commercially available • Limited to coastal areas • Limited to tidal areas	

Ocean Wave	Wave	25-32%	Wave energy is used to drive an electric generator	• Predictable resource • Complementary generation profile	• Requires coast access • Relatively expensive per kWh • Immature technology	• Commercially available • Limited to coastal areas	
Run-of-River Hydro	Hydropower	40-80%	Water flow is used to drive an electric generator	• Relatively low $/kWh capex • Firm capacity	• Community resistence • Subject to rainfall	• Commercially available • 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 • Includes storage • Firm capacity	• Community resistance • Subject to rainfall • Subject to other uses, e.g. fish	• Commercially available • 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 • Methane reduction boost • Firm capacity	• Local emissions from combustion	• Commercially available • Limited to areas with significant waste streams	
Biomass	Biomass	50-60%	Methane is captured from biomass or biomass is burned directly to drive a combustion turbine	• Firm capacity	• Local emissions from combustion	• Commercially available • Limited to areas with significant biomass streams	• Improvements in bio-digester technology increases efficiency and reduces cost

Source: Energeia research

Table B2 – Key Future Storage Technologies

Name	Category	Roundtrip Losses	Description	Advantages	Disadvantages	Availability	Potential Breakthroughs
Capacitors	Seconds	5%	Capacitors used to rapidly charge and discharge small amounts of electricity directly	• Fastest response of any technology • Mature technology	• Relatively expensive per kWh • Unable to store significant energy • 10-20% losses per day	• Widely available	
Flywheels	Seconds	5%-50%	Uses a flywheel to rapidly charge and discharge relatively small amounts of electricity using an electric generator	• Relative fast response times • Mature technology	• Relatively large footprint • Relatively expensive per kWh • 20-50% losses over 2 hours	• Widely available	
Battery	Hours	10%	Electrochemical reactions are used to store and discharge electricity directly	• Relatively responsive • Relatively low losses • Mature technology	• Relatively high cost per kWh • Thermal runaway	• Widely available	• Metal air and liquid metal formulations may improve cost effectiveness
Flow	Hours	40%	Stores electricity in two chemicals, which can be stored indefinitely	• No standing losses if turned off • Relatively safe	• Unproven technology • High parasitic losses while on • Relatively high $/kWh	• Commercially available • Pilot scale	
CSP	Hours	1%	Stores energy as heat in working fluid, which is then used to drive a heat recovery-based steam generator	• Very low round trip losses • Can be coupled with CSP • Relatively low $/kWh capex	• Unproven technology • Safety of high operating temp	• Commercially available • Pilot scale	• High temp steam turbine technology could increase efficiency, lower $/kWh
Hydrogen-Compression	Hours	53%	Uses steel or carbon fiber based receiving vessels to store relatively small amounts of hydrogen	• Mature technology • Relatively compact footprint • Relatively low $/kWh capex	• Amount of space required • High round trip losses	• Widely available	• Material science could reduce cost
Hydrogen-Salt Cavern	Weeks	42-55%	Uses air compressors to store large amounts of hydrogen in salt caverns	• Relatively low cost per kWh • Mature technology	• Requires access to a salt cavern • High losses • Relatively slow response	• Limited availability of salt caverns	

Compressed Air Energy Storage (CAES)	Weeks	42-55%	CAES stores electricity in underground formations including salt caverns and an expander to drive a turbine generator	• Relatively low $/kWh capex • Mature technology	• Requires access to a salt cavern • High losses • Relatively slow response	• Limited availability of salt caverns	• Isobaric systems potentially reduce volume by 77%
Hydrogen-Organics	Months	59-89%	Uses chemical processes to store hydrogen, typically as ammonia or methanol	• Mature technology • Relatively high energy density	• Storage of volatile chemicals • Relatively high losses • Relatively high $/kWh	• Widely available	• High potential for cost reduction
Pumped Hydro	Months	80%	Pumps water into reservoirs for later use to drive water turbine generators	• Mature technology • Relatively low $/kWh capex • Relatively low standing losses	• Requires access to reservoir • Scale required • Relatively slow response	• Limited availability of reservoirs	

Source: Energeia research

Appendix C – Detailed Portfolio Results

This appendix contains detailed resource capacities (Table C1), resource costs (Table C2) and total costs (Table C3) for each risk-impacted portfolio Energeia assessed. The grey rows indicate scenarios which were not assessed due to not being feasible given the scenario assumptions.

