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Premise and Embedded Generator Connection Forecasts – Final Report

Prepared for Power and Water Corporation

9 December 2022

ENERGEIA

Executive Summary

Power and Water Corporation (PWC) is obligated under the National Electricity Law and National Electricity Rules as in Force in the Northern Territory (NEL and NT NER) to base its forecast capital (capex) and operating (opex) expenditure in its building blocks proposal on the levels required to meet or manage demand for standard control services over the period.[1] The NT NER further requires that the Australian Energy Regulator (AER) accept these forecasts if they reasonably reflect a realistic expectation of demand.[2]

Although they are developed for the Australian Energy Market Operator in their role as the developer of the Integration System Plan (ISP) and not for a Distribution Network Service Provider (DNSP) like PWC, the AER's Best Practice Forecasting Guidelines (the Guidelines) provide insight into the AER's view on best practice forecasting methods. Under the NT NER[3], the Guidelines must reflect the following key principles:

1. Forecasts should be as accurate as possible, based on comprehensive information and prepared in an unbiased fashion.
2. The basic inputs, assumptions and methodology that underpin forecasts should be disclosed.
3. Stakeholders should have as much opportunity to engage as is practicable.

Forecast new consumer and generator connections on a gross basis[4] are used as a key driver in a range of PWC forecasts including system and spatial peak and minimum demand, export demand and energy consumption. These forecasts are in turn used to develop PWC's capex and opex forecasts for the building blocks proposal, to develop network prices and to respond to the AER's Regulatory Information Notices (RINs).

Key factors expected to impact on PWC's connections forecasts include COVID-19, due to its impact on population and Gross State Product (GSP) growth rates, and the rising financial attractiveness of rooftop solar PV systems, which impact on rates of new generator connections. Importantly, neither of these factors are suitable for typical regression-based modelling due to their non-linear patterns.

Scope and Approach

PWC engaged Energeia to develop new consumer and generator connection forecasts on a gross basis that would be accepted by the AER and fit for purpose, to be factored into its:

- capex and opex forecasts in its Initial Regulatory Proposal (IRP);
- the network prices contained in its Tariff Structure Statement (TSS);
- the new connections in its Reset Regulatory Information Notice[5] (Reset RIN) submission; and
- sundry other business activities.[6]

[1] National Electricity Rules As in force in the Northern Territory Version 96 Sections 6.5.6(a)(1), 6.5.7(a)(1)

[2] Ibid. 6.5.6(c)(3), 6.5.7(c)(1)(iii)

[3] Ibid. Clause 4A.B.5(b)

[4] Net basis includes decommissioned National Metering Identifiers (NMIs), due, e.g. to major renovations, knock-down rebuilds, etc.

[5] National Electricity (South Australia) Act 1996, Section 28D

[6] See Section 0

Energeia worked closely with PWC to develop the following scope and approach for this project:

1. **Document Requirements –** Energeia reviewed the regulatory framework, recent regulatory determinations and engaged with stakeholders to define PWC's key forecasting requirements.
2. **Identify Industry Best Practices –** Energeia benchmarked peer-DNSP forecasting methodologies from recent regulatory cycles to identify industry best practices.
3. **Develop Methodology –** Based on the outcomes from steps 1 and 2, Energeia developed a best practice, fit-for-purpose procedure for producing AER acceptable connection forecasts.
4. **Gather Inputs –** Energeia gathered the most recent inputs from PWC, as well as a variety of external inputs from reputable sources, for use in the forecasting methodology.
5. **Forecast Connections –** Energeia produced forecasts to 2030-31 of gross and net new connections by Category Analysis RIN connection type, for PWC's network.
6. **Model Validation –** Energeia worked closely with PWC subject matter experts (SMEs) to validate the methodology, inputs, and outputs of the connections forecasting model.
7. **Documentation –** Energeia provided documentation for the produced forecasts, including presentation materials and this report.

The above methodology reflects the AER's Guidelines and is suitable for producing forecasts that are reasonably realistic as required by the NT NER.

Methodology

The methodology that Energeia developed and implemented utilised dynamically optimised, multi-factor regression as the core forecasting technique, which included specialist sub-models for distributed solar PV. The process consisted of the following key steps:

1. **Develop Connection Forecasting Procedure –** Energeia first developed a fit-for-purpose connection forecasting procedure that satisfied PWC's key requirements and reflected industry best practice.
2. **Data Gathering and Processing –** Energeia collected and processed the historical RIN connections data, including back-casting to extend the data history.
3. **Forecast Model Optimisation –** Energeia carried out the regression-based procedures, including identification of the optimal model parameters given fitness[7], sign and p-value and ran the PV uptake model for embedded generation connections.
4. **Validate Optimised Results –** Energeia reviewed the technically optimised forecasts against historical trends and validated them with published forecasts[8], PWC subject matter experts (SMEs) and stakeholders prior to finalising them.

A detailed discussion of the above steps and key inputs is presented in Section 3 and 0, respectively.

[7] Fitness is defined as the model's 'R-squared' value, also known as its explanatory power.

[8] Utilities Commission, 2021 NT Electricity Outlook Report, 2022

Results

The forecast results for gross and new connections are shown in Table ES1 and Table ES2, respectively. Generally, gross and new connections were forecasted to grow steadily.

Table ES1 – Historical and Forecast Gross Connections by Connection Type

Financial Year	Res - Simple LV	Res - Complex LV	Res - Complex HV	Com - Simple LV	Com - Complex LV (minor HV)	Com - Complex LV (upstream)	Com - Complex HV	Com - Complex Sub-transm.	Sub - Complex LV	Sub - Complex HV (no upstream)	Sub - Complex HV (with upstream)	EG - Simple LV	EG – Complex HV (small capacity)	EG - Complex HV (large capacity)
2017-18	64,356	281		10,145	1,260	567	47	-				10,888	3	-
2018-19	63,000	125		10,368	925	567	49	-				13,683	2	-
2019-20	60,300	173		10,052	1,216	576	70	-				17,426	-	10
2020-21	59,609	229		9,925	1,550	576	62	-				17,854	8	5
2021-22	60,441	242		9,981	1,595	579	66	-				19,674	8	5
2022-23	61,274	245		10,011	1,639	580	69	-				21,679	8	5
2023-24	62,106	247		10,033	1,684	581	73	-				23,781	8	5
2024-25	62,938	249		10,055	1,728	582	76	-				25,972	8	5
2025-26	63,771	252		10,078	1,773	583	80	-				28,241	8	5
2026-27	64,603	254		10,102	1,818	584	83	-				30,578	8	5
2027-28	65,435	257		10,127	1,862	585	87	-				32,963	8	5
2028-29	66,268	259		10,151	1,907	586	91	-				35,376	8	5
2029-30	67,100	261		10,177	1,951	588	94	-				37,802	8	5
2030-31	67,932	264		10,203	1,996	589	98	-				40,214	8	5

Res – Residential, Com – Commercial, Sub – Subdivision, EG – Embedded Generation
Columns in grey indicate no historical existing connections were reported in PWC's RIN response, and hence no gross connections forecast
Light green cells represent the historical data values
Source: Energeia, PWC

