Appendix 1.4: Evoenergy Net Zero Modelling Journey

Regulatory proposal for the ACT electricity distribution network 2024–29

economics
public policy
markets
strategy

Evoenergy Net Zero Modelling Journey

Supplementary EN24 submission to AER

17 January 2023

A Marsden Jacob Report

Prepared for Evoenergy
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Contents

Tables

Figures

Executive summary

Purpose of this paper and EDEFM

This document provides a detailed summary of the Net Zero Modelling (NZM) that was undertaken by Evoenergy using prototype EDEFM[1] (MS Excel) from October 2021 to September 2022. The prototype EDEFM model will be superseded by enterprise EDEFM (coded in the "R" programming language) in early 2023, however projections from prototype EDEFM have been used in Evoenergy strategy and stakeholder development and has been used to support Evoenergy's EN24 submission to the Australian Energy Regulator (AER).

Model Design

The Consulting Consortium developed the Evoenergy Dynamic Energy and Financial Model to quantify the impacts of emission reduction targets and policies on the Joint Venture, customers, and other key stakeholders.

EDEFM is a simulation model that allows the user to define different pathways and scenarios (i.e., policy variables) to achieve net zero emissions (NZE) in the ACT by 2045 (or other specified dates) for a defined set of exogenous variables or assumptions (e.g., economic growth, climate change, demographic factors, financial factors etc). The model has been designed to calculate and compare the costs associated with the achievement of the emissions reductions target (in effect enables cost-effectiveness analysis).

Scenarios and Pathways

Evoenergy have undertaken a number of studies on the economic and financial impacts of achieving, or moving towards, NZE by 2045 in the ACT. Since the initial October 2021 study, further studies have been undertaken as the policy direction of the ACT Government (ACTG) has become clearer. Following the release of ACTG Base Case modelling paper in April 2022, Evoenergy updated base case assumptions and modelled the Realistic Base Case in June 2022[2] which was based on announced policy settings by the ACTG at that time. The ACTG announced further policy settings later in the year, which required Evoenergy to model the Electrification Adhoc Scenario in September 2022.

Five scenarios, with multiple subsidiary pathways for the "Full Electrification" and "Electrification and Green Gas" scenarios, that have been developed since October 2021 are depicted in ES Table 1 (below). In this study, 'Green Gas' refers to using low or zero emission gas sources, such as biomethane or hydrogen, as a replacement for natural gas in the Evoenergy gas network.

For the Full Electrification and Electrification and Green Gas scenarios, technology investments are made to ensure that the ACT achieves zero net emissions in the ACT by 2045. However, in the other

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[1] Evoenergy Dynamic Economic and Financial Model

[2] This June 2022 Base Case was developed for comparison with the ACTG modelling work completed in April 2022: GHD Advisory and ACIL Allen, Economic and Technical Modelling of the ACT, Electricity Network Strategic Report, EPSDD, 26 April 2022

scenarios, Base Case, Realistic Base Case and Realistic Electrification Adhoc, there is no requirement to achieve NZE by 2045 in the ACT.

ES Table 1 Scenario Assumptions

Scenario and Pathway Results	Full Electrification Scenarios (Planned, Adhoc & Hybrid) (Oct 2021)	Electrification & Green Gas Scenarios (Planned and Hybrid) (Oct 2021)	Realistic Base Case (Adhoc) (June 2022)	Realistic Electrification Adhoc (Sept 2022)	Base Case (Oct 2021)
Behind the meter solar PV and battery storage	Medium	Medium	Medium	Medium	Medium
Battery Electric Vehicle Penetration	High	Medium	Low	Medium	Medium
Fuel Cell Electric Vehicles	Low	Medium	None	Low	Medium
Economic conditions	Medium	Medium	Medium	Medium	Medium
NSW emissions reduction	By 2050	By 2050	By 2050	By 2050	By 2050
ACT Emissions reduction policy	By 2045	By 2045	No commitment	No commitment	No commitment
Hydrogen source	No local production or pipeline	H_2 Blend by 2028, full H_2 conversion by 2035	No hydrogen	No hydrogen	No hydrogen
Biomethane blended into gas network	None	High	None	None	None
Premise gas to electric conversion rate	High	Low	Low	Low	Low
Premise conversion churn from gas to electric by area	Adhoc - Random by location Planned – Planned by location Hybrid – Random until	Planned - Planned by location Hybrid – Random until 2030 and then planned after this	Random by location	Random by location	Random by location

Scenario and Pathway Results	Full Electrification Scenarios (Planned, Adhoc & Hybrid) (Oct 2021)	Electrification & Green Gas Scenarios (Planned and Hybrid) (Oct 2021)	Realistic Base Case (Adhoc) (June 2022)	Realistic Electrification Adhoc (Sept 2022)	Base Case (Oct 2021)
	2030, planned after this				
Gas network	Adhoc - Obliged to maintain network until all customers have churned or no longer economically viable Planned – planned closure of District Regulators as gas churn occurs Hybrid – initially adhoc, but then do planned closures of District Regulators as gas churn occurs	Most (if not all) of the Evoenergy gas network is maintained indefinitely for later use	No change to operation of gas network as it continues to supply natural gas to customers	No change to operation of gas network as it continues to supply natural gas to customers	No change to operation of gas network as it continues to supply natural gas to customers

Summary of Results

Detailed modelling results for each EDEFM modelling run can be found in the following chapters:

- Chapter 3 – Scenario Assumptions and Modelling Results for October 2021 (all scenarios and pathways)
- Chapter 4 – Realistic Base Case Scenario assumptions and Modelling Results (June 2022)
- Chapter 5 – Realistic Electricity Adhoc Scenario Assumptions (September 2022)

A comparison of study results (all in June 2024 dollars) can be found in Chapter 6.

Key drivers of modelled outcomes for selected scenarios are shown below.

ES Table 2 Scenario Results (June 2024 dollars) – Results by 2033/34

Scenario and Pathway Results by 2033/34	Full Electrification (Planned) (Oct 2021)	Full Electrification (Hybrid) (Oct 2021)	Realistic Base Case (Adhoc) (June 2022)	Realistic Electrification Adhoc (Sept 2022)	Base Case (Adhoc) (Oct 2021)
ACT Electricity Consumption (MWh)	6,462,296	6,462,296	3,167,429	3,122,790	5,259,716
ACT Electricity Demand (MW) - PoE 10	1,339	1,339	761	823	1,171
Driver of Consumption and Demand	No. of BEV 288,099 Evening recharging	No. of BEV 288,099 Evening recharging	No. of BEV 68,507 Evening recharging with gradual transition to daytime charging	No. of BEV 120,544 Evening recharging with gradual transition to daytime charging	No. of BEV 128,412 Evening recharging
Cumulative Electricity CAPEX (2024-25 to 2033-34) $M	1,475	1,611	1,165	1,230	1,518
Driver of Electricity CAPEX	High demand driving investment	High demand driving investment	Medium demand driving lower level of investment	Medium demand driving lower level of investment	High demand driving investment
Gas Consumption (TJ per annum)	2,961	2,961	5,837	5,837	5,292
Gas Customers (No.)	89,508	89,508	136,436	136,436	131,646
Driver of Gas Consumption and Customer No.	High Gas Churn	High Gas Churn	Moderate Gas Churn	Moderate Gas Churn	Moderate Gas Churn
Cumulative Gas CAPEX (2024-25 to 2033-34) $M	45.0	50.6	57.7	57.7	57.7
Driver of Gas CAPEXs	CAPEX only required to maintain existing network (no capacity constraints).				

1. Purpose of this document and EDEFM[3]

1.1 Purpose of this document

This document provides a detailed summary of the Net Zero Modelling that was undertaken by Evoenergy using prototype EDEFM (MS Excel) from October 2021 to September 2022 to support the CAPEX required to support the energy transition towards Net Zero by 2045. The prototype EDEFM model will be superseded by enterprise EDEFM (coded in the "R" programming language) in early 2023, however projections from prototype EDEFM have been used in Evoenergy strategy and stakeholder development and has been used to support Evoenergy's EN24 submission to the Australian Energy Regulator.

1.2 Context

The Consulting Consortium[4] was appointed by Evoenergy (Client) to develop a dynamic model of the Australian Capital Territory (ACT) energy system to support its ongoing analysis of the potential impacts on customers, ActewAGL Joint Venture, and the ACT government for a range of scenarios and pathways to meet net zero emissions by 2045.

Evoenergy have used the dynamic model to:

- Inform the Board on the investment capital required and long-term investment profile by investor
- Engage with:
  - ACT Government - including around cost profile and customer impacts (from both a shareholder and government/policy lens) as well as timing and opportunity in the short term (coming five years) toward the interim targets and beyond.
  - Selected customer advisory groups - including around pathway, timing and costs.
- Management analysis of the scenarios and pathways towards achieving net zero GHG emissions from the energy networks. Including to:
  - assist in identification of implications - for customers, community, regulators and other stakeholders
  - identify key decision points (triggers)
  - provide a tool for management and internal technical expertise to use over time.

1.3 Scenarios and Pathways

The model is capable of supporting analysis of three core scenarios and multiple subsidiary pathways with various assumptions as outlined in the figure below.

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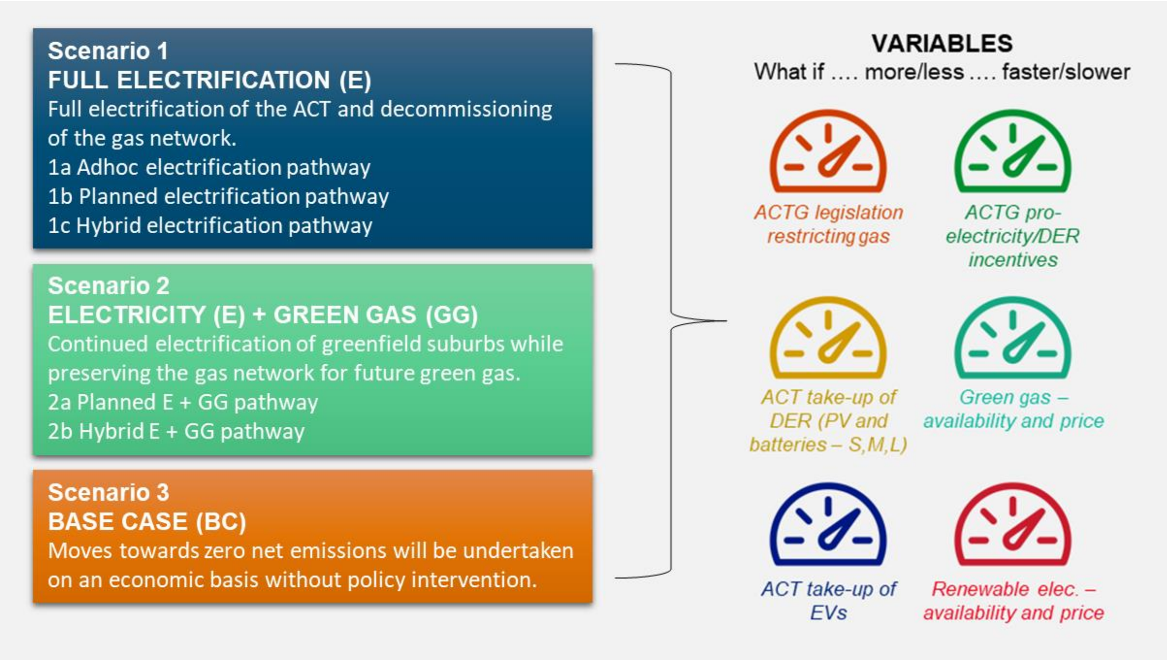
[3] Evoenergy Dynamic Economic and Financial Model
[4] Comprising Marsden Jacob Associates, Entura, and Frazer-Nash Consultancy Ltd.

Figure 1: Evoenergy Scenarios



Source: *Evoenergy, Evoenergy Net Zero Modelling Services, Request for Proposal (RFP), 21-0224, p.10. and Marsden Jacob 2021*

The different pathways for Evoenergy to plan the expansion or contraction of the electricity and gas network include the following:

- **Adhoc** – jurisdictional incentives and/or regulation for customers to convert from gas to electric appliances are applied broadly across the ACT. As a result, much of Evoenergy's gas distribution must remain operational over the study period of 2021-22 to 2044-45 despite only having a few customers connected to each District Regulator (DR) in the ACT. Expansion of the electricity system to accommodate gas churn to electric can occur anywhere throughout the ACT, which means that electricity upgrade costs (CAPEX) will be more expensive when compared to a more orderly gas churn (Planned).
- **Planned** – jurisdictional incentives and/or regulation for customers to convert from gas to electric appliances are targeted and promote an orderly transition for the decommissioning of the gas network (by District Regulator) and expansion of the electricity network. Potentially, the costs of upgrading the electricity network (CAPEX) will be lower than in the 'Adhoc' case as crews remaining in one targeted area of the network can do more jobs in a single day when compared to an Adhoc approach. Evoenergy can decommission parts of the gas network on a rolling basis, which reduces Business as Usual (BAU) CAPEX[5] that needs to be spent on maintaining the network.
- **Hybrid** – initially gas churn to electricity is Adhoc and then gas churn to electric is targeted at specific regions within the ACT.

[5] BAU CAPEX refers to "end of life" asset replacement, investment to improve efficiency of operations and other investments required to maintain current business operations.

In this study, 'Green Gas' refers to using low or zero emission gas sources, such as Biomethane or Hydrogen, as a replacement for natural gas in the Evoenergy gas network.

In theory, natural gas can also be regarded as a Green Gas if combined with carbon offsets (such as Australian Carbon Credit Units or ACCUs) to ensure that no emissions are generated from the supply and use of natural gas in the ACT. While initially the purchase of ACCU's can be used to offset carbon emissions from continued use of natural gas in the ACT, eventually it may be difficult to source ACCU's to meet ACT demand in future years as Australia moves to zero net emissions by 2050. Both industry and governments will likely use ACCU's to offset emissions produced from activities where it is hard to eliminate emissions (e.g., methane as a chemical feedstock, coking coal in steel production).

Given these concerns, ACCU's will only be used sparingly to offset emissions in the ACT in most scenarios given that almost all existing gas uses in the ACT (i.e., space heating, cooking and hot water heating) can readily be converted to either Green Gas or electricity.

For Scenario 1 (Full Electrification) and Scenario 2 (Electrification and Green Gas), technology investments are made to ensure that the ACT achieves zero net emissions in the ACT by 2045. In Scenario 3 (Base Case), we have assumed that natural gas can continue to be used to meet energy needs in the ACT and that the emissions that arise from continued natural gas use are offset using ACCU's.

1.4 EDEFM

The Consulting Consortium developed the Evoenergy Dynamic Energy and Financial Model to quantify the impacts of emission reduction targets and policies on the Joint Venture, customers, and other key stakeholders.

For this assignment, the Consulting Consortium was required to complete two main stages of model development:

1. Development of the prototype EDEFM in MS Excel with outputs ready for the Evoenergy Board meeting (5 October 2021).
2. Development of the enterprise EDEFM using the open-source programming language R which better integrates the various modules of EDEFM (i.e., energy demand, electricity load flow, gas distribution system, economic and financial module) and permits multiple scenario development with Monte Carlo analysis to generate statistical distributions of outcomes for each (emission reduction) scenario in the ACT. Enterprise EDEFM is a model that will be handed over to Evoenergy staff to utilise and maintain and would be a tool used in gas and electricity network pricing proposals, financial planning and budgeting, and for supporting submission to the ACT Government on its net zero emission reduction strategy.

The development of the prototype EDEFM was completed in October 2021 and the enterprise EDEFM is due to be completed in early 2023.

1.5 Report Outline

The outline of the report is provided below

Chapter 1: Purpose of this report and EDEFM

Chapter 2: Overview of prototype EDEFM - Overview of model design

Chapter 3: Scenario Descriptions and Modelling Results for October 2021– Descriptions of each scenario and alignment with AEMO ISP/ESOO forecasts. Results for five scenarios.