Table C1 – Resource Capacities by Portfolio (MW)

#	Scenario	Electricity Type	Scenario Summary	Solar	Wind	Geothermal	Small Hydro	Large Hydro	4-Hr	8-Hr	12-Hr	OCGT
Sensitivity												
1	HBH	Carbon Free		0.0	39.3	11.3	0.0	0.0	42.3	65.4	10.6	112.3
2	HBH	Renewable		0.0	39.3	11.3	0.0	0.0	42.3	65.4	10.6	112.3
3	HBH	Carbon Free	No Hydro									
4	HBH	Renewable	No Hydro	0.0	39.3	11.3	0.0	0.0	42.3	65.4	10.6	112.3
5	HBH	Carbon Free	No OCGT	0.0	28.4	29.1	0.0	0.0	83.5	74.3	24.2	0.0
6	HBH	Renewable	No OCGT	0.0	28.4	29.1	0.0	0.0	83.5	74.3	24.2	0.0
7	HBH	Carbon Free	No CAISO Revenue	0.0	39.3	11.3	0.0	0.0	42.3	65.4	10.6	112.3
8	HBH	Renewable	No CAISO Revenue	0.0	39.3	11.3	0.0	0.0	42.3	65.4	10.6	112.3
9	HBH	Carbon Free	No OCGT, No CAISO Revenue	0.0	28.4	29.1	0.0	0.0	83.5	74.3	24.2	0.0
10	HBH	Renewable	No OCGT, No CAISO Revenue	0.0	28.4	29.1	0.0	0.0	83.5	74.3	24.2	0.0
11	HBH	Carbon Free	No Hydro, No OCGT									
12	HBH	Renewable	No Hydro, No OCGT	0.0	28.4	29.1	0.0	0.0	83.5	74.3	24.2	0.0
13	HBH	Carbon Free	No Hydro, No OCGT, No CAISO Revenue									
14	HBH	Renewable	No Hydro, No OCGT, No CAISO Revenue	0.0	28.4	29.1	0.0	0.0	83.5	74.3	24.2	0.0
15	CN	Carbon Free		0.0	26.1	0.0	0.0	0.0	100.0	7.7	0.0	0.0
16	CN	Renewable		0.0	26.1	0.0	0.0	0.0	100.0	7.7	0.0	0.0
17	CN	Carbon Free	No Hydro									
18	CN	Renewable	No Hydro	0.0	26.1	0.0	0.0	0.0	100.0	7.7	0.0	0.0
19	CN	Carbon Free	No OCGT	0.0	26.1	0.0	0.0	0.0	100.0	7.7	0.0	0.0
20	CN	Renewable	No OCGT	0.0	26.1	0.0	0.0	0.0	100.0	7.7	0.0	0.0
21	CN	Carbon Free	No CAISO Revenue									
22	CN	Renewable	No CAISO Revenue									
23	CN	Carbon Free	No OCGT, No CAISO Revenue									
24	CN	Renewable	No OCGT, No CAISO Revenue									
25	CN	Carbon Free	No Hydro, No OCGT									
26	CN	Renewable	No Hydro, No OCGT	0.0	26.1	0.0	0.0	0.0	100.0	7.7	0.0	0.0
27	CN	Carbon Free	No Hydro, No OCGT, No CAISO Revenue									
28	CN	Renewable	No Hydro, No OCGT, No CAISO Revenue									
Risk												
2	HBH	Renewable	Drought	36.0	72.4	7.2	0.0	0.0	31.1	13.1	12.4	282.9
3	HBH	Renewable	Electric Vehicle Uptake	39.0	71.7	3.3	0.0	0.0	0.0	10.0	7.2	273.5
4	HBH	Renewable	Building Electrification Uptake	0.0	100.0	16.6	0.0	0.0	0.0	0.0	0.0	267.4
6	CN	Renewable	Drought	15.4	5.1	0.0	9.3	0.0	49.2	11.5	15.2	0.0
7	CN	Renewable	Electric Vehicle Uptake	0.0	0.0	2.6	5.3	0.0	12.5	22.0	6.5	0.0
8	CN	Renewable	Building Electrification Uptake	2.3	33.2	0.0	7.4	0.0	14.7	8.1	6.1	0.0