Table ES2 – Historical and Forecast New Connections by Connection Type

Financial Year	Res - Simple LV	Res - Complex LV	Res - Complex HV	Com - Simple LV	Com - Complex LV (minor HV)	Com - Complex LV (upstream)	Com - Complex HV	Com - Complex Sub-transm.	Sub - Complex LV	Sub - Complex HV (no upstream)	Sub - Complex HV (with upstream)	EG - Simple LV	EG – Complex HV (small capacity)	EG - Complex HV (large capacity)
2017-18	201	2	8	30	40	-	-	-	394	12	-	1,998	-	-
2018-19	266	1	9	56	42	1	1	-	310	5	2	2,609	-	-
2019-20	95	7	12	9	25	4	2	-	249	4	2	3,328	-	5
2020-21	187	8	3	16	19	5	2	-	276	2	1	1,895	-	5
2021-22	202	8	3	22	17	2	2	-	310	2	1	2,774	-	5
2022-23	217	8	3	25	16	2	3	-	310	2	1	2,909	-	5
2023-24	232	8	3	27	14	2	3	-	310	2	1	3,050	-	5
2024-25	247	8	3	29	13	2	3	-	310	2	1	3,198	-	5
2025-26	261	8	3	32	11	2	3	-	310	2	1	3,350	-	5
2026-27	276	8	3	34	10	2	4	-	310	2	1	3,507	-	5
2027-28	291	8	3	36	8	2	4	-	310	2	1	3,668	-	5
2028-29	306	8	3	39	7	2	4	-	310	2	1	3,830	-	5
2029-30	321	8	3	42	5	2	5	-	310	2	1	3,993	-	5
2030-31	336	8	3	44	3	2	5	-	310	2	1	4,155	-	5

Res – Residential, Com – Commercial, Sub – Subdivision, EG – Embedded Generation
Columns in grey indicate no historical new connections were reported in PWC's RIN response, and hence no gross connections forecast
Light green cells represent the historical data values
Source: Energeia, PWC

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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 Power and Water Corporation, 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, with the exception of the Australian Energy Regulator, should use or rely on the report for any purpose.

For further information, please contact:

Energeia Pty Ltd
Level 1, 1 Sussex St
Barangaroo NSW 2000

T: +61 (0)2 8097 0070
E: info@energeia.com.au W: www.energeia.com.au

1. Background

Power and Water Corporation (PWC) is obligated under the National Electricity Law and National Electricity Rules as in force in the Northern Territory (NEL and NT NER) to base its forecast capital (capex) and operating (opex) expenditure in its building blocks proposal on the levels required to meet or manage demand for standard control services over the period.[9] The NT NER further requires that the Australian Energy Regulator (AER) accept these forecasts if they reasonably reflect a realistic expectation of demand.[10]

This section details the key regulatory and business requirements for producing fit-for-purpose consumer and embedded generator connection forecasts, including a summary of Australian distribution network service provider (DNSP) methodologies, comparable public domain forecasting benchmarks, and insights into emerging connection forecast factors.

1.1. Key Regulatory Requirements

PWC's connection forecasts are regulated under Sections 6.5.6, 6.5.7, 6.18.5 and 6.18.7 of the NT NER, covering their role in producing capex and opex forecasts, setting optimal network prices for retail customers and populating the Reset Regulatory Information Notice (RIN).

1.2. Capex and Opex Forecasts

The NT NER Sections 6.5.6 and 6.5.7[9,10,11] cover the key requirements of capital and operating expenditure forecasts. As connection forecasts are an input into capex and opex estimations, these rules directly apply to connection forecasting. The relevant rules are as follows:

> *(a) A building block proposal must include the total forecast capital/operating expenditure for the relevant regulatory control period which the Distribution Network Service Provider considers is required in order to achieve each of the following (the capital/operating expenditure objectives):*
>
> > *(1) meet or manage the expected demand for standard control services over that period;*
>
> *…*
>
> *(b) The forecast of required capital/operating expenditure of a Distribution Network Service Provider that is included in a building block proposal must:*
>
> > *(1) comply with the requirements of any relevant regulatory information instrument[12];*
>
> *…*
>
> *(e) The AER must:*
>
> > *(1) subject to subparagraphs (c)(2), accept the forecast of required capital/operating expenditure of a Distribution Network Service Provider that is included in a building block proposal if the AER is satisfied that the total of the forecast capital/operating expenditure for the regulatory control period reasonably reflects each of the following (the capital/operating expenditure criteria):*
> >
> > > *…*

[9] National Electricity Rules As in force in the Northern Territory Version 96 Sections 6.5.6(a)(1), 6.5.7(a)(1)

[10] Ibid. 6.5.6(c)(3), 6.5.7(c)(1)(iii)

[11] Ibid. 6.5.6(b)(1), 6.5.7(b)(1)

[12] The definition of regulatory information instrument includes RINs, as stated in the NEL Glossary

(iii) a realistic expectation of the demand forecast and cost inputs required to achieve the capital/operating expenditure objectives.

These rules require that connection forecasts should provide an accurate outlook of connection volumes. The forecasts should therefore accurately reflect the trends of expected connection drivers whilst respecting the relevant connection history.

1.3. Network Pricing Principles

Section 6.18.5 of the NT NER also require that tariffs recover the target revenue while minimising the impact on the consumer[13]:

(g) The revenue expected to be recovered from each tariff must:

(1) reflect the Distribution Network Service Provider's total efficient costs of serving the retail customers that are assigned to that tariff;

(2) when summed with the revenue expected to be received from all other tariffs, permit the Distribution Network Service Provider to recover the expected revenue for the relevant services in accordance with the applicable distribution determination for the Distribution Network Service Provider;

…

(h) A Distribution Network Service Provider must consider the impact on retail customers of changes in tariffs from the previous regulatory year and may vary tariffs from those that comply with paragraphs (e) to (g) to the extent the Distribution Network Service Provider considers reasonably necessary having regard to:

(1) the desirability for tariffs to comply with the pricing principles referred to in paragraphs (f) and (g), albeit after a reasonable period of transition (which may extend over more than one regulatory control period);

(2) the extent to which retail customers can choose the tariff to which they are assigned; and

(3) the extent to which retail customers are able to mitigate the impact of changes in tariffs through their decisions about usage of services.

In order to meet the requirement of the NT NER, PWC must set prices that recover revenue, while managing impact on customers. This is achieved through developing accurate forecasts of the expected need for services on the network, where connection forecasts are one of the key inputs. With accurate foundational forecasts, this ensures customer impacts are accurately predicted and managed.

The NT NER Section 6.18.7 further outlines pricing principles of recovering revenue[14]. The regulation requires that networks aim to accurately meet the actual revenue received to the target:

(b) The amount to be passed on to retail customers for a particular regulatory year must not exceed the estimated amount of the designated pricing proposal charges adjusted for over or under recovery

(c) The over and under recovery amount must be calculated in a way that:

(1) subject to subparagraphs (2) and (3) below, is consistent with the method determined by the AER in the relevant distribution determination for the Distribution Network Service Provider;

(2) ensures a Distribution Network Service Provider is able to recover from retail customers no more and no less than the designated pricing proposal charges it incurs; and

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[13] National Electricity Rules As in force in the Northern Territory Version 96 Sections 6.18.5(g)(1,2), 6.18.5(h)(1,2,3)

[14] Ibid. 6.18.7(b), 6.18.7(c)(1,2,3)

(3) *adjusts for an appropriate cost of capital that is consistent with the allowed rate of return used in the relevant distribution determination for the relevant regulatory year.*

Accurate connection forecasts are required to collect the correct revenue in each year. This will meet the aims of the NT NER by minimising the impacts on annual revenues recovered through the over and under recovery process.

1.4. Regulatory Information Notices

The Australian Energy Regulator (AER) collects information from DNSPs through Regulatory Information Notices (RINs) during regulatory determinations and for performance reporting. The Reset RIN requires forecast connection numbers.[15] Section 28D of the NEL[16] details the obligation DNSPs have to provide data requested in RINs, stating:

> *A regulatory information notice is a notice prepared and served by the AER in accordance with this Division that requires the regulated network service provider, or a related provider, named in the notice to do either or both of the following:*
>
> > *(a) provide to the AER the information specified in the notice;*
> >
> > *(b) prepare, maintain or keep information specified in the notice in a manner and form specified in the notice.*

Connection forecasts requested in the Reset RIN must therefore be provided in the format specified, which are shown in Table 1 for this regulatory reset.