Chapter 4: Realistic Base Case Scenario Assumptions Modelling Results June 2022 – modelling results for Realistic Base Case, which was based on ACTG policy announcements at that time (April 2022).

Chapter 5: Modelling Results September 2022 – modelling results for Realistic Adhoc Electrification Case, which was based on latest ACTG policy announcements (i.e., adoption of 'Optimistic' EV take-up scenario and locational projections).

Chapter 6: Compare and Contrast Modelling Results – key drivers of differences in modelling results.

2. Overview of prototype EDEFM

2.1 Approach

EDEFM is a simulation model that allows the user to define different pathways and scenarios (i.e., policy variables) to achieve zero net emissions in the ACT by 2045 (or other specified dates) for a defined set of exogenous variables or assumptions (e.g., economic growth, climate change, demographic factors, financial factors etc). The model has been designed to calculate and compare the costs associated with the achievement of the emissions reductions target (in effect enables cost-effectiveness analysis).

Fundamental questions for this study and for the model include:

- if the ACT moves to full electrification, is it less costly to plan the decommissioning of the gas network in a structured way (by district regulator/suburb), rather than maintain most of the gas network until the final decommission date of 2045 (zero net emissions) or, alternatively,
- can the ACT move to partial electrification and a green gas scenario which is less costly than the above full electrification scenarios?

While the Evoenergy NZM is not explicitly assessing the effectiveness of policy measures, the model outcomes will suggest policy initiatives or improvements. For example, what level should financial incentives be to ensure the uptake of EV's or gas to electric appliances consistent with the scenario and minimises cost impacts on customers.

2.2 Design Principles

Evoenergy and the Consulting Consortium decided on the following critical design principles that have underpinned the development of EDEFM:

1. This is a scenario modelling tool that quantifies the impact of various emission reduction targets and policies on Evoenergy (financial), customers ('behind the meter' capital and energy prices) and the ACT government. It is not an optimisation model that calculates the least cost path to achieve a given emission reduction trajectory. However, the model can be used to run various scenarios to look at the total cost impacts of each scenario
2. Must be able to model the impact of a range of scenarios proposed by Evoenergy (three main central scenarios)
3. Methodology must provide the capability for the end user to perform sensitivity testing and scenario analysis in an intuitive manner; and
4. Implementation must allow Evoenergy to run and update parameters and scenarios post-delivery of the model by the Consulting Consortium.

An outcome of the third and fourth principles is that the design of EDEFM must facilitate the model's use by end-users without specialist statistical, mathematical, or software development backgrounds.

2.3 Model overview

The model has three major components:

1. **Scenario Modelling** - An input sheet that allows users to define the exogenous factors (such as population growth and State Final Demand) and policy variables (e.g., emission reductions or technology deployment targets or incentives) for each Scenario, and
2. **Energy Demand and Physical Network** – The exogenous factors or policy variables can be altered to generate a new forecast of energy demand in the ACT by customer segment. This includes the following energy types: electricity, natural gas, hydrogen, and liquid fuels.

Changing policy variables may increase grid electricity demand and technology deployment within the ACT (i.e., Distributed Energy Resources or Electric Vehicles' etc), which then results in a different pattern of investment in the ACT electricity network and gas network. This investment will result in changes in the physical electricity and gas networks to ensure that peak demand, energy throughput requirements and reliability settings are met. The purpose of this sub-model is to calculate the changes in the physical capacity of the network to meet energy demand.

3. **Economic and Financial Model** – Once we have identified the physical changes in the gas and electricity network, the costs of those investments, as well as the impact of changes in energy consumption on Evoenergy' revenues, will be incorporated into the Evoenergy Gas and Electricity Financial Model.

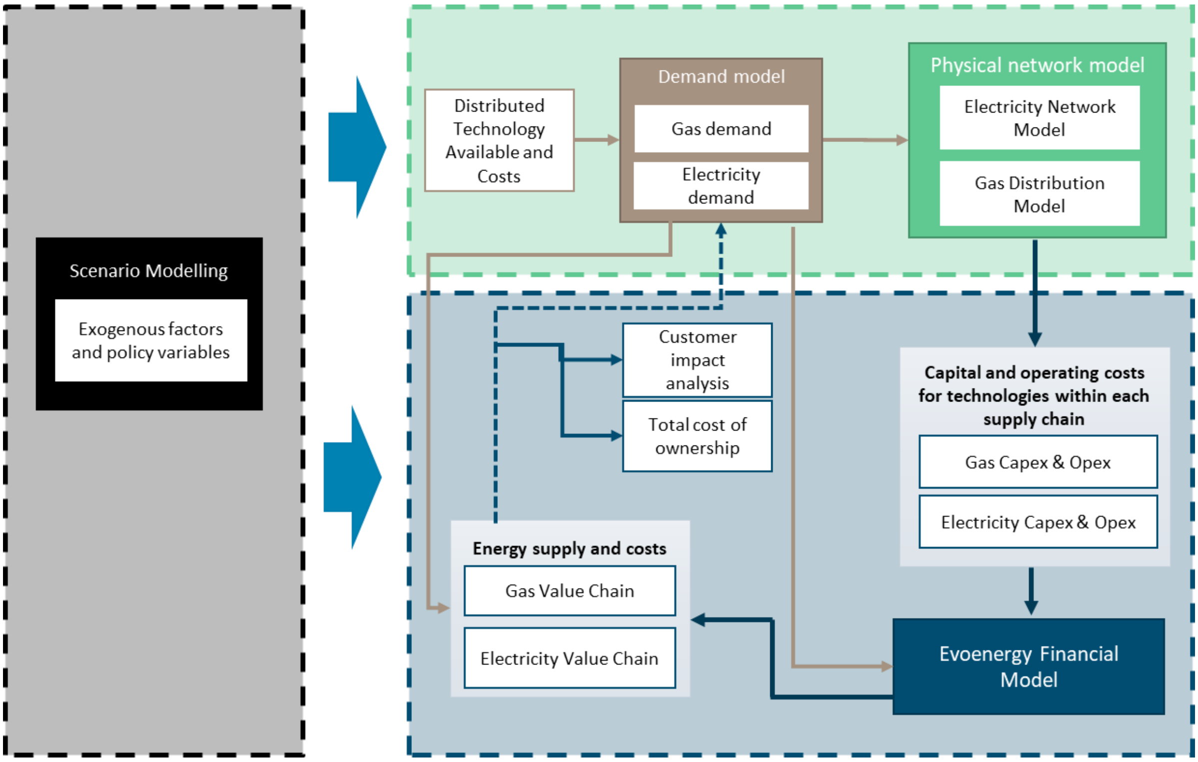
In turn, the calculated Evoenergy gas and electricity access tariffs will feed into the respective supply chains for the delivery of both electricity and gas services to various customer segments in the ACT. That is, we shall calculate delivered energy prices for all fuel types to final customers.

For example, the delivered price of electricity will include the cost of Power Purchase Agreements (PPAs) to achieve 100% renewables in the ACT, along with the cost of buying firming services from the wholesale market, as well as transmission and Evoenergy distribution costs

The interrelationships between the sub-models of prototype EDEFM are shown in Figure 2.

As investment in the electricity and gas networks are a function of energy demand which is in turn a function of electricity prices, and hence electricity and gas access charges, this creates an interdependence between the two sub-models (effectively a simultaneous equation system). The model will have the ability to be run several times to find a stable solution if the price elasticity of demand is significant for each customer segment.

Figure 2: Evoenergy Dynamic Energy and Financial Model (EDEFM) - prototype



The detailed specification of the model is outlined in “EDEFM Detailed Design Document”.

3. Scenarios Assumptions and Modelling Results for October 2021

3.1 Introduction

This chapter provides an overview of the scenarios and assumptions that underpinned each scenario. Electrification Scenario

Key features of the electrification scenario are outlined below. All assumptions are the same for the electrification sub scenarios except for the assumed churn of existing gas customers to electric appliances (1 a – Adhoc, 2 b – planned, 2 c – hybrid).

Table 1: Electrification Scenario Assumptions

Exogenous Variable	Level	Potential Impact
Existing gas to electric premise churn with ACT	1 (a) Random gas churn by location	Adhoc means that incentives and regulation for gas to electric churn (i.e., space heating, cooking, and hot water) are applied broadly across the ACT (not location specific)
	1 (b) Planned gas churn by location	Planned means that incentives and regulation for gas to electric churn (i.e., space heating, cooking, and hot water) are applied to specific locations within the ACT.
	1 (c) Random for first 10 years and then Planned gas churn to electric	Hybrid means that incentives and regulation for gas to electric churn (i.e., space heating, cooking, and hot water) are applied broadly across the ACT (not location specific) initially (first 10 years) and then are applied to specific locations.
Behind meter solar PV and battery storage	High	Reduce grid electricity demand and energy requirements in ACT. Network upgrades required to manage reverse network flows.
Battery Electric Vehicle (BEV)	High	Increased grid electricity demand and energy in the ACT
Fuel Cell Electric Vehicles (FCEVs) - Rigid trucks, semi-trailers and buses	Low	No impact on Evoenergy gas and electric network as fuel produced in NSW and then transported (truck or rail) into the ACT.
Economic Conditions	Medium	Expected change in consumption per capita and No. of new premises built in the ACT.
NSW emission reductions achieved through partial electrification and green gas.	Zero net emissions by 2050	Green gas replacement in East Coast gas network moderates' electricity price increases in the NSW regional reference node.

Exogenous Variable	Level	Potential Impact
ACT emissions reductions policy	Zero net emissions by 2045	Low emission reduction case set by the ACT Government with zero net emissions by 2045.
No biomethane or hydrogen blended into Evoenergy network	None	Higher emissions from continued use of natural gas until closure of the network by 2045.
All new premises must be electric and existing gas premises converted to electric	High Conversion Rate	Conversion required likely to exceed appliance replacement rate and increase capital costs to customers

3.2 Electrification and Green Gas Scenario

Key features of the Green Gas scenarios are outlined below. The sub-scenarios only differ in accordance with initial gas churn to electricity (2 a – planned, 2 b – hybrid).

Table 2: Electrification and Green Gas Scenario Assumptions

Exogenous Variable	Level	Potential Impact
Gas to electric premise conversion is planned initially (until 2028), then green gas use is permitted after this.	2 (a) Planned gas churn by location for first 10 years of study period. No gas churn required after this.	Most (if not all) of the Evoenergy gas network is maintained indefinitely for later use.
	2 (b) Adhoc gas churn in the ACT for first 10 years. No incentives for gas churn to electric after this.	Most (if not all) of the Evoenergy gas network is maintained indefinitely for later use.
Behind meter solar PV and battery storage	Medium	Reduce grid electricity demand and energy in ACT. Network upgrades required to manage reverse network flows.
Battery Electric Vehicle (BEV)	Medium	Increased grid electricity demand and energy in the ACT
Fuel Cell Electric Vehicles (FCEVs) - Rigid trucks, semi-trailers and buses	Medium	No impact on Evoenergy gas and electric network as fuel produced in NSW and transported into ACT. Have assumed that due to impurities in Evoenergy gas system, cannot utilise Evoenergy H2 distribution network from 2035-36 to supply FCEVs.
Economic Conditions	Medium	Expected change in consumption per capita and No. of new premises built in the ACT.

Exogenous Variable	Level	Potential Impact
NSW emission reductions achieved through partial electrification and green gas.	Zero net emissions by 2050	Green gas replacement in East Coast gas network moderates' electricity price increases in the NSW regional reference node. Green Gas Renewable Energy Certificates (GRECS) implemented.
ACT emissions reductions Policy	Zero net emissions by 2045	Emission reductions achieved by combination of electrification and green gas.
Biomethane and Hydrogen blended into ACT gas network. Pure hydrogen network commences 2035-36.	High	Likely increase in cost of gas sourcing in short term. Costs associated with full conversion to Pure Hydrogen commencing 2035-36.
All new premises must be electric and existing gas premises encouraged to convert to electric	Low Conversion Rate	Customers can continue to be supplied with green gas. Conversion to electric only occurs on basis of economics.

3.3 Base Case Scenario

Key features of the Base Case Scenario.

Table 3: Base Case Scenario Assumptions

Exogenous Variable	Level	Potential Impact
Existing gas to electric premise churn is Adhoc within ACT	(3) Adhoc gas churn by location for first 10 years. No requirement after this.	Most (if not all) of the Evoenergy gas network is maintained until 2045
Behind meter solar PV and battery storage	Medium	Reduce grid electricity demand and energy in ACT. Network upgrades required to manage reverse network flows.
Battery Electric Vehicle (BEV)	Low	Increased grid electricity demand and energy in the ACT
Fuel Cell Electric Vehicles (FCEVs) - Rigid trucks, semi-trailers and buses	Medium	No impact on Evoenergy gas and electric network as fuel produced in NSW and transported (truck or rail) into the ACT.
Economic Conditions	Medium	Expected change in consumption per capita and No. of new premises built in the ACT.
NSW emission reductions achieved through partial electrification and green gas.	Zero net emissions by 2050	Green gas replacement in East Coast gas network moderates' electricity price increases in the NSW regional reference node. Green Gas Renewable Energy Certificates (GRECS) implemented.

Exogenous Variable	Level	Potential Impact
ACT emissions reduction policy	No requirement	Emissions reductions only achieved if economic to do so.
No biomethane or hydrogen blended into Evoenergy network	None	Higher emissions from natural gas

3.4 Summary of Initial Scenario Settings

Provided below is a summary of the initial Scenario Settings that underpin the Modelling Results in the next chapter of this report.