Source: Energeia modelling

Table C2 – Resource Costs by Portfolio ($M/Yr)

#	Scenario	Electricity Type	Scenario Summary	Solar	Wind	Geothermal	Small Hydro	Large Hydro	4-Hr	8-Hr	12-Hr	OCGT
Sensitivity												
1	HBH	Carbon Free		$0.0	$3.3	$7.3	$0.0	$0.0	$5.3	$14.4	$3.3	$12.9
2	HBH	Renewable		$0.0	$3.3	$7.3	$0.0	$0.0	$5.3	$14.4	$3.3	$12.9
3	HBH	Carbon Free	No Hydro									
4	HBH	Renewable	No Hydro	$0.0	$3.3	$7.3	$0.0	$0.0	$5.3	$14.4	$3.3	$12.9
5	HBH	Carbon Free	No OCGT	$0.0	$2.4	$18.8	$0.0	$0.0	$10.6	$16.4	$7.5	$0.0
6	HBH	Renewable	No OCGT	$0.0	$2.4	$18.8	$0.0	$0.0	$10.6	$16.4	$7.5	$0.0
7	HBH	Carbon Free	No CAISO Revenue	$0.0	$3.3	$7.3	$0.0	$0.0	$5.3	$14.4	$3.3	$12.9
8	HBH	Renewable	No CAISO Revenue	$0.0	$3.3	$7.3	$0.0	$0.0	$5.3	$14.4	$3.3	$12.9
9	HBH	Carbon Free	No OCGT, No CAISO Revenue	$0.0	$2.4	$18.8	$0.0	$0.0	$10.6	$16.4	$7.5	$0.0
10	HBH	Renewable	No OCGT, No CAISO Revenue	$0.0	$2.4	$18.8	$0.0	$0.0	$10.6	$16.4	$7.5	$0.0
11	HBH	Carbon Free	No Hydro, No OCGT									
12	HBH	Renewable	No Hydro, No OCGT	$0.0	$2.4	$18.8	$0.0	$0.0	$10.6	$16.4	$7.5	$0.0
13	HBH	Carbon Free	No Hydro, No OCGT, No CAISO Revenue									
14	HBH	Renewable	No Hydro, No OCGT, No CAISO Revenue	$0.0	$2.4	$18.8	$0.0	$0.0	$10.6	$16.4	$7.5	$0.0
15	CN	Carbon Free		$0.0	$2.2	$0.0	$0.0	$0.0	$12.7	$1.7	$0.0	$0.0
16	CN	Renewable		$0.0	$2.2	$0.0	$0.0	$0.0	$12.7	$1.7	$0.0	$0.0
17	CN	Carbon Free	No Hydro									
18	CN	Renewable	No Hydro	$0.0	$2.2	$0.0	$0.0	$0.0	$12.7	$1.7	$0.0	$0.0
19	CN	Carbon Free	No OCGT	$0.0	$2.2	$0.0	$0.0	$0.0	$12.7	$1.7	$0.0	$0.0
20	CN	Renewable	No OCGT	$0.0	$2.2	$0.0	$0.0	$0.0	$12.7	$1.7	$0.0	$0.0
21	CN	Carbon Free	No CAISO Revenue									
22	CN	Renewable	No CAISO Revenue									
23	CN	Carbon Free	No OCGT, No CAISO Revenue									
24	CN	Renewable	No OCGT, No CAISO Revenue									
25	CN	Carbon Free	No Hydro, No OCGT									
26	CN	Renewable	No Hydro, No OCGT	$0.0	$2.2	$0.0	$0.0	$0.0	$12.7	$1.7	$0.0	$0.0
27	CN	Carbon Free	No Hydro, No OCGT, No CAISO Revenue									
28	CN	Renewable	No Hydro, No OCGT, No CAISO Revenue									
Risk												
2	HBH	Renewable	Drought	$2.4	$6.0	$4.7	$0.0	$0.0	$3.9	$2.9	$3.8	$28.3
3	HBH	Renewable	Electric Vehicle Uptake	$2.6	$5.9	$2.1	$0.0	$0.0	$0.0	$2.2	$2.2	$34.8
4	HBH	Renewable	Building Electrification Uptake	$0.0	$8.3	$10.8	$0.0	$0.0	$0.0	$0.0	$0.0	$38.1
6	CN	Renewable	Drought	$1.0	$0.4	$0.0	$7.9	$0.0	$6.2	$2.5	$4.7	$0.0
7	CN	Renewable	Electric Vehicle Uptake	$0.0	$0.0	$1.7	$4.5	$0.0	$1.6	$4.8	$2.0	$0.0
8	CN	Renewable	Building Electrification Uptake	$0.2	$2.8	$0.0	$6.3	$0.0	$1.9	$1.8	$1.9	$0.0