Table 1 – List of Connection Types by Class

Class	Type
RESIDENTIAL	Simple connection LV
	Complex connection LV
	Complex connection HV
COMMERCIAL/INDUSTRIAL	Simple connection LV
	Complex connection HV (customer connected at LV, minor HV works)
	Complex connection HV (customer connected at LV, upstream asset works)
	Complex connection HV (customer connected at HV)
	Complex connection sub-transmission
SUBDIVISION	Complex connection LV
	Complex connection HV (no upstream asset works)
	Complex connection HV (with upstream asset works)
EMBEDDED GENERATION	Simple connection LV
	Complex connection HV (small capacity)
	Complex connection HV (large capacity)

Source: Energeia, PWC

[15] AER, Explanatory statement – Final regulatory information notices to collect information for category analysis, 2014

[16] National Electricity (South Australia) Act 1996, Section 28D

1.5. Best Practice Forecasting Guidelines

Although they are developed for the Australian Energy Market Operator in their role as the developer of the Integration System Plan (ISP) and not for a Distribution Network Service Provider (DNSP) such as PWC, the AER's Best Practice Forecasting Guidelines (the Guidelines) provide insight into the AER's view on best practice forecasting methods. Under the NT NER[17], the Guidelines must reflect the following key principles:

1. Forecasts should be as accurate as possible, based on comprehensive information and prepared in an unbiased fashion.
2. The basic inputs, assumptions and methodology that underpin forecasts should be disclosed.
3. Stakeholders should have as much opportunity to engage as is practicable.

Connection forecasts that comply with the above best practices are more realistically likely to occur than those that do not, as required by the NT NER Sections 6.5.6(c)(3) and 6.5.7(c)(1)(iii) .

1.6. Business Requirements

Energeia worked with PWC to identify the key business requirements for a range of forecasts, including the connection forecasts that pertain to this report. Table 2 reports on the forecasts PWC needs by business function and highlights that connections forecasts are a key input to a wide range of core business functions.

Table 2 – PWC Business Requirements by Forecast Type

Function	New Connect-ions	Total Connect-ions	Spatial Max Demand	Spatial Min Demand	System Max Demand	System Min Demand	Sales (MWhs)	Solar PV	Batteries	EV Charging Impacts
Regulation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pricing	✓	✓	✓	✓	✓	✓	✓			
Finance	✓	✓			✓	✓	✓			
Network Planning	✓	✓	✓	✓				✓	✓	✓
Metering	✓							✓	✓	
Demand Management	✓	✓	✓	✓				✓	✓	✓
Supply Chain	✓	✓	✓	✓				✓	✓	✓
System Planning	✓	✓			✓	✓	✓	✓	✓	✓

Source: Energeia, PWC
Note: Purple indicates the connection forecast covered in this report

[17] National Electricity Rules As in force in the Northern Territory Version 96 Clause 4A.B.5(b)

As Table 3 summarises, PWC's customer connection forecasts are used for planning at different levels within the network. The business requires ten-year forecasts, which are longer than required for the Reset RIN response. The connection forecasts contained in this report are therefore 10-years in duration.

Table 3 – Power and Water Business Requirements for Forecasting

Forecast	Period	Purpose
Region	10* years	Overall demand, based on economic considerations, for comparison with corporate forecasts and lower-level forecasts.
Sub transmission substations (132/66 kV or 66/22 kV or 66/11 kV), transmission connected customers and generators		To plan the development of the transmission network and existing and new transmission connected substations.
Zone and Modular substations (132/22 kV or 66/22 kV or 66/11 kV)	10* years	To plan the development of the sub transmission network and existing and new sub transmission connected zone substations.
High Voltage Distribution Feeders (22 or 11 kV)		To plan the development of the High Voltage network.
Customer connections (all voltages)		Both above

Source: Energeia, PWC
*Note: Current year plus. i.e., equals 1+10; purple indicates the connection forecasts covered in this report

1.7. Industry Practice

Energeia carried out a review of over 53 documents from the Australian Energy Market Operator (AEMO) and Australian DNSPs on their network forecasting methodologies, which included connection forecasting. This was completed to ensure that the connection forecasting methodology selected for this project considered best practice and previous regulator feedback. This section summarises the findings of this review.

1.7.1. AEMO Forecasting Practice

Energeia reviewed AEMO's connection forecasting methodology[18], which is based on a building stock model. The forecast method can be summarised as follows:

- **First four forecast years** – Forecast based on a trend of National Meter Identifier (NMI) connections, but transitions on a 0-100% sliding scale in the first four years of the forecast to using Australian Bureau of Statistics (ABS) household projections.
- **Fifth forecast year and onward** – Forecast entirely from the ABS household projections.

1.7.2. Industry Forecasting Assessment

Energeia identified industry best practice from a review of Australian DNSP connection forecasts and benchmarking approaches across a number of key forecasting factors, including:

- **Forecasting Methodology** – Methodology employed, e.g. trending / projection, averaging, regression, logit or probit models, machine learning, etc.
- **Outputs** – Forecast outputs and any methods used to map them to RIN inputs.
- **Drivers Used** – Key inputs used to produce the forecasts.
- **Years of History Used** – Years of historical data used to produce forecasts.

The detailed results of our benchmarking are presented in Appendix B – Industry Practice.

Energeia's research found that the industry most frequently used trends and/or projections (including AEMO) to forecast connections. Regressions are also common, as is the tendency to treat low-volume (and generally large) customer connections differently to the rest. Building stock/construction activity and population were the most common drivers used to forecast connections, followed by economic indicators – most commonly Gross State Product (GSP).

Energeia considered the above key findings when developing and implementing a best practice, fit-for-purpose connection forecasting methodology for PWC.

1.8. Public Benchmarks

Energeia was not aware of any external gross or new consumer connections forecasts that have been conducted for PWC's network that could be relevant for comparison at the time of the analysis. However, whilst not explicitly an embedded generation connections forecast, the NT Utilities Commission has produced a forecast of cumulative solar PV capacity[19], which Energeia took as a point of comparison for validating the solar PV uptake model used to produce the embedded generation forecast, as shown in Section 5.2.1.

[18] AEMO, Forecast Approach – Electricity Demand Forecasting Methodology (2021)

[19] Utilities Commission, 2021 NT Electricity Outlook Report, 2022

1.9. *Rapidly Evolving and Newly Emerging Factors*

Rapidly evolving and newly emerging factors can lead to existing public forecasting benchmarks and methods used by industry becoming rapidly out of date. Energeia therefore reviewed the latest forecasting literature in combination with its own subject matter expertise to identify key factors requiring special attention.

Key factors expected to impact on PWC's connections forecasts include COVID-19, due to its impact on population and GSP, and the rising financial attractiveness of rooftop solar PV systems, which impact on rates of new generator connections. Importantly, neither of these factors are suitable for typical regression-based modelling due to their non-linear patterns.

1.9.1. COVID-19

The global pandemic has impacted international and domestic economies and societal behaviours significantly[20], including demand for electricity[21]. Uncertainty remains concerning how permanent behavioural shifts will be, and the extent to which demand will return to pre-pandemic dynamics. This adds an additional challenge to long-term connection forecasting.

In particular, connection drivers were all likely to be impacted by COVID-19, which can impact the forecasts produced using regression methods. Generally, COVID-19 had a negative-growth impact on connection drivers, reducing the number of new connections per year. Some key drivers that Energeia considered, such as population and GSP, were forecast to account for COVID-19 impacts, which would feed through to our forecast outcomes.

1.9.2. Rooftop Solar PV

Rooftop solar PV installations in the NT have grown significantly and are expected continue to grow into the future[22]. This will reduce household consumption and increase excess generation exported to the grid. This directly increases the number of embedded generation connections in PWC's network, including upgrades to metering required to support solar PV systems.

Energeia forecast solar PV uptake, and resulting embedded generation connections, separately from the other connection types – using the methodology outlined in Section 3.1.2.