Table 4: Evoenergy NZN scenario settings (initial)

Exogenous Variables	Full Electrification			Electrification + Green Gas		Base Case
Sub-Scenario	Adhoc	Planned	Hybrid	Planned	Hybrid	Adhoc
Behind the meter solar PV and battery storage	Medium	Medium	Medium	Medium	Medium	Medium
Battery Electric Vehicle	High	High	High	Medium	Medium	Medium
Fuel Cell Electric Vehicles	Low	Low	Low	Medium	Medium	Medium
Economic conditions	Medium	Medium	Medium	Medium	Medium	Medium
NSW emissions reduction	By 2050	By 2050	By 2050	By 2050	By 2050	By 2050
ACT Emissions reduction policy	By 2045	By 2045	By 2045	By 2045	By 2045	No commitment
Hydrogen source	No local production or pipeline	No local production or pipeline	No local production or pipeline	H_2 Blend by 2028, full conversion to H_2 by 2035	H_2 Blend by 2028, full conversion to H_2 by 2035	No hydrogen
Biomethane blended into gas network	None	None	None	High	High	None
Premise gas to electric conversion rate	High	High	High	Low	Low	Low
Premise conversion churn from gas to electric by area	Random by location	Planned by location	Random until 2030, then planned	Planned by location	Random by location until 2030, then planned	Random by location

Exogenous Variables	Full Electrification			Electrification + Green Gas		Base Case
Sub-Scenario	Adhoc	Planned	Hybrid	Planned	Hybrid	Adhoc
Gas network	Obliged to maintain network until all customers have churned or no longer economically viable	Planned closure of gas network as churn occurs	Obliged to maintain network until all customers have churned or no longer economically viable	Most (if not all) of the Evoenergy gas network is maintained indefinitely for later use	Most (if not all) of the Evoenergy gas network is maintained indefinitely for later use	No change to operation of gas network as it continues to supply natural gas to customers

3.5 October 2021 Modelling Results

3.5.1 Electricity Demand

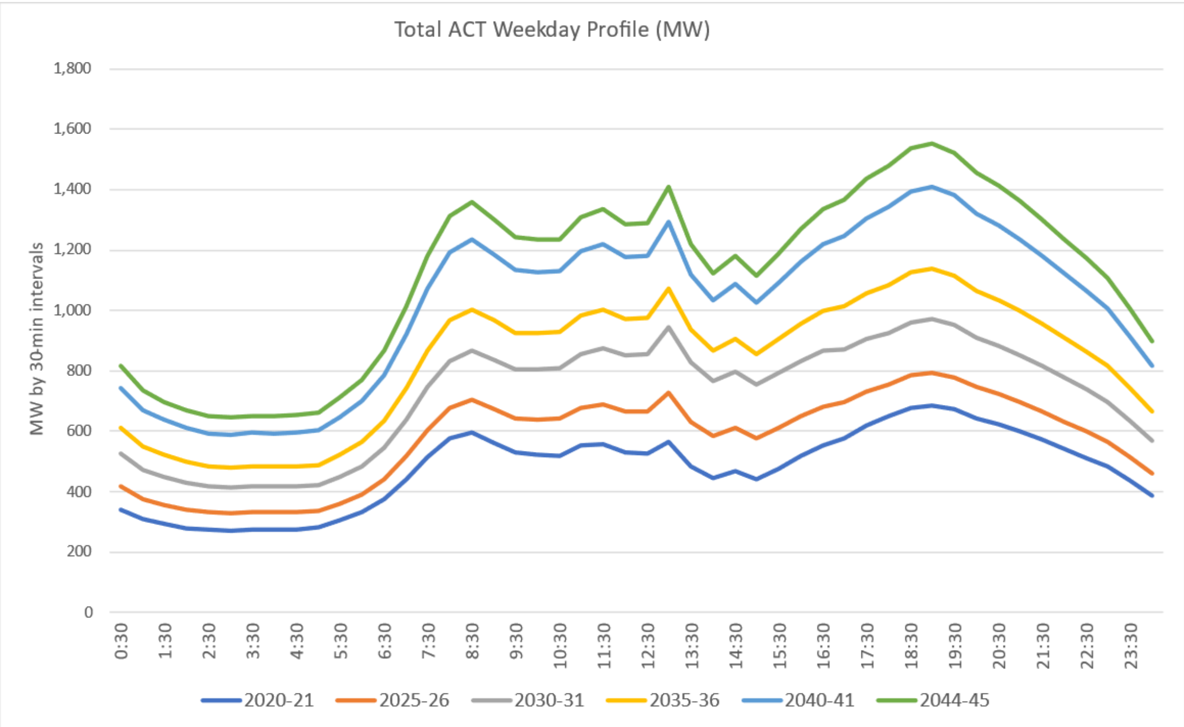
For each scenario we have forecast annual electricity consumption and peak demand (10%, 50% and 90% PoE levels). Typically, a 10% PoE demand is a major driver of augmentation in the ACT electricity system, although with the increasing penetration of embedded generation in the ACT, minimum demand and reverse flows from embedded generation may also trigger investment in the network.

The annual and peak demand forecasts consider the following factors:

- Take-up of embedded generation and storage (assuming storage is discharged in the evening period)
- Take-up of battery electric vehicles and charging profile for these vehicles (based on "convenience" charging profile, which involves more evening charging relative to daytime charging)
- Population growth (increases overall consumption)
- Relative price of gas and electricity (retail) – lower electricity prices encourage higher consumption.
- Gas churn to electric (increases morning and evening peaks as electricity is increasingly used for space heating in winter months)
- Energy efficiency (reduces per capita energy consumption)
- Heating and Cooling Degree Days

Shown below is the peak winter demand forecast for the Electrification Adhoc scenario. Peak demand is forecast to occur in the evening period and is currently around 650 MW in 2020-21. This is forecast to increase to almost 1600 MW by 2044-45.

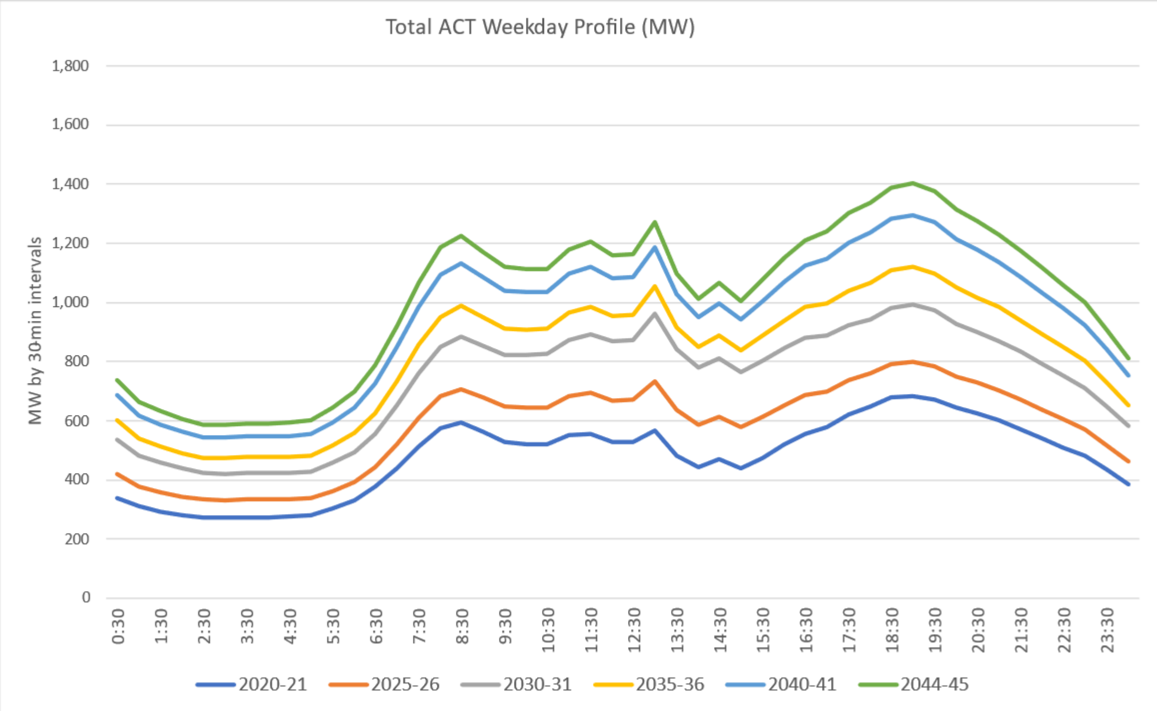
Figure 3: Winter Maximum Demand (10% PoE level) – Electrification Scenarios



Source: *Marsden Jacob 2021*

For the Green Gas Scenarios, Winter Maximum Demand is also expected to be strong and is projected to be 1400 MW by 2044-45. Base Case Demand is also similar to the demand level in the Green Gas Scenarios.

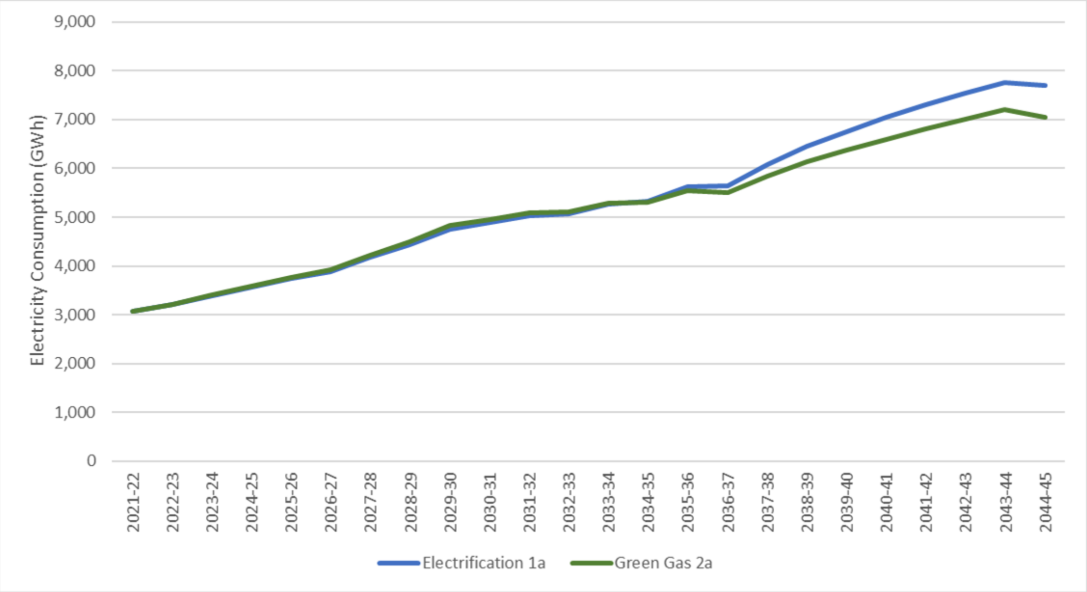
Figure 4: Winter Maximum Demand (10% PoE level) – Green Gas Scenarios



Source: *Marsden Jacob 2021*

Annual Electricity Demand is similar in the early years as higher electricity demand resulting from gas churn to electric is offset by lower PV penetration in the Green Gas scenario. Eventually, electricity demand in the Electrification Scenario drives annual electricity consumption higher than the Green Gas scenario from the mid 2030's, although there is a reduction in the last year of the study in both cases as the growth in PV penetration and energy efficiency offsets growth in PV demand and population growth, as there is limited further conversion of gas customers to electricity in this last year of the study period.

Figure 5: Annual Electricity Demand by Scenario (GWh)



Source: Marsden Jacob 2021

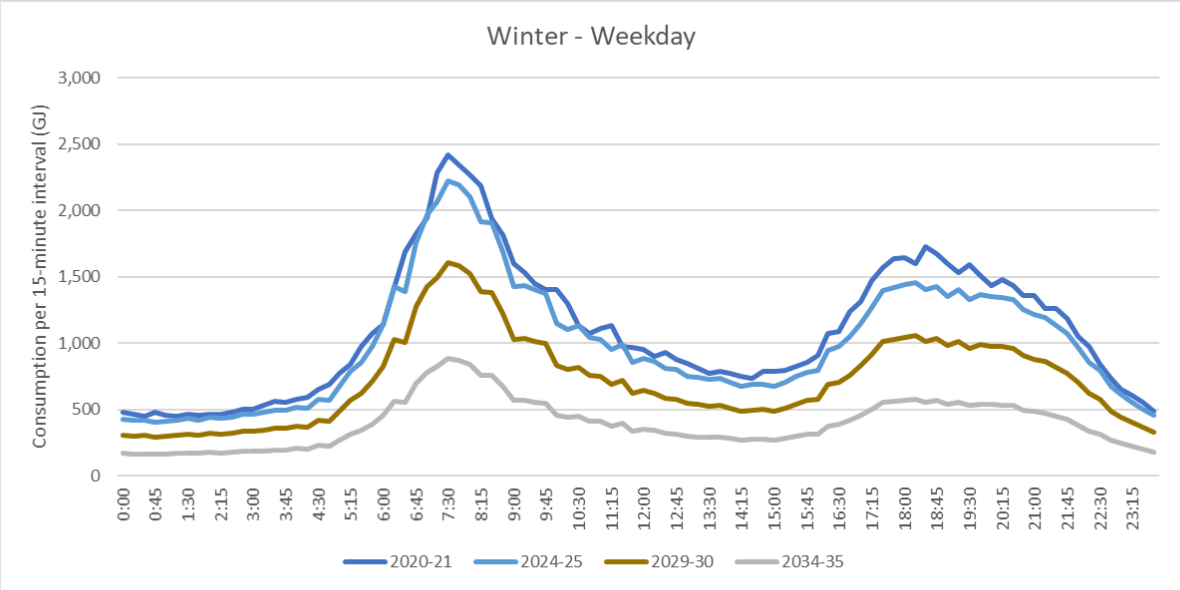
3.5.2 Gas Demand

Gas Demand in the ACT is a function of the following:

- Gas churn to electric
- Relative prices of electricity and gas
- Energy efficiency
- Population growth
- Heating degree days

In the electrification scenarios, peak gas demand falls from around 2400 GJ in a 15-minute period currently to around 800 GJ in 2035.

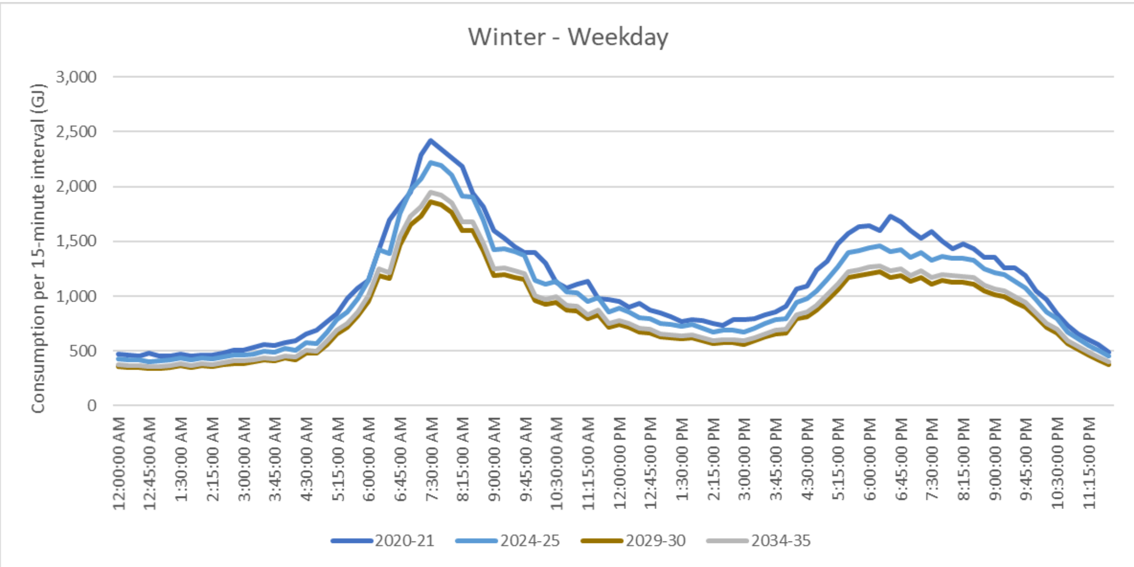
Figure 6: Peak Gas Demand – Electrification Scenarios



Source: Marsden Jacob 2021

In the Green Gas and Base Case scenarios, peak gas demand does initially fall with gas churn, but remains at 1750 GJ by 2035.