Source: Energeia modelling

Table C3 – Total Portfolio Costs by Portfolio ($M/Yr)

#	Scenario	Electricity Type	Scenario Summary	Resources	RA/AS/FRA	CAISO	Net Cost
Sensitivity							
1	HBH	Carbon Free		$46.5	$0.0	-$3.9	$42.6
2	HBH	Renewable		$46.5	$0.0	-$3.9	$42.6
3	HBH	Carbon Free	No Hydro				
4	HBH	Renewable	No Hydro	$46.5	$0.0	-$3.9	$42.6
5	HBH	Carbon Free	No OCGT	$55.6	$0.0	-$5.8	$49.8
6	HBH	Renewable	No OCGT	$55.6	$0.0	-$5.8	$49.8
7	HBH	Carbon Free	No CAISO Revenue	$46.5	$0.0	$0.0	$46.5
8	HBH	Renewable	No CAISO Revenue	$46.5	$0.0	$0.0	$46.5
9	HBH	Carbon Free	No OCGT, No CAISO Revenue	$55.6	$0.0	$0.0	$55.6
10	HBH	Renewable	No OCGT, No CAISO Revenue	$55.6	$0.0	$0.0	$55.6
11	HBH	Carbon Free	No Hydro, No OCGT				
12	HBH	Renewable	No Hydro, No OCGT	$55.6	$0.0	-$5.8	$49.8
13	HBH	Carbon Free	No Hydro, No OCGT, No CAISO Revenue				
14	HBH	Renewable	No Hydro, No OCGT, No CAISO Revenue	$55.6	$0.0	$0.0	$55.6
15	CN	Carbon Free		$16.5	$0.0	$0.5	$17.0
16	CN	Renewable		$16.5	$0.0	$0.5	$17.0
17	CN	Carbon Free	No Hydro				
18	CN	Renewable	No Hydro	$16.5	$0.0	$0.5	$17.0
19	CN	Carbon Free	No OCGT	$16.5	$0.0	$0.5	$17.0
20	CN	Renewable	No OCGT	$16.5	$0.0	$0.5	$17.0
21	CN	Carbon Free	No CAISO Revenue				
22	CN	Renewable	No CAISO Revenue				
23	CN	Carbon Free	No OCGT, No CAISO Revenue				
24	CN	Renewable	No OCGT, No CAISO Revenue				
25	CN	Carbon Free	No Hydro, No OCGT				
26	CN	Renewable	No Hydro, No OCGT	$16.5	$0.0	$0.5	$17.0
27	CN	Carbon Free	No Hydro, No OCGT, No CAISO Revenue				
28	CN	Renewable	No Hydro, No OCGT, No CAISO Revenue				
Risk							
2	HBH	Renewable	Drought	$52.0	$0.0	-$5.0	$47.0
3	HBH	Renewable	Electric Vehicle Uptake	$49.9	$0.0	-$4.3	$45.6
4	HBH	Renewable	Building Electrification Uptake	$57.1	$0.0	-$2.4	$54.8
6	CN	Renewable	Drought	$22.8	$0.0	$1.6	$24.4
7	CN	Renewable	Electric Vehicle Uptake	$14.6	$0.0	$2.8	$17.4
8	CN	Renewable	Building Electrification Uptake	$14.7	$0.0	$4.9	$19.6