[20] ABS, Effects of COVID-19 strains on Australian Economy, 2022

[21] AER, State of The Energy Market 2021

[22] AEMO, 2022 Integrated System Plan Inputs and Assumptions, 2021

2. Scope and Approach

PWC engaged Energeia to develop new consumer and embedded generator connection forecasts on a gross basis that would be accepted by the AER and fit for purpose, to be factored into its:

- capex and opex forecasts in its Initial Regulatory Proposal (IRP);
- the network prices contained in its Tariff Structure Statement (TSS);
- the new connections in its Reset Regulatory Information Notice[23] (Rest RIN) submission; and
- sundry other business activities.[24]

The forecasts were to provide a 10-year outlook to reach the 2030-31 financial year, from the most recent year of historical response data (i.e., the 2020-21 financial year). The RIN connection categories are listed in Table 4.

Table 4 – RIN Connection Categories

Class	Type
RESIDENTIAL	Simple connection LV
	Complex connection LV
	Complex connection HV
COMMERCIAL/ INDUSTRIAL	Simple connection LV
	Complex connection HV (customer connected at LV, minor HV works)
	Complex connection HV (customer connected at LV, upstream asset works)
	Complex connection HV (customer connected at HV)
	Complex connection sub-transmission
SUBDIVISION	Complex connection LV
	Complex connection HV (no upstream asset works)
	Complex connection HV (with upstream asset works)
EMBEDDED GENERATION	Simple connection LV
	Complex connection HV (small capacity)
	Complex connection HV (large capacity)

Source: Energeia, PWC

Items in grey were excluded from gross connection forecasting as they contained a very small number of (< 10), or no, historic connections and were deemed to be inappropriate for analysis.

To ensure forecasts are repeatable, withstand regulatory scrutiny and reflect industry best practice and AER best practice guidelines, this report also documents the methodology and key inputs and assumptions used.

[23] National Electricity (South Australia) Act 1996, Section 28D

[24] See Section 0

Energeia developed the following approach to meet the project objectives:

1. **Document Requirements** – Energeia reviewed the regulatory framework, recent regulatory determinations and engaged with stakeholders to define the key forecasting requirements.
2. **Identify Industry Best Practices** – Energeia benchmarked peer-DNSP forecasting methodologies from recent regulatory cycles to identify industry best practices.
3. **Develop Methodology** – Based on the outcomes from steps 1 and 2, Energeia developed a best practice, fit-for-purpose procedure for producing connection forecasts.
4. **Gather Inputs** – Energeia gathered the most recent inputs from PWC, as well as a variety of external inputs from reputable sources, for use in the forecasting methodology.
5. **Forecast Connections** – Energeia produced forecasts to 2030-31 of gross and new connections by Category Analysis RIN connection type, for PWC's network.
6. **Model Validation** – Energeia worked closely with PWC subject matter experts (SMEs) to validate the methodology, inputs, and outputs of the connections forecasting model.
7. **Documentation** – Energeia documented the process, methodology, key inputs and assumptions used to produce the connection forecasts in presentation materials and this report.

3. Methodology

This section describes the forecasting methodology Energeia used to develop the consumer and embedded generator connection forecasts for PWC's three systems (Darwin-Katherine, Alice Springs and Tennant Creek), which can be summarised into the following key stages:

1. **Develop Connection Forecasting Procedure** – Energeia first developed a fit-for-purpose connection forecasting procedure that satisfied PWC's key requirements and reflected industry best practice.
2. **Data Gathering and Processing** – Energeia collected and processed the historical RIN connections data, including back-casting to extend the history where appropriate.
3. **Forecast Model Optimisation** – Energeia carried out the regression-based procedure, including identification of the optimal model parameters given fitness, sign and p-value, and running the PV uptake sub-model for embedded generation connections.
4. **Validate Optimised Results** – Energeia reviewed the technically optimised forecasts against historical trends and validated them with published forecasts[25] and PWC stakeholders prior to finalising them.

3.1. Develop Connection Forecasting Procedure

The fit-for-purpose connection procedure Energeia developed for producing best practice connections forecasts was informed by our subject matter expertise, our experience developing forecasts for other DNSPs in Australia, our in-depth technical research and industry benchmarking of PWC's peer DNSPs[26] carried out for this study, and our consideration of the data available.

3.1.1. Premise Connections

Table 5 shows the connection types considered in this section, along with a summary of the methodology used, which depended on the number of historical connections recorded in the latest RIN response.

Table 5 – Premise Connections Methodology Summary

Number of Historical Connections Recorded in RIN Response Data	Connection Type	Methodology Summary
>30 Gross Connections	Residential – Simple LV	5-year and 10-year historical regression model, with trend or average used if historical relationships were insignificant, or results did not pass sense-check
	Residential – Complex LV	
	Commercial – Simple LV	
	Commercial – Complex LV (minor HV)	
	Commercial – Complex LV (upstream)	
	Commercial – Complex HV	
	Subdivision – Complex LV	
<30 Gross Connections	Residential – Complex HV	Flat forecast set to value of most recent year of historical connection data (2021)
	Commercial – Complex Sub-transmission*	
	Subdivision – Complex HV (no upstream)	
	Subdivision – Complex HV (with upstream)	

* Note that Commercial – Complex Sub-transmission had no reported existing or new connections, resulting in a zero-connection forecast
Source: Energeia

Note the connection types with <30 recorded connections in the RIN response, as well as Subdivision – Complex LV, did not have any recorded historical existing connections, only new connections. Thus, they were only considered for the new connections forecasting, as there was no way to deduce gross connections.

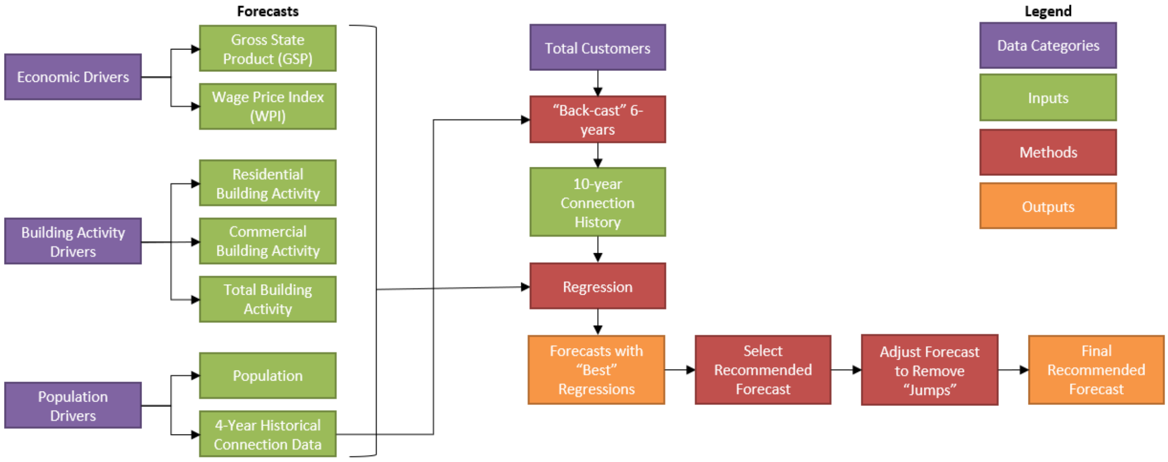
[25] Utilities Commission, 2021 NT Electricity Outlook Report, 2022

[26] See Section 1.7.2

The remaining connection types with existing connection histories used the relationship of historical new connections to historical gross connections to generate their respective new connections forecasts.

Figure 1 depicts a diagram of the regression-based procedure used to develop the gross premise connections forecasts, including the back-casting of historical connections.

Figure 1 – Gross Premise Connections Regression Methodology



Source: Energeia

In summary, a statistically-accurate historical relationship was estimated between the desired dependent variable (the connection type in need of forecasting) and a range of independent variables (uptake drivers). External forecasts of these uptake drivers were used as inputs to the regression, which output the desired connection forecast.