Figure 7: Peak Gas Demand – Green Gas and Base Case Scenarios



Source: Marsden Jacob 2021

3.5.3 Modelling of the Physical Gas and Electricity Distribution Networks

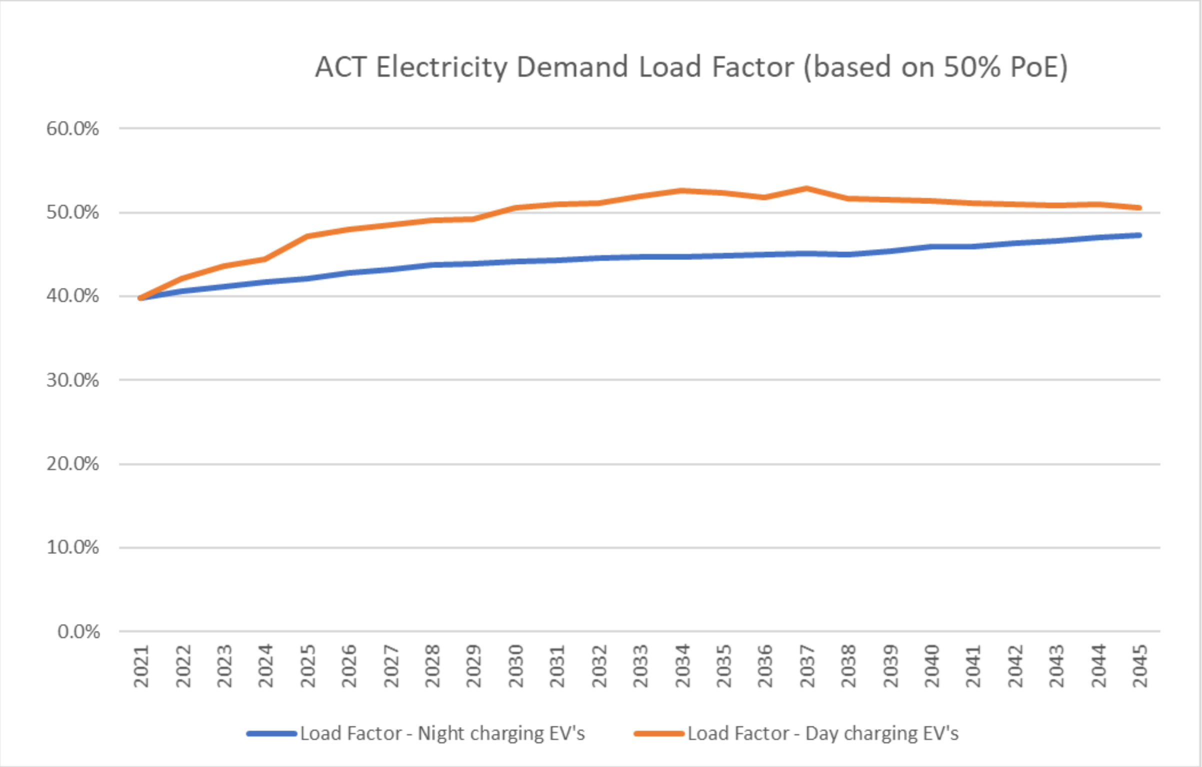
EDEFM includes an Electricity Distribution Model (EDM) and Gas Distribution Model (GDM) to determine whether there are any capacity constraints which will limit the ability of the system to meet the demand forecasts provided above.

The Gas Distribution Network was not constrained under any scenario and only end-of-life asset replacement was required to ensure that the gas network could continue to meet future gas requirements in the ACT.

The key findings from the EDM were the following:

- Significant augmentation of the electricity network was required in all scenarios. This was mainly driven by increases in peak winter demand (10% PoE), which is being driven higher by gas churn, population growth and the assumption of convenience charging for Battery Electric Vehicles (evening charging). These factors offset energy efficiency and higher take-up of behind the meter battery (recharge during the day and discharge in the evening).
- Investment in connection assets and the Low Voltage (LV) network is driven by growth in both customer numbers and peak demand increases.
- Investment in transformers, Medium and High Voltage network, substations and sub-transmission was driven by increases in peak demand in the ACT.
- Growth in peak demand was less than the growth in annual energy consumption in all scenarios. Energy efficiency and investment in behind the meter battery helped moderate increases in evening peak demand. As a result, the utilisation of the electricity network increases and has the potential to reduce unit electricity network charges (see below).

Figure 8: Change in utilisation of the Evoenergy Electricity Distribution System – Electrification Scenario (by BEV charging regime)



Source: Marsden Jacob 2021

3.5.4 Evoenergy Electricity Distribution Business

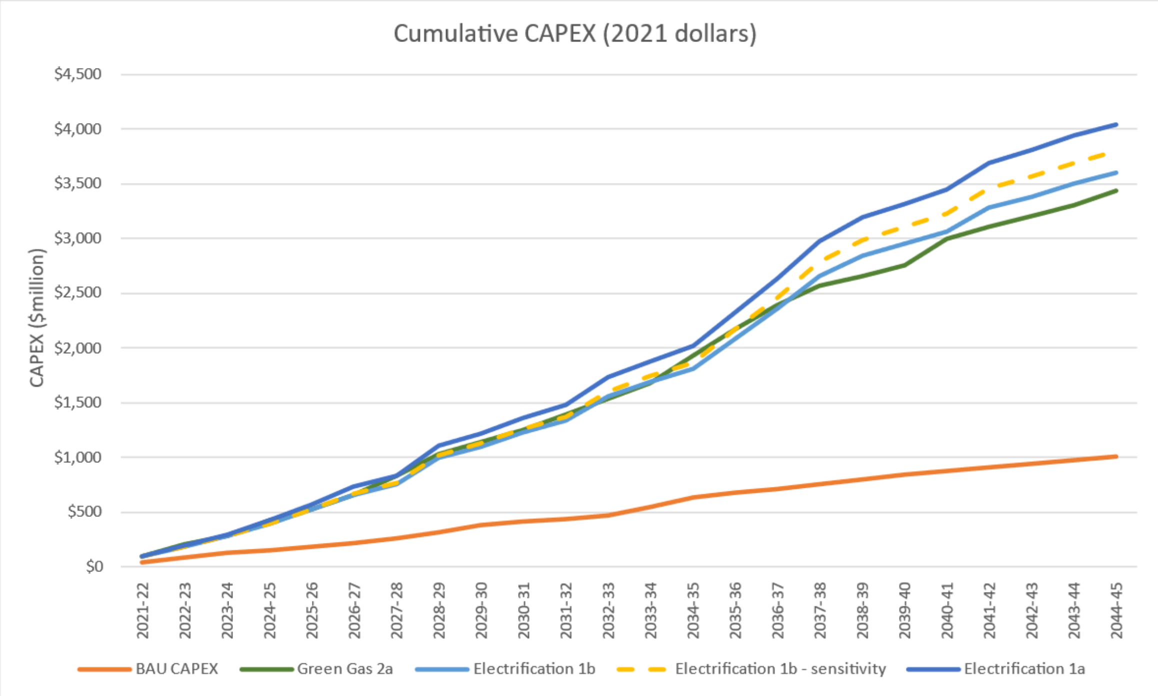
The CAPEX required for each scenario is provided below. CAPEX is highest for the Electrification Adhoc scenario, followed by the Base Case and Green Gas Adhoc Scenario. A lower level of CAPEX is required where gas churn to electric is planned (in both Electrification and Green Gas Scenarios).

Table 5: Electricity Distribution CAPEX ($M June 2021 dollars)

Scenario No.	Scenario	2024-2029	2029-2034	2034-2039	2039-2044	Total
1a	Electrification Adhoc	802.84	778.47	1,311.47	743.22	3,636.00
1b	Electrification Planned	656.84	646.59	1,019.19	611.56	2,934.18
1c	Electrification Hybrid	802.84	620.48	1,031.47	545.89	3,000.68
2a	Green Gas Planned	744.05	640.08	986.00	646.05	3,016.17
2b	Green Gas Adhoc	839.91	660.83	986.00	646.05	3,132.79
3	Base Case	740.00	685.00	1,014.69	674.73	3,114.42

Source: *Marsden Jacob 2021*

Figure 9: Cumulative Electricity CAPEX ($M, June 2021 dollars)

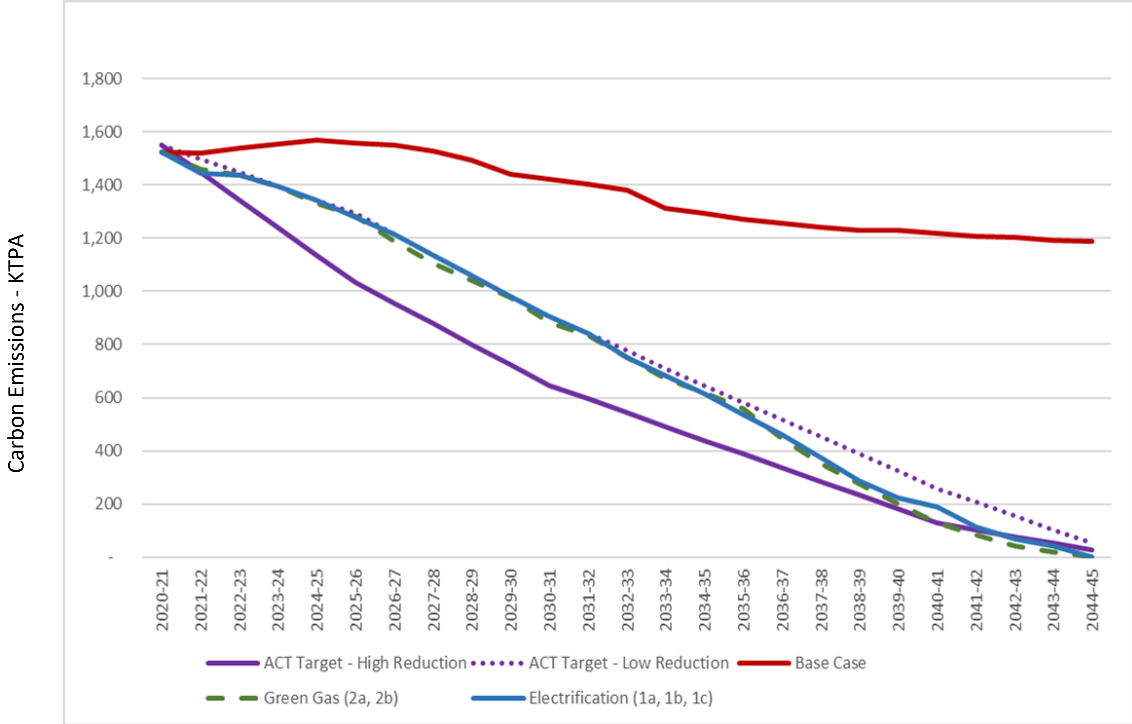


Source: *Marsden Jacob 2021*

3.5.5 Emission Profile for ACTG by Scenario

The carbon emissions profile for the ACT over the study period is provided below for Stationary Gas and Transport Sectors (emissions from Electricity Supply is zero in the ACT). Both the Green Gas and Electrification scenarios achieve net zero emissions by 2045 and broadly follow the ACT Target - Low Reduction scenario. The Base Case emissions profile trajectory is not consistent with the achievement of zero net emissions by 2045.

Figure 10: ACT carbon emissions for October 2021 scenarios (KTPA) – vehicles and stationary gas emissions only



Source: Marsden Jacob 2021

4. Realistic Base Case Scenario Assumptions and Modelling Results June 2022

4.1 Background

The ACTG also commissioned independent modelling to determine the cost impacts of achieving NZE by 2045. The ACTG and their consultants, GHD in consortium with ACIL Allen, developed a Base Case scenario based on existing policy settings.[6] Similar to the Evoenergy Base Case developed in October 2021, the ACTG Base Case did not achieve NZE by 2045. ACTG released the Base Case report on 26 April 2022

Evoenergy set up a new Realistic Base Case that considered the ACTG modelling assumptions to inform revised inputs along with update information since the original Evoenergy Base case in October 2021. The detailed assumptions used in the Realistic Base Case are provided in the table on the next page and compared with ACTG modelling assumptions.

4.2 ACTG Base Case Modelling Assumptions

The major assumptions included the following:

- The ACTG expects per capital electricity consumption to fall substantially over the study period as efficiency gains and rooftop PV installation will offset increases in consumption caused by electrification;
- As a result, despite a rising population in the ACT, declines in per capita electricity consumption results in only a modest increase in total electricity consumption - 2,772 GWh in 2022 to 3,367 GWh in 2045, which represents an increase of around 21% (0.9% p.a.).
- However, while total electricity consumption is modest, the ACTG projected that electricity demand (PoE 50%) will grow from 654 MW in 2022 to 966 MW in 2045, which is an increase of around 48 per cent.
- The ACTG assumed "conservative" growth assumptions for Zero Emission Vehicles (ZEVs) in the ACT. The ACTG Base Case assumed that 28% of car sales (~25,000 cars) will be ZEVs by 2030, and that the growth in passenger ZEVs will result in ZEVs taking up approximately 20% of the ACT's total energy requirements (673 GWh) in 2045. The ACTG Base Case assumed that most charging occurs overnight.
- All financial values were converted to June 2024 prices (real dollars) as part of the EN24 regulatory process (previously EDEFM modelling was based on June 2021 dollars).

[6] https://www.climatechoices.act.gov.au/__data/assets/pdf_file/0011/2052479/Base-Case-Report.pdf

Table 6: ACT Government Base Case Assumptions, by Category

Category	Policy Levers or Exogenous Factor	Realistic Base Case Modelling Assumptions	ACTG Modelling Assumptions
Gas	• The 'no new gas connections' continue for the period to 2045. That is, no greenfield gas connections from 2021-22, and no infill gas developments from 2023. • Existing public housing stock transition to electric appliances over the next 10 years (7% of the ACT housing stock). • There is no cap or intervention placed on gas prices (at a network or retail level). • Wholesale gas price is for natural gas only (no green gas or blends).	• Gas connections fall from 157,659 in 2020-21 to 138,639 in 2029-30 and 125,961 in 2044-45 • Annual demand for gas in the ACT and Queanbeyan drops from 8,005 TJ in 2021 to around 4,119 TJ by 2045 (48.5% steady decline) • Residential consumption per connection is expected to drop from 38.3GJ p.a. in 2021 to 24.7 GJ p.a. by 2045 (35.6% decline). • Small business consumption per connection is projected to drop from approximately 98.8GJ p.a. in 2021 to 63.6GJ p.a. in 2045 (35.6% decline). • Industrial gas consumption is expected to drop from around 23,871 GJ p.a. in 2021 to just under 15,373 GJ p.a. in 2045 (35.6% decline).	• Gas connections fall from 140,000 in 2020 to 127,000 in 2030, and 110,500 in 2045. • Annual demand for gas in the ACT drops from 7,100 TJ in 2021 to around 3,100 TJ by 2045 (57% steady decline) • Residential consumption per connection is expected to drop from 33GJ p.a. in 2021 to 19GJ p.a. by 2045 (42% decline). • Commercial consumption per connection is projected to drop from approximately 500GJ p.a. in 2021 to 300GJ p.a. in 2045 (40% decline). • Industrial gas consumption is expected to drop from around 30,000 GJ p.a. in 2021 to just under 20,000 GJ p.a. in 2045 (33% decline).
Electricity	• Demographic projections based on the most recent ACT Treasury figures. • AEMO ISP 'slow growth' & 'steady progress' energy efficiency projections • An all-electric Molonglo commercial centre will result in an annual energy requirement of approximately 14.5 GWh by 2032. • Electric Vehicle uptake in accordance with the Deloitte 'conservative' projections, with charging profiles in accordance with the AEMO ISP projections • 90 new electric buses being introduced by 2024, followed by phased implementation (linear projection) of the	• The projected annual total grid demand for electricity is expected to grow from 2,781 GWh in 2022 to 3,380 GWh in 2045, which represents an increase of around 20.8% (0.8% p.a.). • Residential average consumption is expected to fall from ~6.63MWh in 2022 to ~5.45MWh in 2045 • LV Commercial average consumption is expected to fall from 70MWh to 63.46MWh by 2045 • HV average consumption is expected to increase from 9,700MWh to ~10,460MWh by 2045 • ACT 50POE peak demand is projected to grow from 659 MW in 2022 to 840 MW in 2045, which is an increase of around 29 per cent.	• The projected annual total grid demand for electricity is expected to grow from 2,772 GWh in 2022 to 3,367 GWh in 2045, which represents an increase of around 21% (0.9% p.a.). • Residential average consumption is expected to rise from ~7MWh in 2022 to ~8MWh in 2045 • LV Commercial average consumption is expected to rise from ~70MWh to 80MWh • HV average consumption is expected to decline from ~11,000MWh to ~10,000MWh • ACT 50POE peak demand is projected to grow from 654 MW in 2022 to 966 MW in 2045, which is an increase of around 48 per cent.

	remaining bus fleet from 2025, reaching 100% in 2040 (~20 GWh). • Build at least 50 electric vehicle recharging stations across Canberra and the region, work with service station providers to explore broader public charging infrastructure. • Stage 2 light rail results in an annual energy requirement of 2.6 GWh by 2025. • Canberra Hospital to be fully electrified by 2024, which results in an additional annual energy requirement of around 25 GWh. • New CIT Facility is scheduled to open in 2025, and that this will result in an additional annual energy requirement of around 5 GWh. • The Base Case assumes a 5% increase in ACT Government use in electricity consistent with the Government's commitment to ensure all new Government buildings, including leases are fossil-fuel-gas free and to retrofit with an aim of net zero emissions.	10POE peak demand is projected to increase to 1074 MW by 2045 (increase of 65%).	
Large-scale Storage	• Deliver at least 250MW of new 'large-scale' battery storage distributed across the ACT.	• This large-scale storage has no impact on reducing peak demand at Evoenergy zone substations and is not factored into the Peak Demand and CAPEX forecasts.	• ACT's 'large-scale' battery capacity commitments to 660MW by 2025, being 110MW in 2023 and increasing by 430MW and 120MW in 2024 and 2025 respectively.
Zero Emission Vehicles (ZEV)	• Engage with the ZEV industry and adopt an ambitious target for new ACT vehicle sales to be zero emission by 2030.	• The Base Case assumes that 28% of sales are new BEVs in 2030, and that the growth in passenger BEVs will result in BEVs taking up approximately 20.7% of the ACT's total energy requirements (698 GWh) in 2045.	• The Base Case assumes that 28% of sales are new ZEVs in 2030, and that the growth in passenger ZEVs will result in ZEVs taking up approximately 20% of the ACT's total energy requirements (673 GWh) in 2045.