Source: Energeia modelling

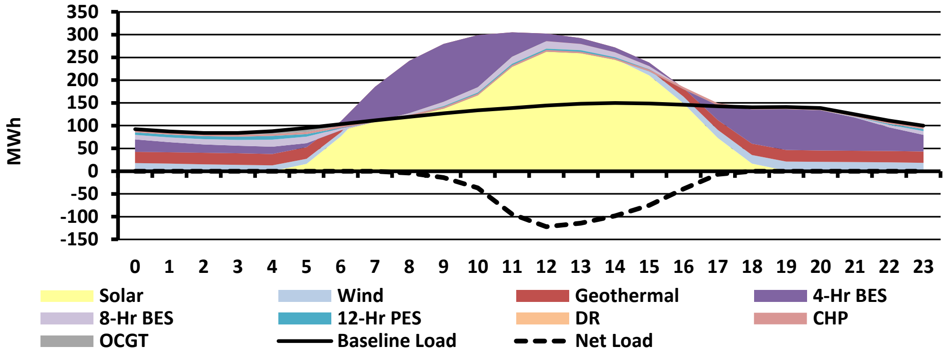
Appendix D – Additional Portfolio Views

This appendix includes additional hourly HBH and CN portfolio profile charts for average summer and winter days and the annual minimum demand day.

Across both scenarios, summer days experiences higher demand on average compared to winter days. All HBH charts show load being met every hour of every day, while the CN charts show gaps between resources and load where CAISO energy must be purchased. Additionally, the HBH minimum day exports almost no excess generation to CAISO, and the CN minimum day does not have any excess generation to export.

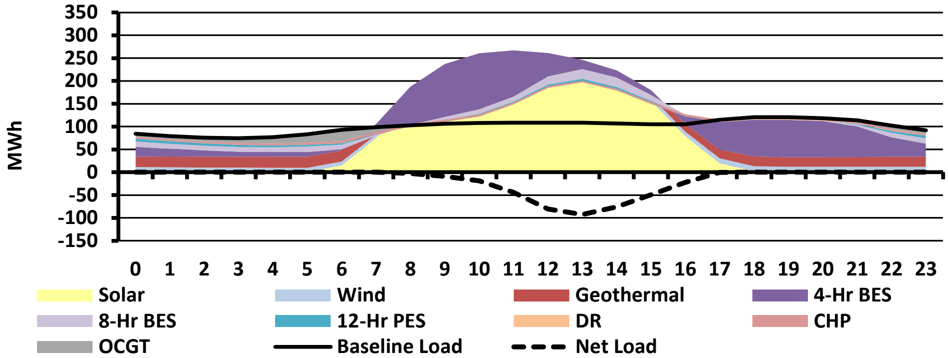
Hour-by-Hour

Figure D1 – 2030 Hour-by-Hour Average Summer Day Profile



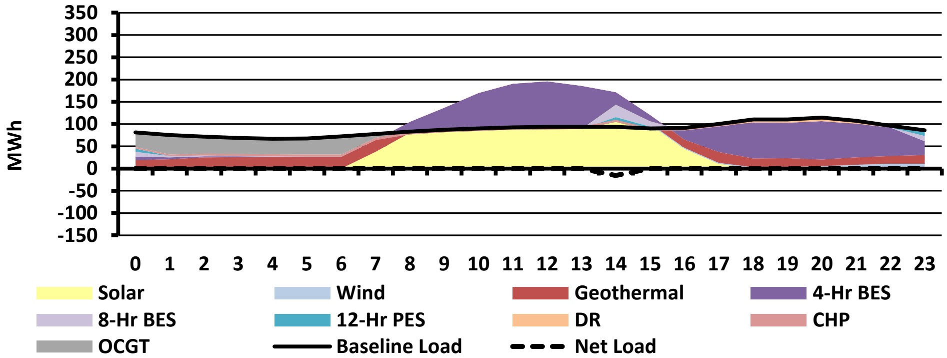
Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