3.1.2. Embedded Generation Connections

Table 6 shows the connection types considered in this section, along with a summary of the methodology used, which depended on the number of historical connections recorded in the latest RIN response.

Embedded generation connections were assumed to be driven entirely by behind-the-meter solar PV, which aligns with PWC's expectations of this connection class, as outlined in Appendix C – Definitions.

Table 6 – Embedded Generation Connections Methodology Summary

Number of Historical Connections Recorded in RIN Response Data	Connection Type	Methodology Summary
>30 Gross Connections	Embedded Generation – Simple Connections LV	8-year historical regression model based on calculated first-year return-on-investment
<30 Gross Connections	Embedded Generation – Complex HV (small capacity)	Flat forecast set to value of most recent year of historical connection data (2021)
	Embedded Generation – Complex HV (large capacity)	

Source: Energeia

To forecast solar PV uptake, and hence embedded generation connections, Energeia developed a single-factor regression between historic annual uptake and first-year return on investment (ROI).[27] First-year ROI was

[27] More information regarding our solar PV forecasting methodology can be found at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/Distributed-Energy-Resources-and-Electric-Vehicle-Forecasts---Report-by-Energeia.pdf

defined as the sum of financial returns from PV ownership (including feed-in tariff revenue and electricity bill savings) as a percentage of the capital cost of the PV system, for the first year of ownership. PV uptake was defined as a percentage of remaining potential market for solar PV (i.e. installs / total PV-eligible dwellings).

As with the premise connections, forecast gross connections was used to forecast new connections based on their historical relationship.

3.2. Data Gathering and Processing

Energeia collected the latest available connection data from historic RINs and back-casted it where necessary per the methodology reported in Section 3.1 to extend the years of historical gross connections available.

Table 7 details the RIN connection data gathered.

Table 7 – Connection Data Sources

Data Type	Data Description	Source	Start/End Year
Historical Existing PWC Customer Connections	Annual reported existing connections by connection type (E.g., Simple Connection LV)	PWC 2020-21 Category Analysis RIN - Templates	FY18 – FY21
Historical New PWC Customer Connections	Annual reported new connections by connection type (E.g., Simple Connection LV)		FY14 – FY21

Source: Energeia

3.2.1. Back-Casting

The RIN response connection data contained only four years of recorded history for gross connections. To provide an extended history that could improve the results of regression-based forecasting methods, Energeia back-casted the historical gross connections to 2010-11.

To do this, Energeia used the ratio between historical distribution customer numbers – separated into residential and commercial customer totals – and recorded four years historic gross connections, to estimate an extended history of gross connections using the actual records of historical customer numbers.

3.3. Forecast Model Optimisation

The resulting gross connection histories were used in their respective multi-factor regression and PV uptake models, to forecast premise and embedded generation gross connection. The data history length and variables used in these models were chosen to provide an unbiased, reasonable, and accurate forecast.

The following sections detail our approach to optimising the regression model used to product gross connection forecasts for premises and embedded generators. Optimised in this context refers to the selection of the most appropriate forecasting method, and the most appropriate inputs to the given method, including factor selection and length of history considered.

3.3.1. Premise Connections

Model Overview

All regression drivers identified by Energeia's best practice review and desktop research were considered as potential independent variables into single and two-factor regression models. Each variable was assessed to determine its regression statistics and to identify the most statistically significant regression approach with the correct signs and lowest p-values.

External forecasts of the independent variables selected as part of the optimised regression model were used as inputs into the regression to forecast gross connections

Both 5 and 10-year annual input data regression models were considered, with up to two independent variables. In addition to these regressions, simple linear trends (5 and 10-year) were considered to cover instances where regression results were statistically insignificant or deemed unsuitable based on subject matter expertise. If the trends were still not reasonable, then an average was used – which applied a constant forecast based on a 5-year average.

Data History

The combined reported actuals and back-casted history allowed Energeia to produce regressions using both 5-years and 10-years of history. 10-year models reflect a history comparable to the forecast horizon, potentially capturing longer-term factors, which could be out of date. 5-year models more heavily weight near-term factors, including solar PV, but also factors like COVID, which may not persist.

Number of Independent Variables

Seven potential independent variables were ultimately considered to drive regressions, with up to two variables per regression model. Energeia chose to test no more than two independent variables to avoid overfitting and potential multicollinearity issues, based on experience developing regression-based forecasts for other DNSPs and TNSPs.

Independent Variables (Drivers)

Table 8 lists the independent variables tested in the regression analysis by category and their definitions. Energeia used a variety of categories to cover a reasonably broad range of potential connection drivers, without biasing a particular category, e.g., having only economic indicators drive the regression.

Table 8 – Regression Independent Variables, Categories and Definitions

Category	Independent Variable	Definition
Population	Population	Total number of people in the NT
	Lagged (N-1) Connections	The previous year of annual connection volume
Economic	Gross State Product (GSP)	Monetary metric of the total value added across all industries in the NT
	Wage Price Index (WPI)	Measure of the price of labour in the NT, unaffected by changes in labour force, hours worked or employee characteristics
Building	Cumulative Residential Building Activity	Monetary measure of the total value of residential building work done in the NT
	Cumulative Commercial Building Activity	Monetary measure of the total value of commercial building work done in the NT
	Total Cumulative Building Activity	Monetary measure of the total value of building work done in the NT

Source: Energeia

Selection of Optimal Gross Connection Forecast

Six potential forecasts arose from the set of tested regressions and trends, which were as follows:

- 5-Year History, Single Variable Regression
- 5-Year History, Two Variable Regression
- 5-Year History, Trended
- 10-Year History, Single Variable Regression
- 10-Year History, Two Variable Regression
- 10-Year History, Trended

Regression forecasts were prioritised over trend forecasts as being better able to reflect changes in forecast conditions, however, trends were used if the regression models were inadequate, which occurred when:

- Factor P-values were above >0.05, which is considered statistically insignificant
- R^2 was too low (<0.9)
- Factor coefficients were the wrong sign. This occurred when an inverse to the expected relationship was found, e.g., it is unreasonable to have increasing population drive decreasing connections.
- Forecasts did not pass an expert sense check. Where the forecast produced unreasonable results, which was validated with PWC stakeholders, it was not selected.

Where linear trends did not pass a sense-check, a 5-year average trend was used as a final methodology, i.e. the average growth rate over 5-years of history was applied to the forecast period.

Alignment of Forecast to Final Historical Datapoint

After selecting the recommended forecast, an adjustment was made to align the first year of the forecast with the last year of history to avoid unreasonable jumps up or down.

To do this, the final historical year of gross connections (2021) was forecast using the model and compared to the actual historical datapoint, with the difference between the two used as a constant to adjust all future forecast years. Cases where the average trend was chosen excludes this step.

3.3.2. Embedded Generation Connections

The methodology used for embedded generation forecasting differed to the methodology used in premise connection forecasting due to solar PV adoption being identified as a rapidly evolving, recently emerging factor. Energeia instead applied its regression-based ROI forecasting methodology, which has been constantly tested and refined over the last ten years, including for AEMO[28] as part of the ISP.

Model Overview

Historical annual uptake (the dependent variable) was taken from the RIN response data for embedded generation new connections and first-year ROI (the independent variable) was calculated from a set of economic and customer load drivers.

Forecasts of each of the economic and load drivers were used to calculate a forecast of first-year ROI[29], which in turn, were used as inputs in the regression model to output the PV uptake forecast.

Data History Length

The complete 8 years of historical new embedded generation connections from the Category Analysis RIN response were used to generate the strongest statistical relationship available.

[28] Found at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/Distributed-Energy-Resources-and-Electric-Vehicle-Forecasts---Report-by-Energeia.pdf

[29] First year ROI is comparable to a payback metric, which is typically used by residents, who represent the largest connection segment.