		• However, prior to 2038 they are projected to only make up a small component (1% to 11%) of the ACT's energy requirements.	• However, prior to 2038 they are projected to only make up a small component (1% to 9%) of the ACT's energy requirements.
Energy Efficiency and Technology Incentives	• Sustainable Household Scheme provides eligible households to get a loan of $2,000 to $15,000 to buy energy-efficient products such as rooftop solar panels, household battery storage systems and electric vehicles.	• This is expected to increase the rate of PV and battery energy storage but is not factored specifically into the base case, as the base case uses AEMO 'base case' assumptions on energy efficiency which accounts for current government policies. • The Base Case assumes 3 different charging profiles for ZEVs, namely a late evening, a daytime profile and an overnight profile. The Base Case assumes most charging occurs overnight, in accordance with AEMO charging profiles. There is a gradual transition to daytime charging overtime.	• This is expected to increase the rate of PV and battery energy storage but is not factored specifically into the base case, as the base case uses AEMO 'base case' assumptions on energy efficiency which accounts for current government policies. • The Base Case assumes 3 different charging profiles for ZEVs, namely a late evening, a daytime profile and an overnight profile. The Base Case assumes most charging occurs overnight, in accordance with AEMO charging profiles. There is a gradual transition to daytime charging overtime.
New Housing Developments	• 70% of new housing within existing town and group centres and along key transit corridors.	• Effects distance for EV's to travel and hence EV charging. • Also increases existing zone-substation demand via infill developments.	• Effects distance for EV's to travel and hence EV charging. • Also increases existing zone-substation demand via infill developments.
Renewable Energy Target	• Legislate a 100% renewable electricity target to continue from 2020.	• Zero emissions for electricity use in the ACT.	• Zero emissions for electricity use in the ACT.

4.3 Realistic Base Case June 2022 Modelling Results

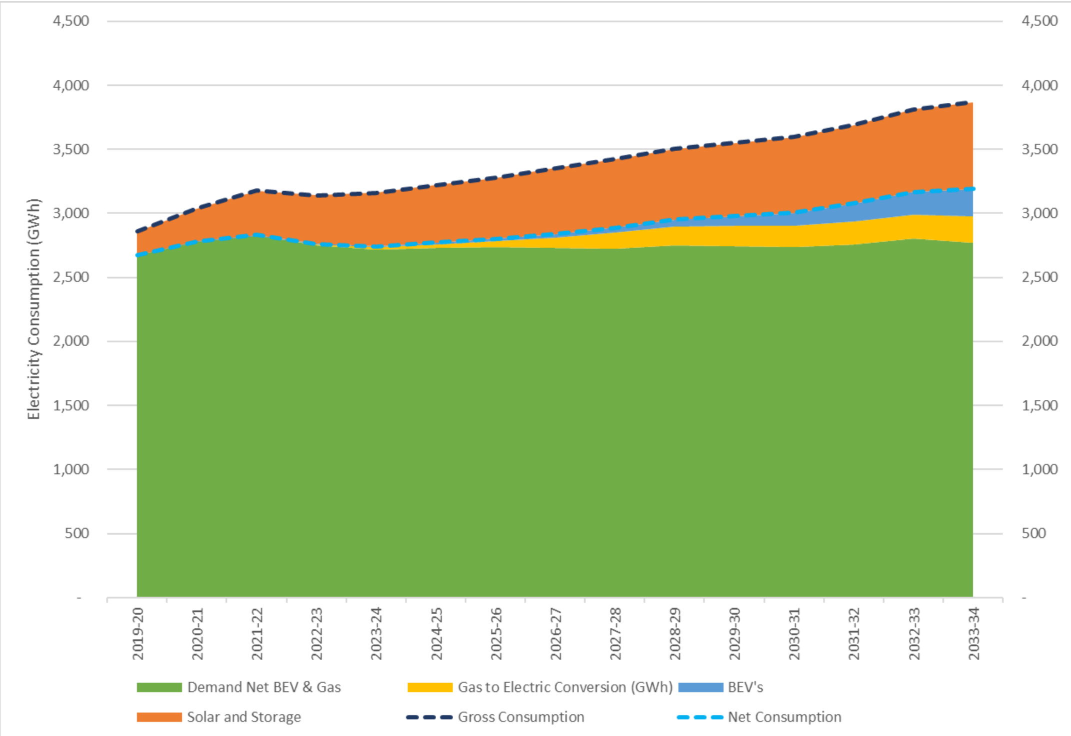
The key results from using Evoenergy's NZM to simulate a Realistic Base Case, with a focus on the period 2020-21 to 2033-34, includes the following:

- Peak electricity demand in the ACT is forecast to increase by 101 MW over the study period (2020/21 to 2033/34), while electricity customer numbers are forecast to increase by 26,407 from 2020/21 to 2033/34. Growth in peak demand and customer numbers explains 50% of the total CAPEX required by 2033/34, with 50% due to Business As Usual (BAU) CAPEX (e.g., replacement of assets at end of useful life and efficiency investments).
- Cumulative CAPEX in the Evoenergy electricity distribution network is estimated to be $1,300M by 2033/34.

4.3.1 Electricity Consumption

Marsden Jacob have incorporated gas churn to electric (Gas Churn), BEV and Solar (behind the meter rooftop PV) and Storage (behind the meter) assumptions that drive electricity consumption (both Gross and Net) in the ACT. Gross Consumption includes generation from rooftop PV solar systems and discharge from behind the meter batteries, while Net Consumption excludes rooftop solar PV and battery supply. Consumption Net BEV & Gas is fairly constant over the period because increased electricity consumption due to population growth is being offset by increased energy efficiency of electric appliances and also due to the increasing installation of rooftop solar PV in the ACT. However, Net Consumption increases over the study period due to increases in BEV and Gas Churn.

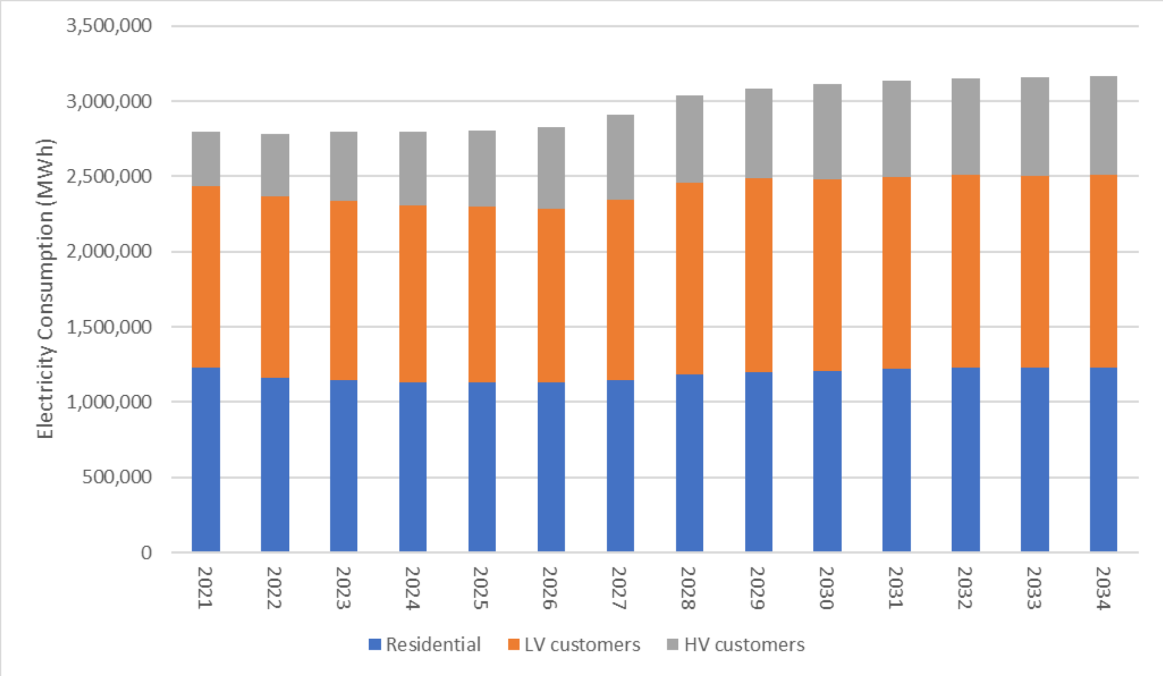
Figure 11: Gross and Net Electricity Consumption (GWh) in ACTG - EN19, EN24 and EN29 regulatory periods



Source: Marsden Jacob 2022

The following graph shows ACT electricity consumption by each customer class in the ACT.

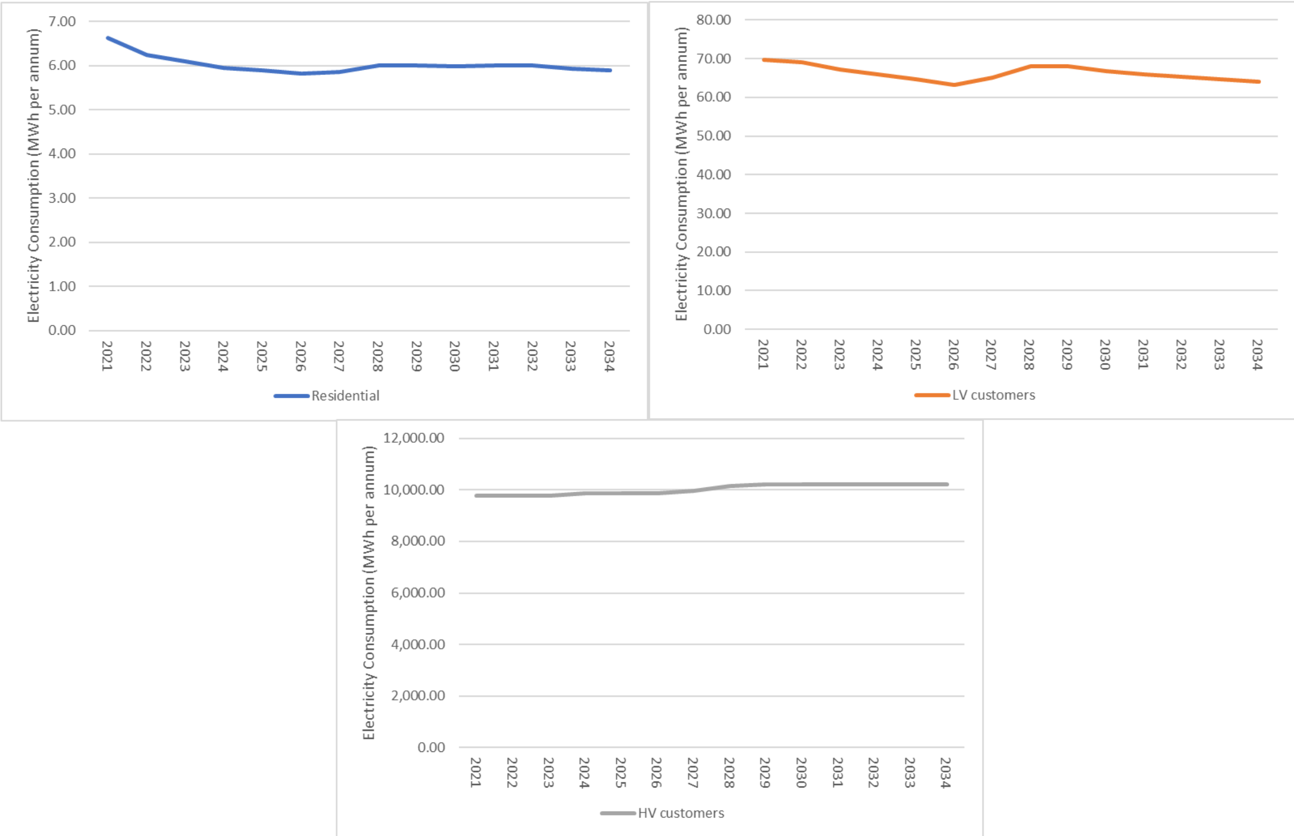
Figure 12: Net Electricity Consumption (GWh) in ACT by Customer Class – EN19, EN24 and EN29 regulatory periods



Source: Marsden Jacob 2022

Overall, electricity consumption increases, but declines in per capita electricity consumption for Residential and LV customers offsets the increase in customer numbers. This is due to increases in appliance energy efficiency and installation of rooftop PVs. The impact of rooftop PV on HV demand is relatively low given that there is limited area available to install rooftop solar systems on commercial buildings relative to the overall electricity demand of the building.

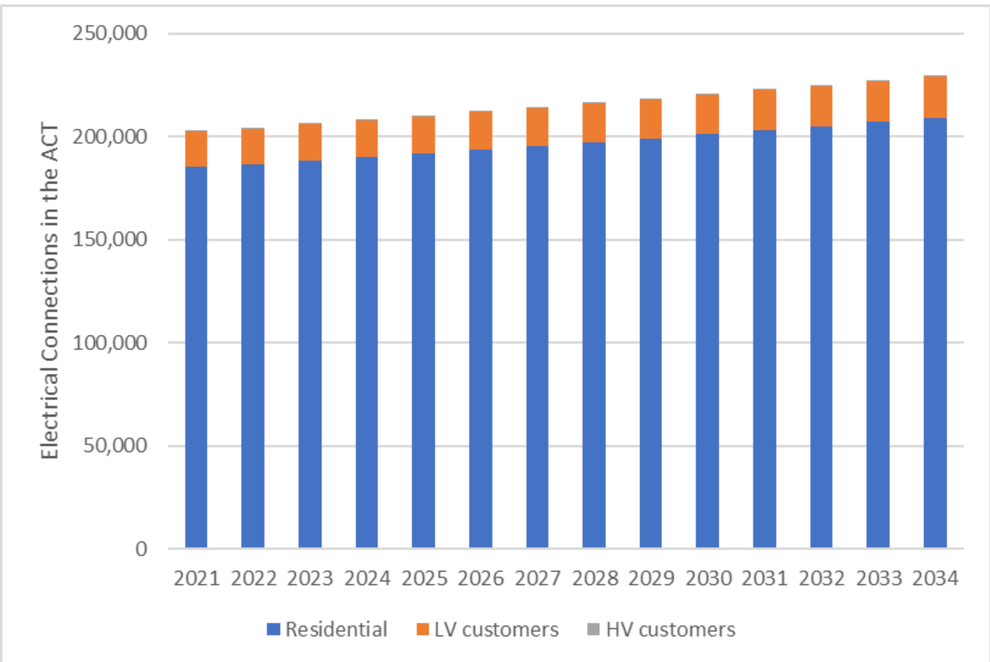
Figure 13: Per Capita Electricity Consumption (MWh) EN19, EN24 and EN29 regulatory periods



Source: Marsden Jacob 2022

The increase in the number of customers (by customer class) is shown below. HV customer numbers commence at 37 in 2020-21 and increase to 64 by 2034.