Figure D2 – 2030 Hour-by-Hour Average Winter Day Profile



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

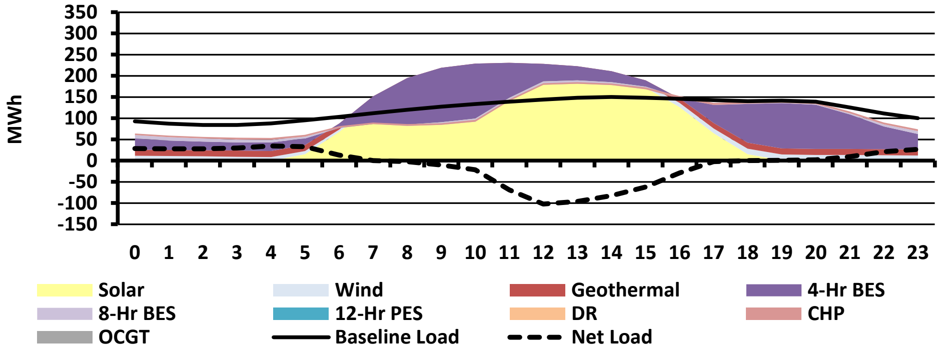
Figure D3 – 2030 Hour-by-Hour Min Day Profile



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

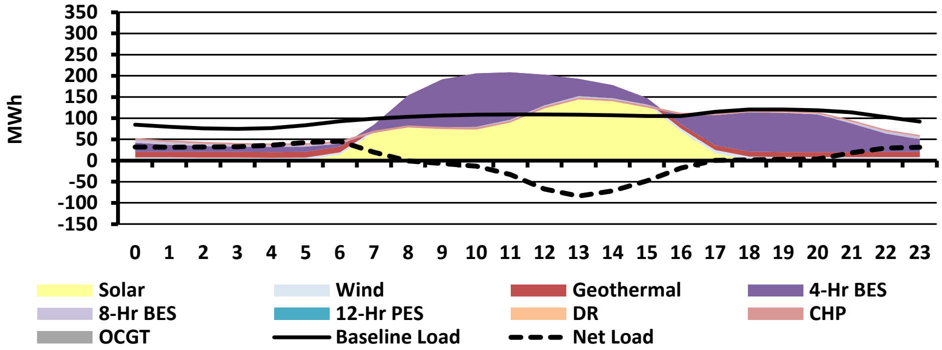
Carbon Neutral

Figure D4 – 2030 Carbon Neutral Average Summer Day Profile



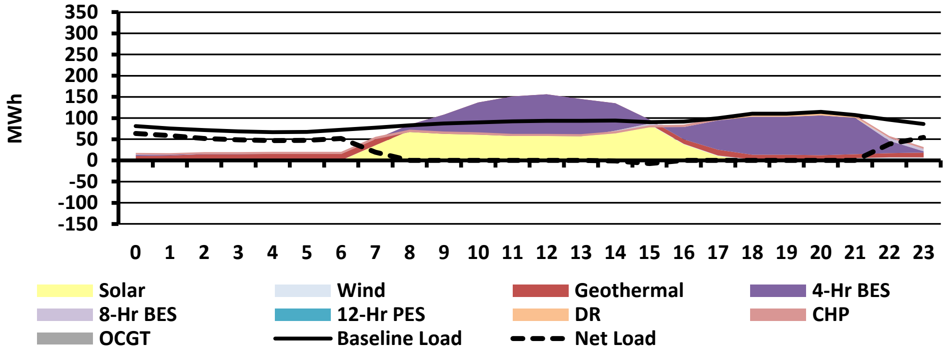
Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

Figure D5 – 2030 Carbon Neutral Average Winter Day Profile



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

Figure D6 – 2030 Carbon Neutral Min Day Profile



Source: VCE (2020), Energeia analysis; Note: BES = Battery Energy Storage, PES = Pumped Energy Storage, DR = Demand Response, CHP = Combined Heat and Power, OCGT = Open Cycle Gas Turbine

Appendix E – Bibliography

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6. Valley Clean Energy (2020), *Integrated Resource Plan 46 MMT Calculations*

Appendix F – About Energeia USA

Energeia USA (Energeia) understands the CCA and utility businesses, and key technical elements required to transform our industry into a clean, sustainable, and still reliable system with affordability as a key objective. We are passionate about helping our clients achieve their 100% carbon free goals.