Variables for Calculating First-Year ROI

First-year ROI was calculated for each customer type using the economic and load drivers defined in Table 9.

Table 9 – Definitions of Variables Used to Calculate First-Year ROI

ROI Calculation Variable	Definition
Retail Electricity Price ($/kWh)	The retail price that customers pay for consumed electricity
Solar PV System Price ($/MW)	Total upfront cost of PV system
Feed-in Tariff (FiT) Rate ($/kWh)	The price that PV owners are paid for their exported PV generation
Average PV System Size (kW)	The average capacity of a PV system for a single customer
Average Customer Consumption Profile (kW)	Daily electricity demand profile for the average customer
Solar Generation Profile (kW)	The typical solar generation profile for a rooftop PV installation

Source: Energeia

First-Year ROI Calculation

The following equation describes how the above variables were used to calculate first-year ROI:

$$First\text{–}Year\ ROI = \frac{First\text{–}Year\ Electricity\ Bill\ Savings\ (\$) + First\text{–}Year\ FiT\ Revenue\ (\$)}{PV\ System\ Price\ \left(\frac{\$}{kW}\right) \times Average\ PV\ System\ Size\ (kW)}$$

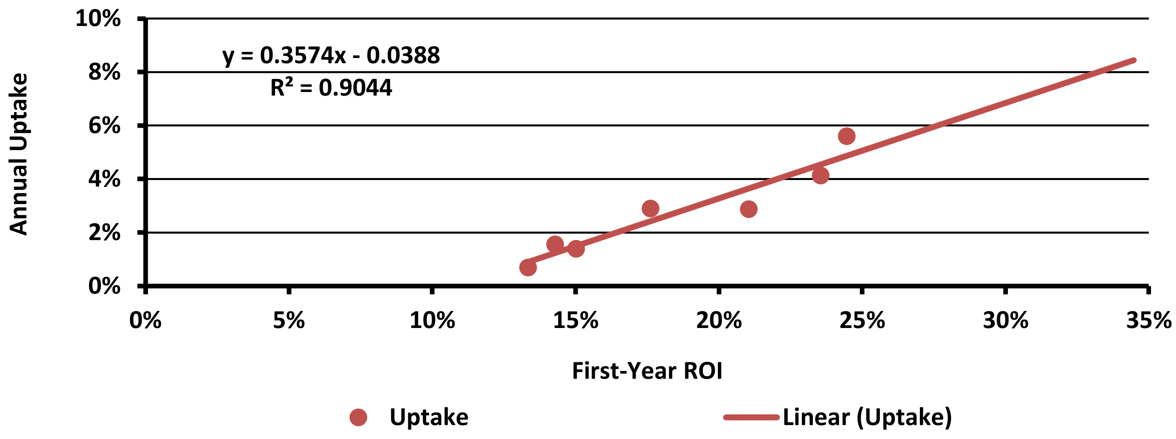
$$\begin{aligned} where, \quad & First\text{–}Year\ Electricity\ Bill\ Savings\ (\$) \\ & = First\text{–}Year\ Exported\ PV\ Generation\ (kWh/kW) \times Average\ PV\ System\ Size\ (kW) \\ & \times Electricity\ Price\ \left(\frac{\$}{kWh}\right) \end{aligned}$$

$$\begin{aligned} and, \quad & First\text{–}Year\ FiT\ Revenue\ (\$) \\ & = First\text{–}Year\ Exported\ PV\ Generation\ \left(\frac{kWh}{kW}\right) \times Average\ PV\ System\ Size\ (kW) \\ & \times FiT\ Rate\ \left(\frac{\$}{kWh}\right) \end{aligned}$$

Historical First-Year ROI and Solar PV Uptake Relationship

Figure 2 shows the statistical relationship found between historical annual solar PV uptake and first-year ROI. This was used to calculate forecast solar PV uptake by substituting forecast first-year ROI. The results show that ROI has a strong relationship with solar PV uptake, hence is appropriate to use as a forecast driver.

Figure 2 – Historical Statistical Relationship Between Annual Solar PV Uptake and First-Year ROI



Source: PWC, Energeia

3.3.3. New Connection Conversion

To determine new connections, Energeia used a simple linear regression of historical gross and new connections from the latest RIN to produce a new connection forecast from a gross connection forecast.

Using a methodology identical to that for gross connections, the new connections forecasts were aligned to the final historical datapoint to prevent unwanted jumps.

Premise connection types that had <30 historical gross connections did not have any historical existing connection history (i.e., only a history of new connections). The forecast for these connection types were only considered as new connections and this conversion was not applicable.

Additionally, the Subdivision – Complex Connection LV connection type was a unique instance where there was no reported history of existing connections, but the reported historical new connections were >30. As a result, the connection type was treated with the full regression analysis methodology used for gross connections, but the resulting gross connection forecast is essentially the new connection forecast – making this conversion inapplicable.

3.4. Validate Optimised Results

Energeia engaged PWC stakeholders throughout the forecasting process to provide an opportunity for feedback on the validity of the recommended connection forecast methodology, inputs and assumptions and results. Additionally, to assist in the validation of the embedded generation forecasts, the solar PV uptake forecast was compared to the forecast produced in the NT Outlook Report for the Utilities Commission, shown in Section 5.2.

4. Key Inputs

This section describes the key inputs used as uptake drivers for both the premise and embedded generation connection forecasts respectively. All inputs were validated with key PWC stakeholders prior to finalisation.

4.1. Premise Connections Uptake Drivers

Table 10 shows a summary of all the premise connection uptake drivers, including their source, how they were forecasted and the years of history and forecast available.

Table 10 – Summary of Premise Connection Uptake Drivers

Driver	Source	Forecasting Summary	Years of History	Years of Forecast
N-1 Gross Connections	AER PWC RIN: https://www.aer.gov.au/networks-pipelines/performance-reporting/power-and-water-corporation-rin-responses + Energeia Connections Forecast Model	Using best performing regression using population/economic variables	N/A	N/A
Population	ABS (undated) https://dbr.abs.gov.au/ (historical) NT Treasury (2019) https://treasury.nt.gov.au/dtf/economic-group/population-projections (forecast)	Applying population growth rates based on NT Treasury projections	40+	25
Cumulative Residential Building Activity ($)	Australia Construction Industry Forum (ACIF) (2019) https://www.acif.com.au/documents/item/869	Applying growth rates based on ACIF NT building activity forecasts to 2028, with trend to 2031	40+	7
Cumulative Commercial Building Activity ($)	ACIF (2019) https://www.acif.com.au/documents/item/869	Applying growth rates based on ACIF NT building activity forecasts to 2028, with trend to 2031	40+	7
Total Cumulative Building Activity ($)	ACIF (2019) https://www.acif.com.au/documents/item/869	Sum of residential and commercial	40+	7
Gross State Product (GSP) ($)	RDA Northern Territory (2020) https://economy.id.com.au/rda-northern-territory/gross-product?WebID=150 (historical) BIS Oxford Economics (BISOE) (2020) https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/bis-oxford-economics-macroeconomic-projections.pdf?la=en (forecast)	Applying annual GSP growth rate forecasts projected by BISOE	30+	30
Wage Price Index (WPI)	ABS, Department of Treasury and Finance (undated) https://e.infogram.com/f136daf4-d710-4c22-b722-22e650873e02?src=embed	Using source for historical and forecast to 2025, applying a trend to 2030	10	4