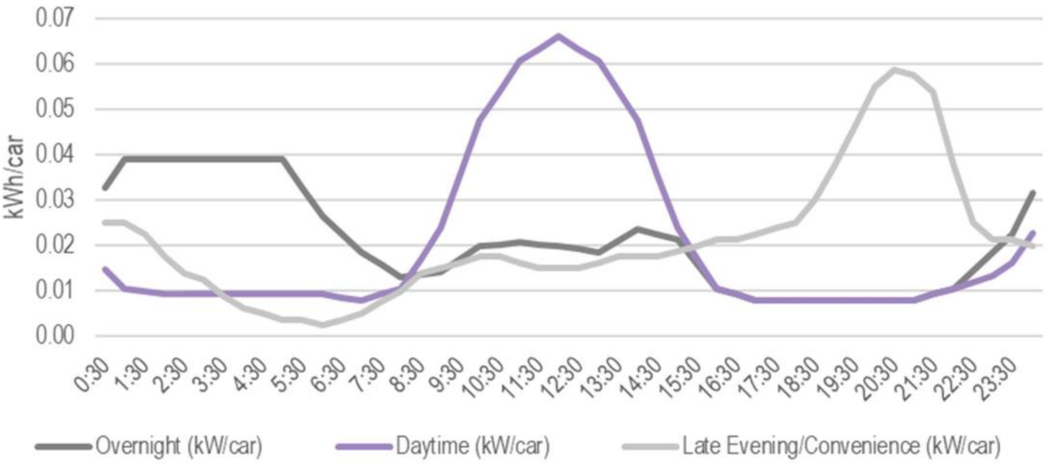
Figure 14: Electricity connections in the ACT by Customer Class – EN19, EN24 and EN29 regulatory periods



Source: Marsden Jacob 2022

The ACTG and Marsden Jacob have used the following charging patterns for BEVs.

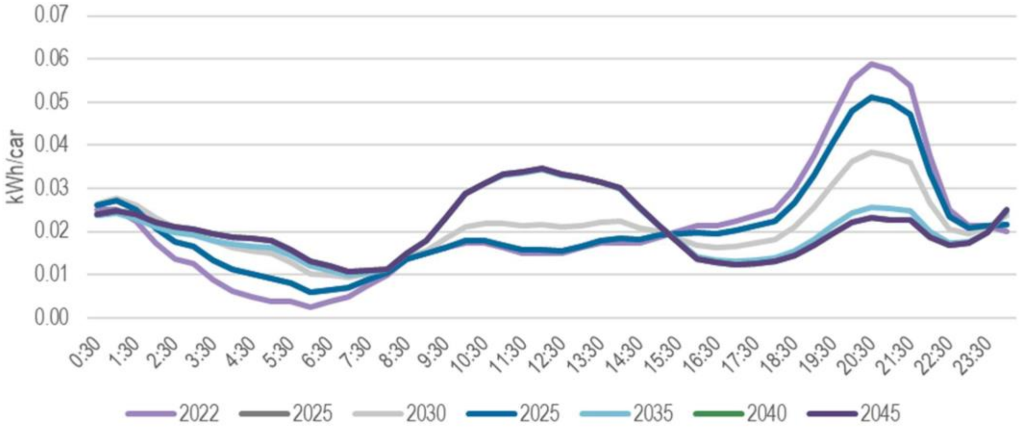
Figure 15: BEV charging patterns



Source: GHD and ACIL Allen, Economic and Technical Modelling of the ACT Electricity Network, for EPSDD, 26 April 2022, p.51.

The assumption is that BEV charging will move from convenience charging (charging in the evening peak) in the early years of the study period to daytime charging profiles in the latter part of the study period. However, by 2030, peak recharging of the BEVs still occurs in the evening. Peak recharging of BEVs only occurs during the daytime from the 2040s.

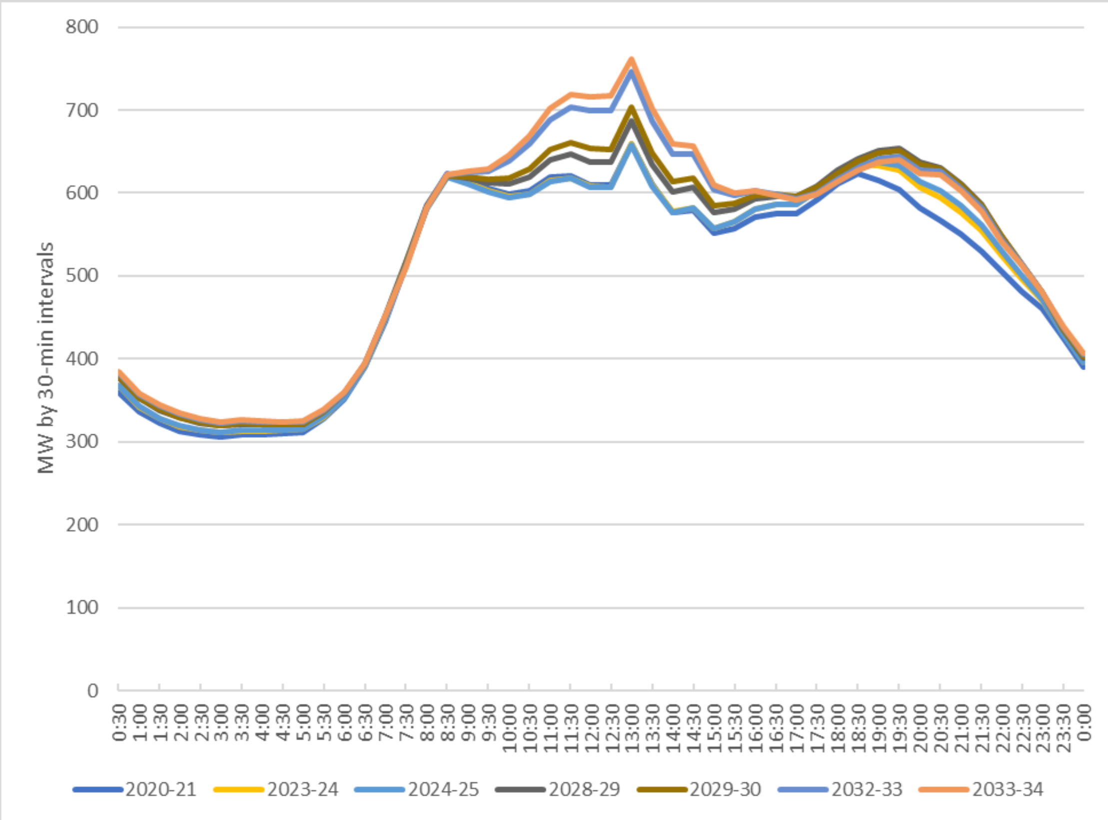
Figure 16: BEV charging patterns



Source: GHD and ACIL Allen, Economic and Technical Modelling of the ACT Electricity Network, for EPSDD, 26 April 2022, p.52.

The impact of these assumptions on peak demand for electricity (10% PoE) is provided below. Peak demand in winter increases from 659 MW in 2020-21 to 761 MW by 2033/34 (15.7% increase), which is slightly above the growth in annual electricity consumption (13% increase). Peak electricity demand occurs in the evening period in 2020-21 (7:30 PM), but due to the assumption that BEVs move from Convenience Charging to Daytime Charging overtime (ACTG assumption), peak electricity demand occurs at 1:00 PM by 2033/34. Contributing factors to this result is that HV Demand customers have peak consumption during the day, since it is assumed that there is a low penetration of rooftop PV for this customer class, and behind the meter battery storage is also recharging during the day.

Figure 17: Winter Peak Demand (MW) for Electricity (10% PoE)



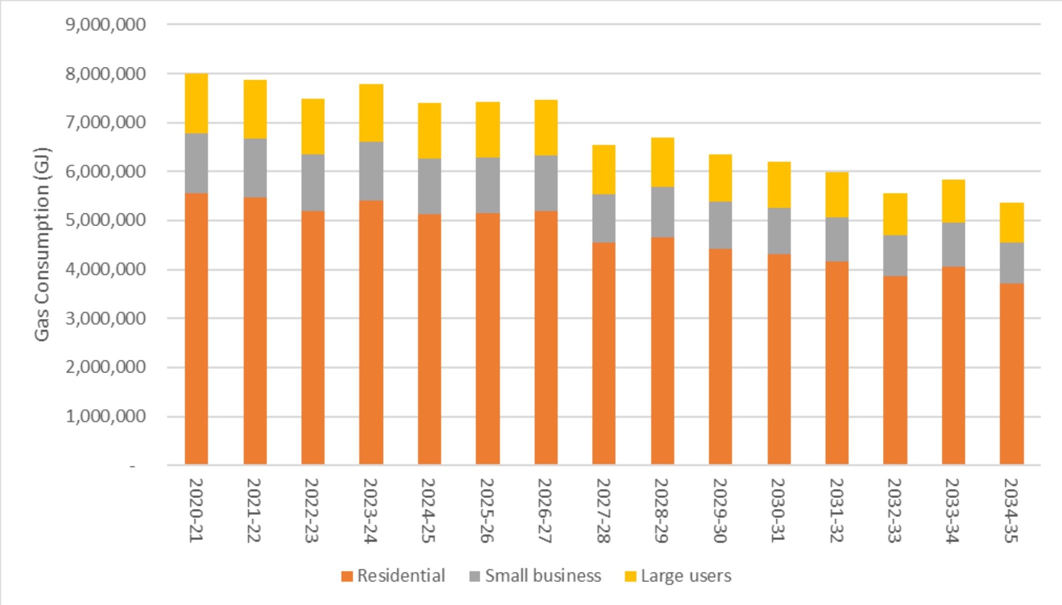
Source: Marsden Jacob 2022

Evoenergy could provide tariffs to encourage both BEVs and energy storage to recharge at other times of the day to help reduce peak demand growth during the day. However, these incentives could be offset by other factors, such as retailers providing incentives for daytime charging due to low wholesale prices occurring during the day due to the high penetration of rooftop PV and large-scale solar systems in NEM states, such as NSW and Victoria.

4.3.2 Gas Demand and Consumption

Due to a combination of gas churn to electric and gas energy efficiency, gas consumption is expected to fall by 27% by 2033/34.

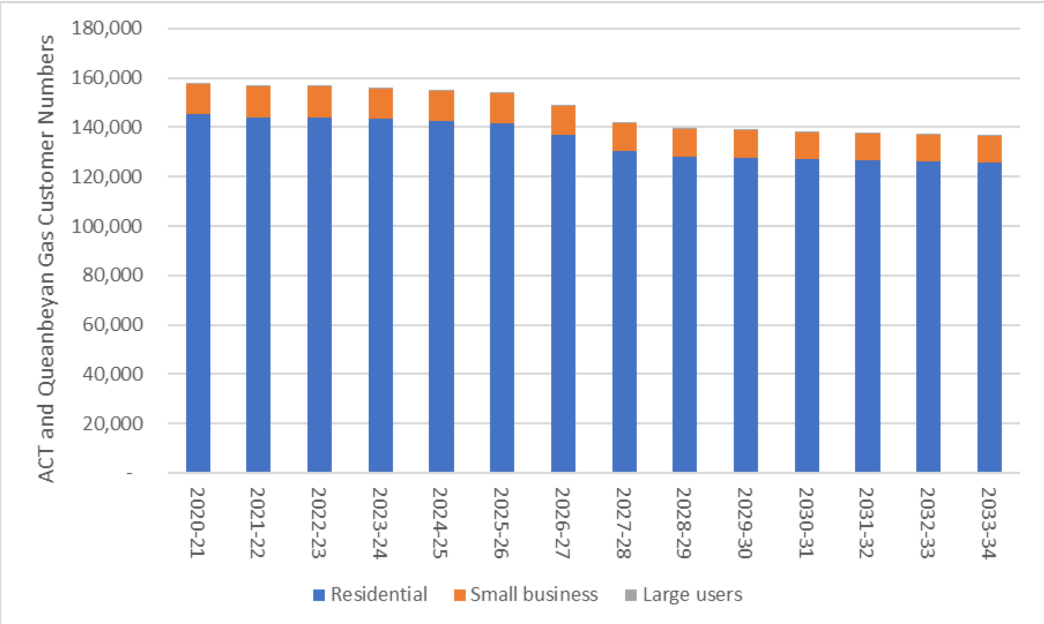
Figure 18: ACT and Queanbeyan Gas Consumption (GJ)



Source: Marsden Jacob 2022

Due to gas churn to electric, the number of gas customers in the ACT and Queanbeyan falls from 157,659 in 2020-21 to 136,436 in 2033-34. The number of large users falls from 51 in 2020-21 to 43 in 2033-34.

Figure 19: ACT and Queanbeyan Gas Customer Numbers



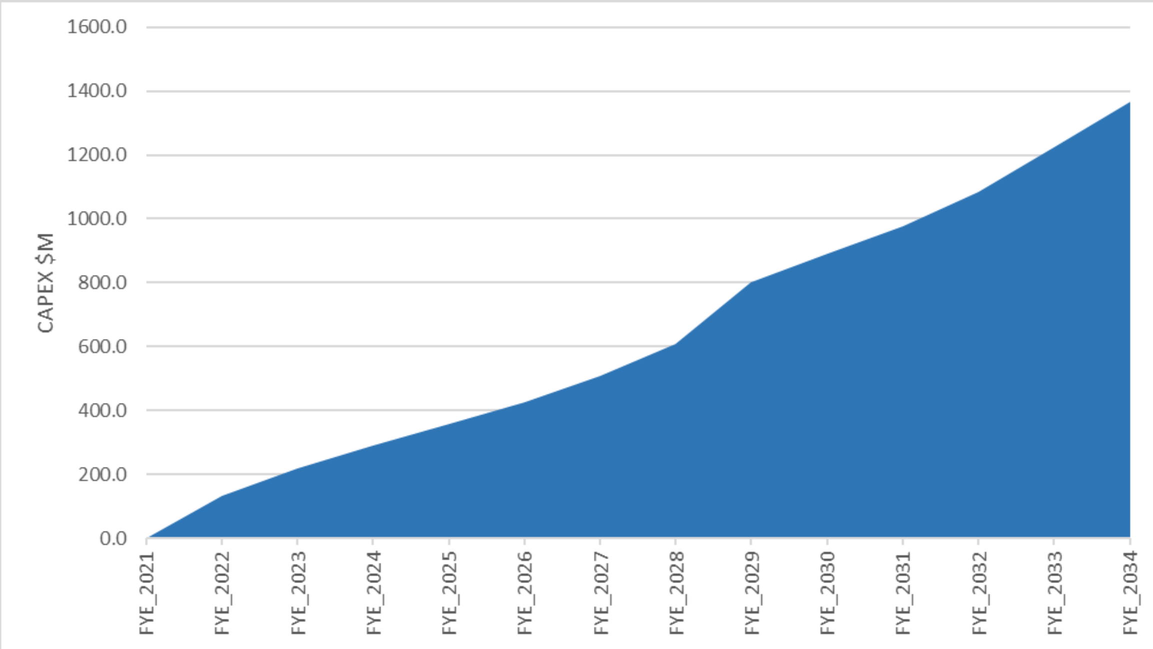
Source: Marsden Jacob 2022

4.3.3 Electricity CAPEX

Shown below is both BAU and Growth CAPEX for Evoenergy's electricity distribution business. Growth CAPEX is caused by required expansions of the network to handle load growth (co-incident demand increase of 101 MW) and increase in investment to manage growth in customer connections (i.e., 26,407 new customers from 2020/21 to 2033/34). In the Evoenergy NZM, growth in customer connections drives the following costs:

- Upgrades from single to three phase
- LV feeders
- HV/LV distribution substations

Figure 20: Electricity Distribution Cumulative CAPEX ($M) – June 2024 dollars

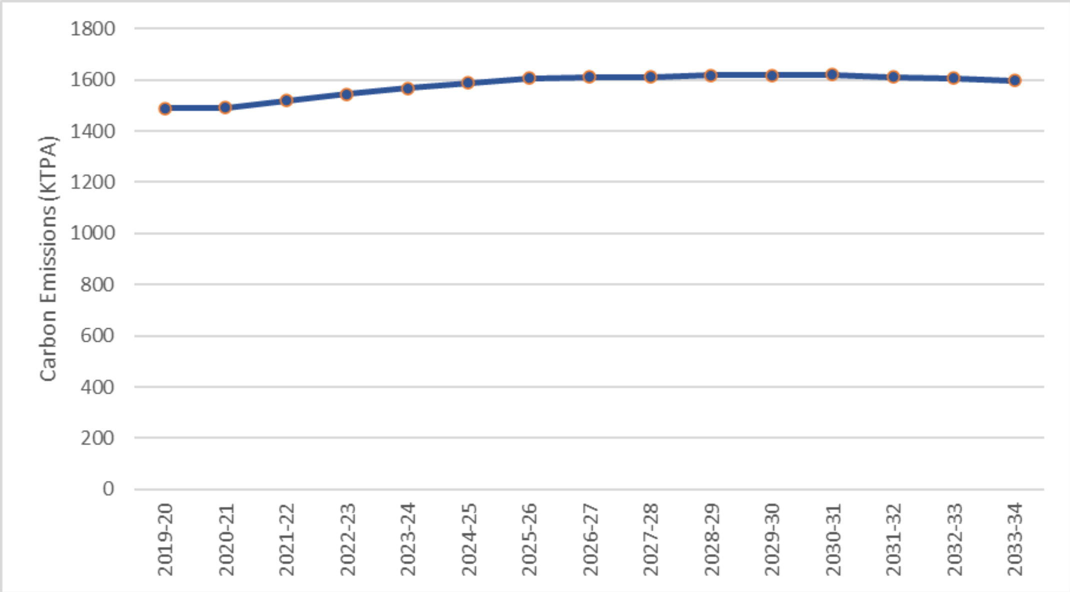


Source: Marsden Jacob 2022

4.3.4 Emissions Profile for Realistic Base Case

The carbon emissions profile for the ACT over the study period is provided below. While carbon emissions from natural gas consumption are reduced from 369 KTPA in 2020-21 to 271 KTPA in 2033-34, emissions from transport (internal combustion engines or ICE) continues to increase over the study period as ICE vehicles in the ACT increase from 318,000 vehicles in 2020/21 to 359,447 vehicles in 2033/34 due to population growth. It is assumed that BEVs increase from only 851 vehicles in 2020/21 to 56,228 vehicles in 2033-34. The realistic Base Case emissions profile trajectory is not consistent with the achievement of zero net emissions by 2045 and substantial reductions in both gas and transport emissions post 2033/34 will be required to achieve the ACTG's net zero emissions target.

Figure 21: ACT carbon emissions for the Base Case Scenario (gas and transport only)



Source: Marsden Jacob 2022

5. Realistic Electrification Adhoc Scenario Assumptions September 2022

5.1 Background

The ACTG recently announced new policies which assist in helping to reduce emissions in the ACT,

The two significant policy changes from the previous Realistic Base Case (June 2022) were the following announcements:

Natural Gas Use in the ACT:

- As the preferred pathway the ACT will transition away from fossil fuel gas use to renewable electricity, with the potential use of renewable gases for specific purposes where needed, by 2045.[7]
- ACT Government is encouraging Canberran's to transition from gas to electricity across the ACT and have indicated that the gas network must remain operational until 2045. This effectively means that conversion of customers from natural gas to electricity will occur on an ad hoc basis (no orderly transition). As a result, the costs of enhancing the Evoenergy distribution network is likely to be higher when compared to an orderly transition (i.e., suburb by suburb closures of the network) since upgrades of the network will occur randomly by location in future years.

Transport Policies:

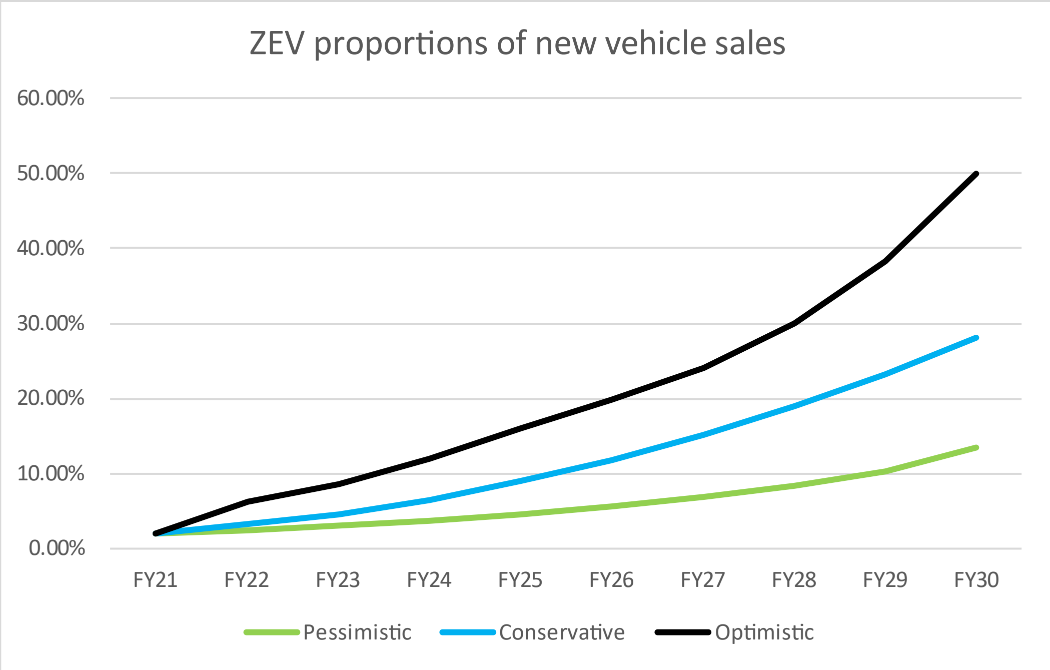
- ZEV sales target (light vehicles) for the ACT of 80-90% by 2030,
- Cease registration of new light non-ZEVs by 2035.

The ACT already provides substantial incentives for ZEV take up with no stamp duty, two years free registration and an interest free loan of up to $15,000 for eligible ZEVs.

Evoenergy used prototype EDEFM to model this new scenario (referred to as the Realistic Electrification Ad hoc scenario). The most significant change was the ACTG moving from the Conservative target for ZEVs in the ACT (had previously indicated that this was the pathway for decarbonisation of the transport sector) to the Optimistic target (based on Deloitte' ZEV forecasts for the ACT).

[7] ACT Government, Powering Canberra, Our Pathway to Electrification, Position Paper, August 2022

Figure 22: Zero emission vehicle forecasts (passenger vehicles only)



Source: Deloitte Analysis, ACT Zero Emission Vehicles

The Electrification Adhoc scenario needs to incorporate the ACTG policy announcements with regard to the Gas Network and adoption of the Optimistic Scenario for ZEV take-up in the ACT.

5.2 Electrification Adhoc scenario

The changes in assumptions compared to the Realistic Base Case scenario June 2022 (Chapter 4) included the following:

- Adopt Optimistic Scenario for light ZEV take-up in the ACT
- Include Fuel Cell Electric Vehicles (FCEVs) in the heavy vehicle fleet so as to consider the impact on emission reduction targets (has no impact on electricity or gas system since we are assuming hydrogen is supplied from production facilities external to the ACT and transported by road transport – analogous to current liquid fuel supply chain)
- Ensure that recharging of ZEVs to minimise the contribution to increases in Peak Demand on the Evoenergy network. This assumes development of incentives and cost reflective tariffs to ensure that most charging occurs outside of peak periods.

All financial values in this report are in June 2024 prices (real dollars) – consistent with the Realistic Base Case June 2022 financial values.

5.3 Electrification Ad hoc modelling results

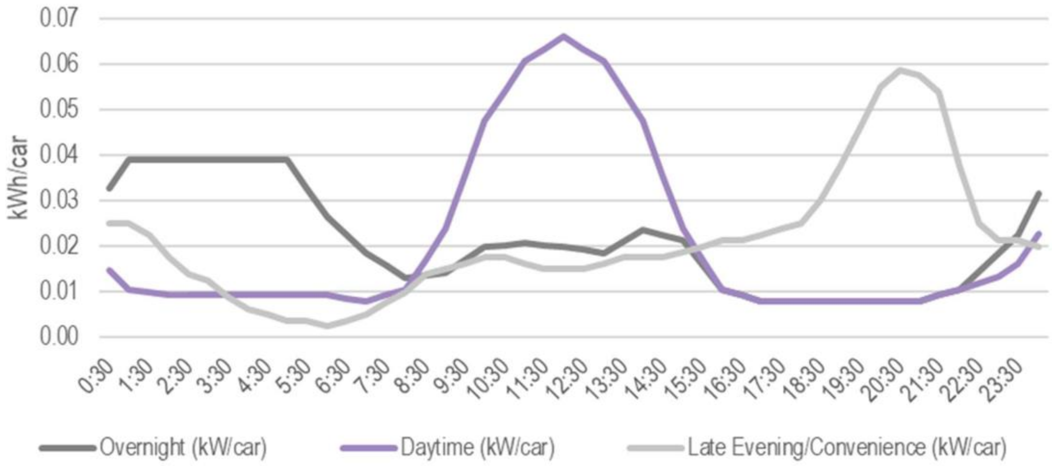
Peak electricity demand in the ACT is forecast to increase by 164 MW over the study period (2020/21 to 2033/34), while electricity customer numbers are forecast to increase by 26,407 from 2020/21 to 2033/34.

Cumulative CAPEX in the Evoenergy electricity distribution network is estimated to be $1,223 M by 2033/34, mainly driven by population growth (i.e., new substations and feeders) and end-of-life asset replacement.

5.3.1 Electricity Demand

Electricity consumption and customer number forecasts are consistent with the Realistic Base Case June 2022 Modelling Assumptions. As for the Realistic Base Case, the Marsden Jacob have used the following charging patterns for BEVs which are the same patterns assumed in the ACTG base case.

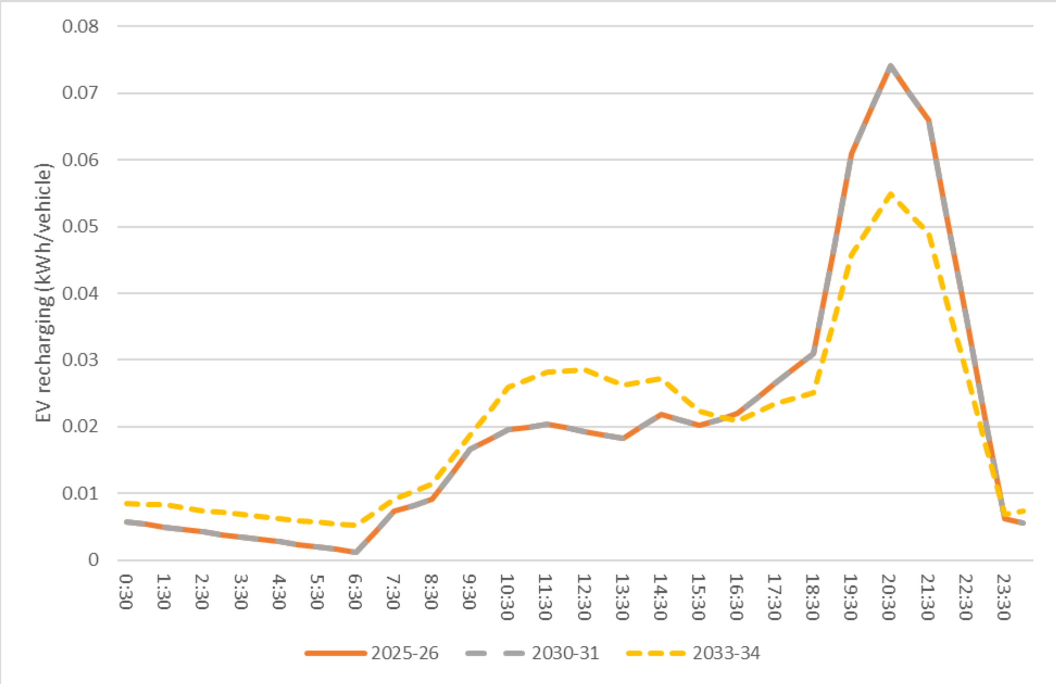
Figure 23: BEV charging patterns



Source: GHD and ACIL Allen, Economic and Technical Modelling of the ACT Electricity Network, for EPSDD, 26 April 2022, p.51.

The different assumption used in the Realistic Adhoc Electrification Scenario September 2022 is that BEV charging will gradually move from convenience charging (charging in the evening peak) in the early years of the study period to increased daytime charging in the latter part of the study period (see figure below) due to increased incentives to shift BEV charging away from peak demand in the evening.

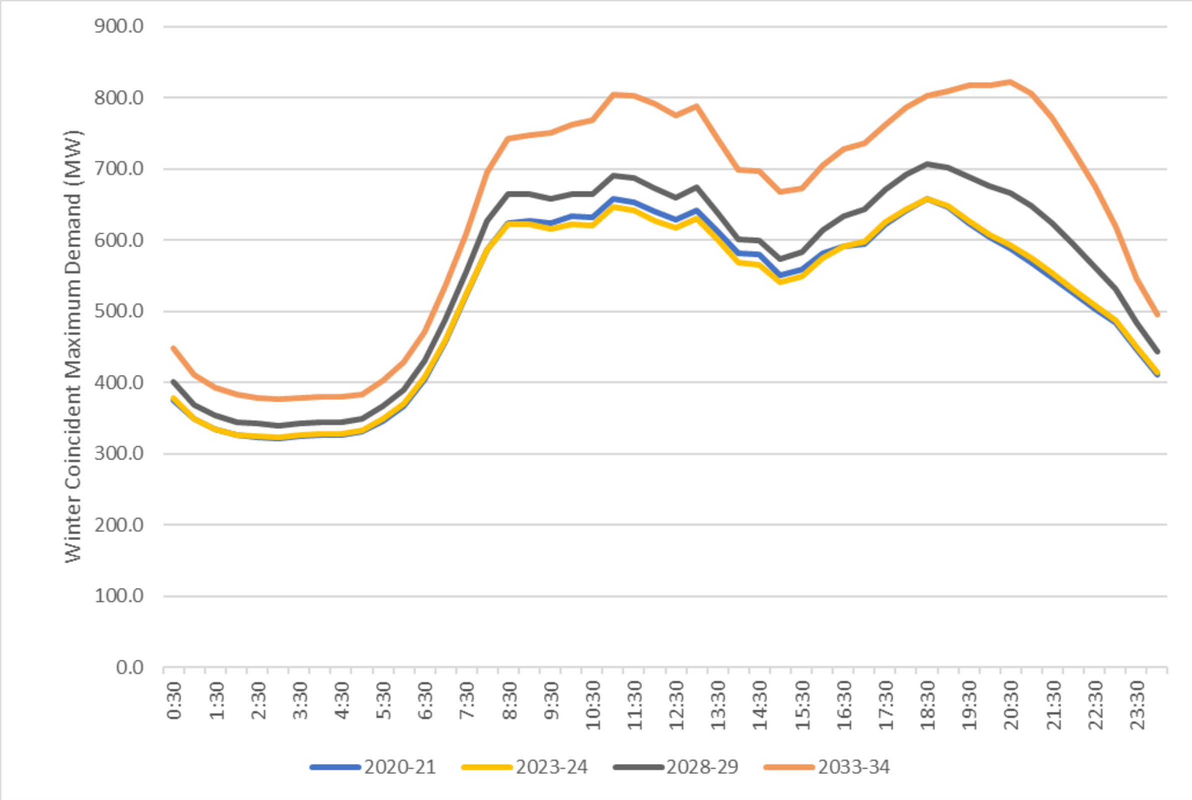
Figure 24: BEV charging patterns



Source: Marsden Jacob 2022

The impact of these assumptions on peak demand for electricity (10% PoE) is provided below. Winter peak demand will drive future investment in the capacity of the Evoenergy electricity distribution system. Modelled peak demand in winter increases from 659 MW in 2020-21 to 824 MW by 2033/34 (25% increase), which is significantly above the growth in annual electricity consumption (12% increase). Peak electricity demand occurs in the evening period due to the use of electricity for space heating (gas substitution) and EV charging in the evening period. However, by 2033-34, peak demand during the day almost matches peak demand in the evening due to the assumption that BEV charging occurs more often in daytime periods (less evening charging).