Energeia was established in 2015 in Davis, CA as the US headquarters of Energeia Pty Ltd, an Australia company founded in 2009. Energeia Pty Ltd has grown since 2009 to become the largest specialist energy consultancy in Australia. Energeia's US ambitions are to establish the best emerging energy focused consultancy in the country in Davis, CA.

Figure D1 – Energeia USA Office in Davis, CA – Same Block as Valley Clean Energy

Energeia specializes in providing advisory, research and analytical tool development services in the following areas:

- Energy system and network planning and optimization
- Cost-of-service and advanced rate / tariff design
- Energy storage, including lithium, pumped hydro, hydrogen and carbon-based
- Electric vehicles and charging infrastructure
- Distributed generation and storage technologies
- Demand management and energy efficiency
- Building electrification
- Hydrogen integration

Energeia delivers its services across three lines of business:

1. **Proprietary research** – We provide in-depth reports on distributed energy resource related markets and technologies of strategic interest, including EVs, solar PV and storage, smart grids, microgrids, energy efficiency and home energy management.
2. **uSim and wSim Utility and Market Simulators** – We have developed industry leading utility simulation software that models customer behaviour, bills, DER adoption, 8760 load profiles, production cost, capacity expansion, rates and financial performance, on an integrated basis.
3. **Professional Services** – We offer tailored services in the areas of rate and incentive design, cost of service analysis, DER and load forecasting, system planning, production cost modelling, and DER technology related strategy and plan development.

We are organized into research, consulting and software development functional units, but there is significant cross-over between the working groups due to the significant quantitative analysis that we perform on behalf of our clients, much of which requires custom tooling.

Proprietary Research Advantage

Through our research capability we are continually monitoring emerging threats and opportunities and assessing their implications. This investment in knowledge ensures that we are able to offer our clients the latest thinking on emerging energy technologies.

Some of our recent reports include:

- Sound and Fury: The Outlook for Storage to 2024
- Brave New World: The Outlook for Smart Meters to 2024
- Awakening: The Outlook for Smart Grid Investment to 2029
- Over the Edge: The Outlook for Embedded Microgrids to 2027
- Off-target: The Residential Energy Efficiency Market to 2020
- Personal Power Stations: Residential micro-CHP Market to 2021

Relevant Experience

Energeia's experience and track record from relevant projects has been summarised below.

Table D1 – Project Descriptions

Client		Project	Relevant Experience
GREEN HYDROGEN COALITION	The Green Hydrogen Coalition	HyDeal LA	HyDeal LA is an initiative to achieve at-scale green hydrogen procurement at $1.50/kg in the Los Angeles Basin by 2030. Energeia is part of a team leading the Industrial Plan and Economics workstream, which will collect data on LA's electricity network, establish demand scenarios and design the first global system designs for the prioritized supply options.
OUC The Reliable One	Orlando Utilities Commission	Battery Valuation and Framework	Energeia developed a production cost and capacity expansion tool to support OUC's evaluation of future battery energy storage projects. We defined the key value streams and methodologies to quantify monetary and non-monetary benefits as they apply to OUC and the Florida Municipal Power Pool (FMPP) and identified the key use cases for battery storage for value stacking.
	Confidential Client	Scenario Based Integrated System Modelling	Energeia modelled a regional power market serving 7 million connections across 5 states over a 20 year period across 10 scenarios. Energeia used its behind-the-meter to transmission system simulator and production cost and capacity expansion software to model the system.
Davis California	The City of Davis	Climate Action and Adaption Plan Analysis	Energeia will be assessing the Davis CAAP through analysis of vehicle and building electrification, rooftop PV and energy efficiency opportunities and the associated costs and benefits. This project will also involve modelling of all connection points and vehicles in Davis.
LA DWP	Los Angeles Department of Water and Power	Distributed Energy Resources Integration Study	Energeia analyzed LADWP's cost-of-service at the system, transmission, 34.5kV and 4.8kV level, and by time period, to identify optimized DER programs, incentives and cost-reflective rate design for delivery of optimized DER adoption patterns and minimization of LADWP's overall cost-of-service and customer electricity costs