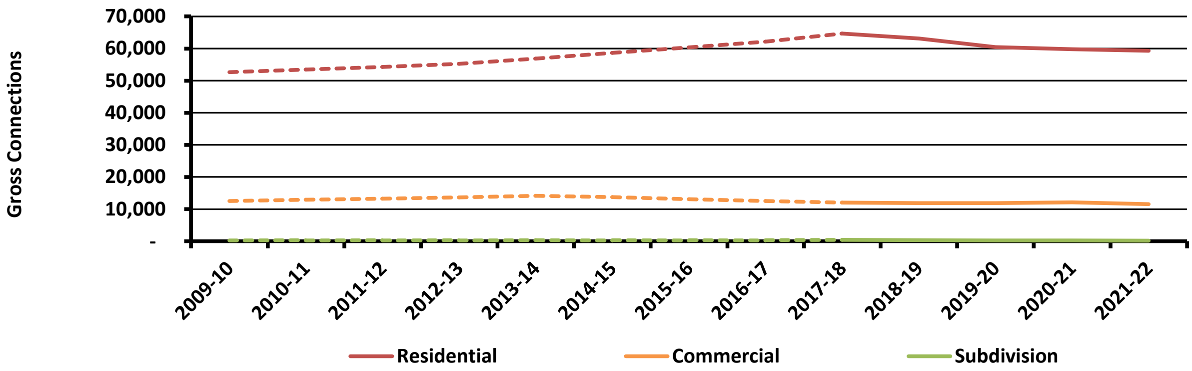
Source: Energeia

4.1.1. Premise Connection History

Figure 3 displays the historical premise connections data taken from the RIN response, as well as the back-casted history, extended using methods described in Section 3.2.1. The lagged connections (or the N-1 connections) were taken as the previous year's gross connection total and were used as a potential uptake driver variable, e.g., forecasted 2023 connections was the regression input for forecasting 2024 connections.

Historical residential and subdivision gross connections (subdivision gross connections consist entirely of new connections) fell in the past 4 years, with commercial gross connections remaining stagnant. The back-casting produced an extended history showing steadily growing residential gross connections, with commercial and subdivision gross connections rising and falling – with a peak in 2013-14.

Figure 3 – Back-cast and Historical Gross Premise Connections

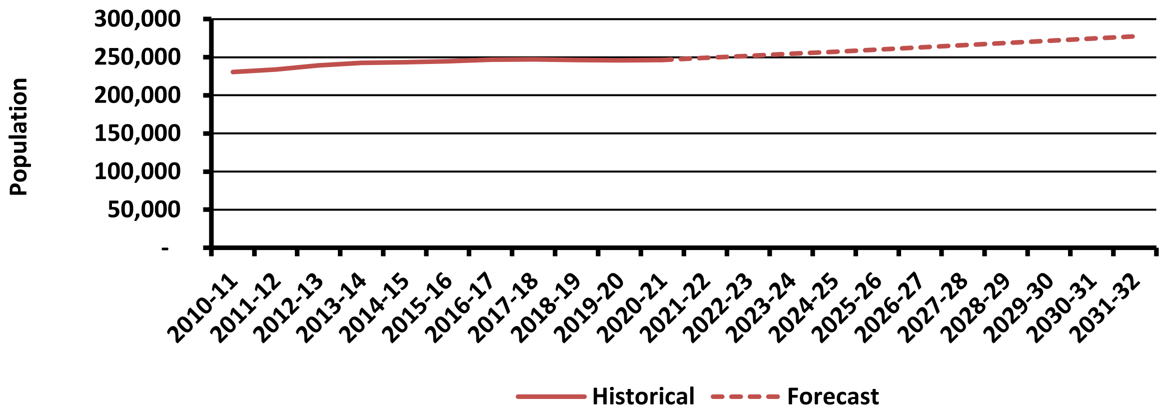


Source: Energeia Analysis, PWC Category Analysis RIN Response

4.1.2. Population

Population growth was expected to correlate with growth in connections, especially residential connections. Figure 4 displays the historical and forecast total population for the NT. Population rose steadily in the past, peaking in 2017-18 and plateauing since. The NT Government predicts a strong growth in population in their future forecasts.

Figure 4 – Historical and Forecast Total Population

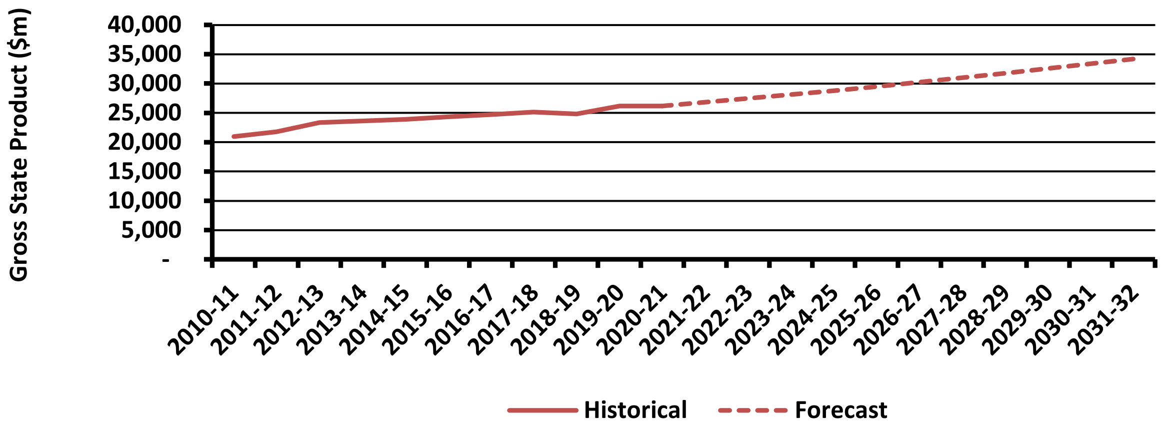


Source: Energeia Analysis, Northern Territory Government (2019)

4.1.3. GSP

GSP growth indicates increased economic activity, which is typically a key driver of non-residential connections. Figure 5 displays the historical and forecast GSP for the NT, which is an economic metric of the total value added across all industries in the NT. Historical GSP rose steadily, though plateaued during the COVID years. The BIS Oxford Economics (BISOE) forecast predicts a continuation of this trend.

Figure 5 – Historical and Forecast Gross State Product



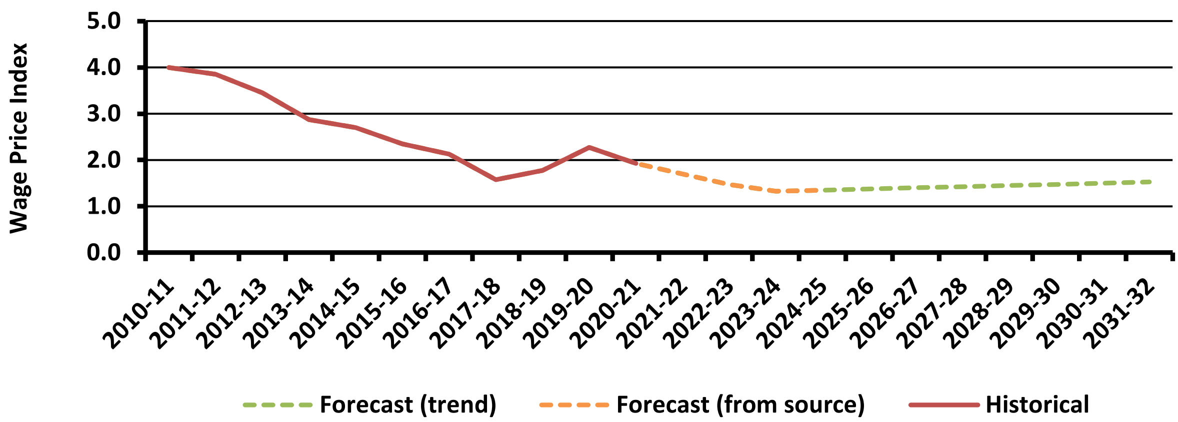
Source: ABS (2021), BIS Oxford Economics (2020)

4.1.4. WPI

Higher wages generally attracts labour, which could stimulate a growth in connections, particularly residential. Figure 6 displays historical and forecast Wage Price Index (WPI) for the NT. WPI is a measure of the price of labour in the NT, unaffected by changes in the labour force, hours worked or employee characteristics[30].