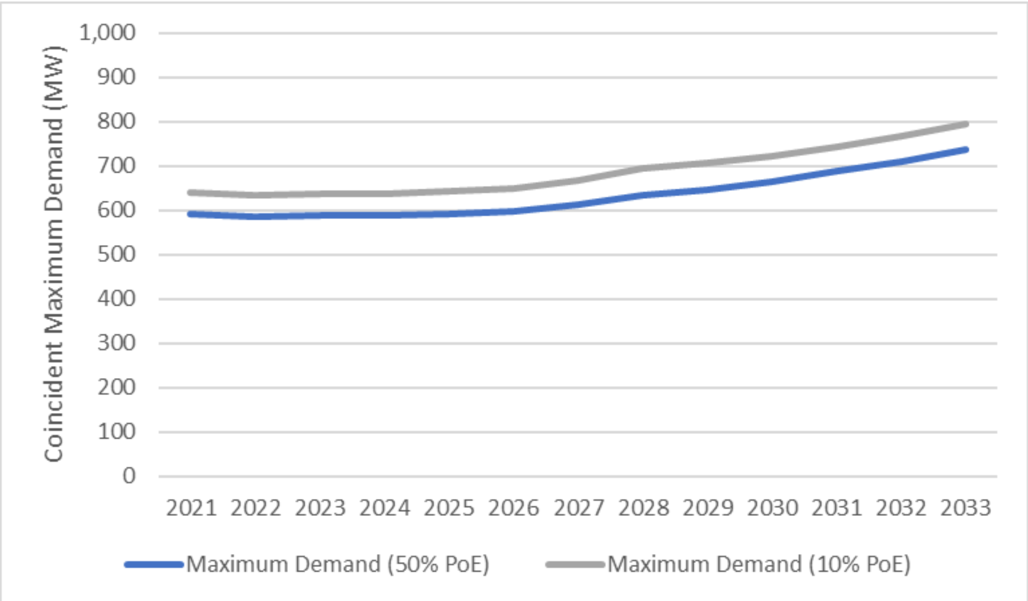
Figure 25: Co-incident Peak Demand for Electricity (10% PoE) – Winter Weekdays



Source: Marsden Jacob 2022

The coincident peak demands for different PoE levels is shown below. Peak demand is relatively flat from 2021 to 2026 but increases after this time due to increased gas substitution and take-up of BEVs.

Figure 26: Coincident Maximum Demand (MW) for the ACT – by Probability of Exceedance (PoE) Level



Source: Marsden Jacob 2022

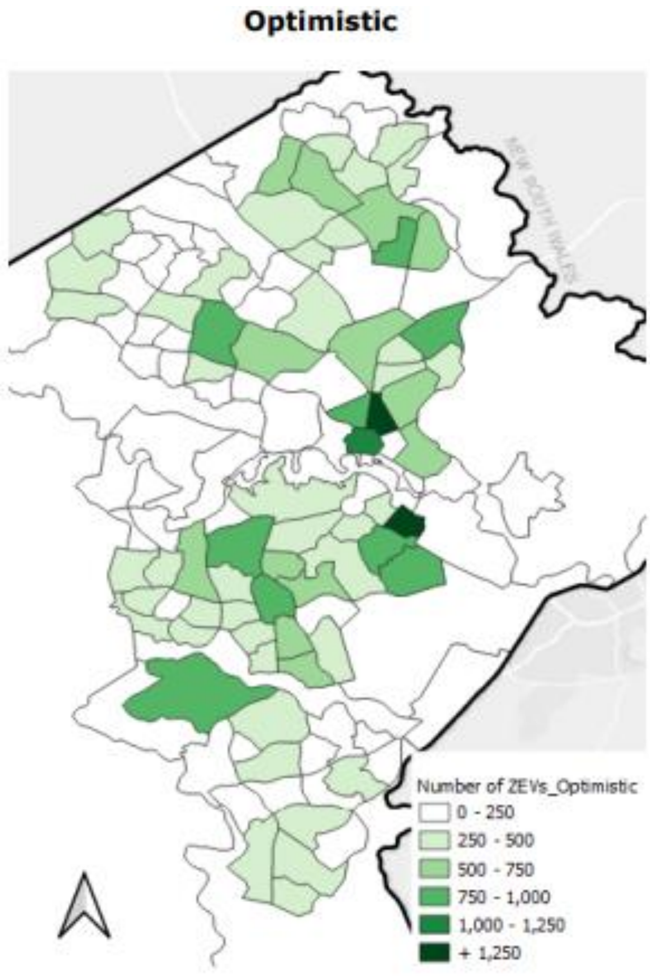
5.3.2 Gas Demand

Gas demand forecasts are consistent with the Realistic Base Case scenario June 2022 (Chapter 4).

5.3.3 Locational ZEV forecasts

Under the ACTG optimistic scenario[8], Zero Emission Vehicles (ZEVs), which are all classified to be BEVs, will increase from 2.1% of new car sales in 2021 to 50% of new car sales by 2030. This implies that ZEVs will increase from 851 vehicles in 2021 to 41,944 vehicles by 2030. The spatial distribution of ZEVs in the ACT is shown in the heat map below. The highest density of ZEVs and hence greatest requirement for public charging infrastructure for these vehicles occurs near City and Kingston (near Parliament House).

Figure 27: Heat Map of ZEVs by Location in the ACT by 2030 – Optimistic Scenario



Source: 22_33787-Document.pdf

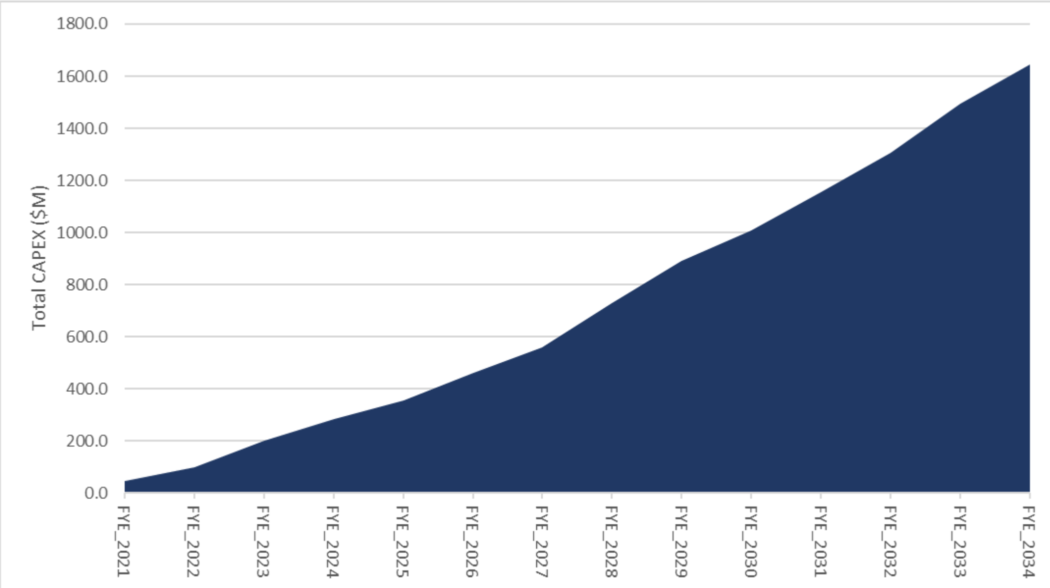
[8] Deloitte Access Economics, Zero Emission Vehicle Charge Rollout, ACT Government, October 2021

5.3.4 Electricity CAPEX

Shown below is both BAU and Growth CAPEX for Evoenergy's electricity distribution business. Growth CAPEX is caused by required expansions of the network to handle load growth (co-incident demand increase of 164 MW) and increase in investment to manage growth in customer connections (i.e., 26,407 new customers from 2020/21 to 2033/34). In the EDEFM, growth in customer connections drives the following costs:

- Upgrades from single to three phase
- LV feeders – especially to accommodate charging of BEVs near various town centre business districts in Canberra, including City, Gungahlin, Woden and Belconnen.
- HV/LV distribution substations

Figure 28: Electricity Distribution Cumulative CAPEX ($M) – June 2024 dollars



Source: Marsden Jacob 2022

5.3.5 Emissions Profile for Realistic Electrification Adhoc Scenario

The carbon emissions profile for the ACT over the study period is provided below. While carbon emissions from natural gas consumption are reduced from 367 KTPA in 2020-21 to 269 KTPA in 2033-34, while emissions from transport (internal combustion engines or ICE) reduce from 1122 KTPA in 2021-22 to 1115 KTPA in 2033-34, as ICE vehicles in the ACT decrease from 318,000 vehicles in 2020/21 to 309,580 vehicles in 2033/34. It is assumed that BEVs increase to 120,544 vehicles in 2033-34 (includes passenger, light commercial, rigid and semi-rigid vehicles). The Realistic Electrification Adhoc emissions profile trajectory is not consistent with the achievement of zero net emissions by 2045 and further reductions in both gas and transport emissions post 2033/34 will be required to achieve the ACTG's net zero emissions target.

Figure 29: ACT carbon emissions for the Realistic Electrification Adhoc Scenario (gas and transport sectors only)

Source: Marsden Jacob 2022

6. Compare and Contrast Scenario Results

We have provided a summary of some of the scenarios that have been modelled from October 2021 to September 2022.

Table 7: Scenario and Key Assumptions

Scenario and Pathway Exogenous Variables	Full Electrification Scenarios (Planned, Adhoc & Hybrid) (Oct 2021)	Electrification & Green Gas Scenarios (Planned and Hybrid) (Oct 2021)	Base Case (Adhoc) (Oct 2021)	Realistic Base Case (Adhoc) (June 2022)	Realistic Electrification Adhoc (Sep 2022)
Behind the meter solar PV and battery storage	Medium	Medium	Medium	Medium	Medium
Battery Electric Vehicle Penetration	High	Medium	Low	Medium	Medium
Fuel Cell Electric Vehicles	Low	Medium	None	Low	Medium
Economic conditions	Medium	Medium	Medium	Medium	Medium
NSW emissions reduction	By 2050	By 2050	By 2050	By 2050	By 2050
ACT Emissions reduction policy	By 2045	By 2045	No commitment	No commitment	No commitment
Hydrogen source	No local production or pipeline	H_2 Blend by 2028, full H_2 conversion by 2035	No hydrogen	No hydrogen	No hydrogen
Biomethane blended into gas network	None	High	None	None	None
Premise gas to electric conversion rate	High	Low	Low	Low	Low
Premise conversion churn from gas to electric by area	Adhoc – Random by location Planned – Planned by location	Planned – Planned by location Hybrid – Random until	Random by location	Random by location	Random by location

Scenario and Pathway Exogenous Variables	Full Electrification Scenarios (Planned, Adhoc & Hybrid) (Oct 2021)	Electrification & Green Gas Scenarios (Planned and Hybrid) (Oct 2021)	Base Case (Adhoc) (Oct 2021)	Realistic Base Case (Adhoc) (June 2022)	Realistic Electrification Adhoc (Sep 2022)
	Hybrid – Random until 2030, planned after this	2030 and then planned after this			
Gas network	Adhoc – Obliged to maintain network until all customers have churned or no longer economically viable Planned – planned closure of District Regulators as gas churn occurs Hybrid – initially adhoc, but then do planned closures of District Regulators as gas churn occurs	Most (if not all) of the Evoenergy gas network is maintained indefinitely for later use	No change to operation of gas network as it continues to supply natural gas to customers	No change to operation of gas network as it continues to supply natural gas to customers	No change to operation of gas network as it continues to supply natural gas to customers

Source: Marsden Jacob 2022

We compare the economic and financial results for the electrification scenarios, as the ACTG is firmly committed to the electrification pathway, with a focus on the period up to 2033-34. Annual electricity consumption for each scenario is shown below with electricity consumption forecasts for the Oct 2021 cases being significantly higher than for the Realistic Base Case June 2022 and Realistic Electrification Adhoc Case September 2022. This can be explained by significantly higher penetration of BEV's, and higher levels of gas transition compared to those announced by the ACTG (that form the basis of Realistic Base Case and Realistic Electrification Adhoc Cases).

Table 8: Electricity Consumption in the ACT (MWh) – Selected Years

Annual Electricity Consumption (MWh)	2020-21	2033-34	Growth
Electrification Planned (Oct 2021)	2,917,751	5,274,008	81%
Electrification Hybrid (Oct 2021)	2,917,751	5,423,707	86%
Realistic Base Case (June 22)	2,798,743	3,167,429	13%
Realistic Electrification Adhoc (Sept 22)	2,798,743	3,122,790	12%
Base Case (Oct 21)	2,798,743	4,961,087	77%

Source: Marsden Jacob

Peak Winter Demand is also higher for the Oct 2021 cases due to higher electricity demand for space heating (gas transition), EV charging in the evening period, which is partially offset by behind the meter battery discharge in the evening.

Table 9: Peak Winter Demand ACT (MW) – Selected Years

Winter Peak Demand (MW) 10% PoE	2020-21	2033-34	Growth
Electrification Planned (Oct 2021)	650	1,157	78%
Electrification Hybrid (Oct 2021)	650	1,190	83%
Realistic Base Case (June22)	659	761	15%
Realistic Electrification Adhoc (Sept 22)	659	823	25%
Base Case (Oct 21)	650	1,131	74%

Source: Marsden Jacob

The forecast Electricity CAPEX for four regulatory periods is shown below for selected scenarios and EDEFM simulations (by date). Because the Electrification Planned and Hybrid cases were attempting to achieve NZE by 2045, the Electricity CAPEX required was higher than the other cases which did not attempt to achieve NZE by 2045. That is, higher gas churn and uptake of EVs resulted in a higher peak demand which resulted in a higher CAPEX requirement for these two cases

The Realistic Electrification Adhoc case had a higher CAPEX requirement due to the higher take-up of BEVs and locational constraints when compared to the Realistic Base Case, as well as additional investment in the 11kV feeder network that is required to meet electricity charging requirements for BEVs in the various town centre business districts of Canberra such as City, Gungahlin, Woden and Belconnen.

Table 10: Electricity CAPEX ($M, June 2024 dollars)

Scenario	2024 to 2029	2029-2034	2034-2039	2039-2044	Total
Electrification Planned (Oct 2021)	743.23	731.64	1,153.24	692.00	3,320.11
Electrification Hybrid (Oct 2021)	908.44	702.09	1,167.14	617.69	3,395.36
Realistic Electrification Adhoc (Sept 22)	607.50	754.05	833.30	740.89	2,935.74
Realistic Base Case (June 22)	443.37	786.19	535.78	497.67	2,263.02
Base Case (Oct 21)	845.99	685	1,014.69	674.73	3,220.41

Source: Marsden Jacob