Client		Project	Relevant Experience
	Fresno County Rural Transit Agency	EV Grid Integration Analysis	Energeia assessed and optimized the impact of vehicle electrification including public transit and DER adoption on PG&E's grid. Energeia evaluated different rate configurations against multiple onsite DER solutions to identify the optimal electric fleet charging and load management solution for our client. We also identified least-cost grid upgrade solutions.
	Los Angeles Department of Water and Power	Once Through Cooling Reliability Study	Energeia developed specific, reliable, implementable, practical and least cost DER solutions tailored to address LADWP's forecast system constraints expected to arise under a range of alternative 1.5 GW thermal generation plant repowering scenarios, including a no repowering scenario.
	Sacramento Municipal Utilities District	Integrated Distributed Resource Plan	Energeia used its advanced, in-house utility simulator tool, uSim, to determine the distribution system impacts and associated costs and benefits of DERs as envisioned in the Sacramento Municipal Utility District's 2018 Integrated Resources Plan. Energeia also estimated DER values as avoided distribution capital and O&M for distribution.
	Sacramento Municipal Utilities District	Alternative Fuels Assessment	Energeia was engaged to perform an alternative fuels assessment to identify optimal low cost, low carbon fuels for retooling of five aeroderivative LM6000 engines. Energeia performed wheel to well analyses of multiple pathways for renewable gas production and ultimately identified multiple key pathways for SMUD to pursue to decarbonize their peaker plants.
	Placer County	Solar Cost of Service and Net Benefits Analysis	Energeia was engaged to provide an estimate of net benefits from the County's proposed Cincinnati Solar Project. For this project, Energeia will compile metered hourly loads and develop a billing model to produce shadow bills for each meter based on the current rate schedule applying to each meter to identify the net impacts of the proposed investment.
	Roseville Electric Utility	Building Electrification Program Design	Energeia reviewed the state of the art in building electrification and fuel switching program designs and then developed a best practice building electrification program including sales targets, incentive levels, funding sources, budgeting and investment case.
	Roseville Electric Utility	EV Charging Demand Plan	Energeia configured its EV uptake model to forecast EV adoption and charging demand by customer segment and time of day. Energeia also developed a spatial model which indicates charging locations and the utility assets most likely to be impacted by the different kinds of EV charging demand for the City of Roseville. Finally, we identified EV program elements that could help mitigate these impacts, including load management and Vehicle-to-Grid technology.
	Smarter Grid Solutions	Microgrid Market Analysis Study	Energeia was commissioned to perform a comprehensive study of California's microgrid market and microgrid-related legislation to determine the optimal position for SGS to enter the CA market. During this project, Energeia performed extensive desktop research and leveraged both CEC and EIA datasets to deliver a complete, up to date report with data-driven recommendations.
	Australian Solar Research Institute	Concentrated Solar Power Cost Targets	Energeia identified grid-scale storage requirements at different locations in the system over time under a range of future scenarios by updating and configuring its whole-of-system National Electricity Market (NEM) simulation platform to provide estimates of when and where peak to off-peak pricing differentials, and therefore marginal storage opportunities, emerge on a geo-spatial and time-of-day basis.

Energeia's mission is to empower our clients by providing the evidence-based advice using the best analytical tools and information available

Heritage

Energeia was founded in 2009 to pursue a gap foreseen in the professional services market for specialist information, skills and expertise that would be required for the industry's transformation over the coming years.

Since then the market has responded strongly to our unique philosophy and value proposition, geared towards those at the forefront and cutting edge of the energy sector.

Energeia has been working on landmark projects focused on emerging opportunities and solving complex issues transforming the industry to manage the overall impact.

Energeia USA

132 E St. #310
Davis, CA 95616

energeia@energeia-usa.com
www.energeia-usa.com

ENERGEIA