WPI fell historically, reaching a low point in 2017-18. It then rose to a peak in 2019-20 but fell again after. The forecast from the ABS predicts this recent fall to continue until 2024-25, when it rises again. Energeia has trended this rise to continue out to 2030-31.

Figure 6 – Historical and Forecast Wage Price Index



Source: ABS (2021), Energeia Analysis

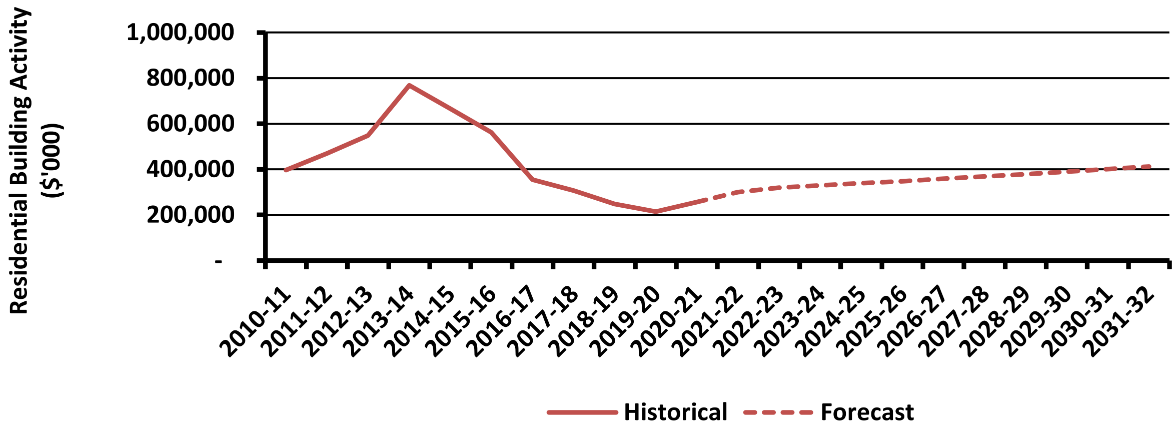
4.1.5. Building Activity

New buildings require new electrical connections. Figure 7 and Figure 8 display the historical and forecast building activity, segmented by residential and commercial building activity, respectively. Building activity is an economic measure of the total value of building work done.

[30]ABS, Wage Prince Index, Australia, from:https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/wage-price-index-australia/latest-release

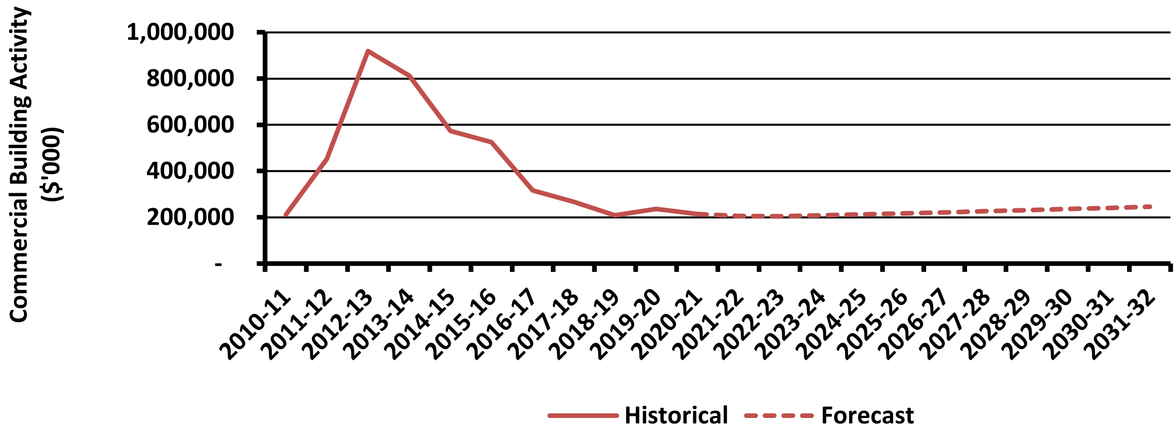
Historically, residential and commercial building activity rose sharply to peaks in 2013-14 and 2012-13, respectively. They then fell sharply, reaching plateaus in the most recent years, with residential building activity rising again. The Australia Construction Industry Forum (ACIF) forecast predicts a steady growth in residential building activity, with some continued plateauing followed by slight growth in commercial building activity.

Figure 7 – Historical and Forecast Residential Building Activity



Source: ACIF (2019), Energeia Analysis

Figure 8 – Northern Territory Historical and Forecast Commercial Building Activity



Source: ACIF (2019), Energeia Analysis

4.2. Embedded Generation Connections Uptake Drivers

Table 11 displays a summary of all the premise connection uptake drivers considered for this analysis, including their source, how they impact forecasts, and the years of history and forecast available.

Table 11 – Summary of Embedded Generation Connection Uptake Drivers

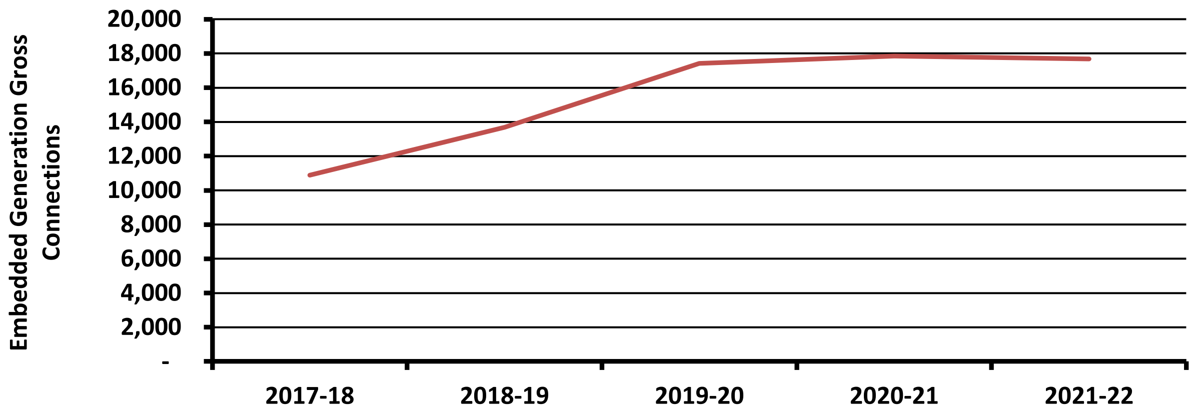
Driver	Source	Forecasting Summary	Years of History	Years of Forecast
Historical Gross Connections	AER PWC RIN: https://www.aer.gov.au/networks-pipelines/performance-reporting/power-and-water-corporation-rin-responses	N/A	4	N/A
Retail Electricity Price	Residential Electricity Price Trends Report (AEMC) (Historical) Energeia Modelling (Forecast)	Impacts potential bill savings	20+	15
Solar PV System Price	PV Panel Costs: CSIRO GenCost (https://www.csiro.au/-/media/EF/Files/GenCost2020-21_FinalReport.pdf) Inverter Costs: Solar Quotes (https://www.solarchoice.net.au/products/inverters/SMA-Inverters-Review) STC Revenue: CER	Impacts upfront cost	20	30
FiT Rate	NT Regulated FiT (NT Government Department of Trade Business and Industry https://industry.nt.gov.au/__data/assets/pdf_file/0008/811628/changes-to-feed-in-tariffs-fact-sheet.pdf) (Historical) Energeia Modelling (Forecast)	Impacts potential bill savings	10+	15
Electricity Consumption Profile	PWC Customer Sample Load Profiles	Interacts with solar profile determines bill savings via FiT vs. consumption	1	Assumed constant
Solar PV Generation Profile	NREL PVWatts	Interacts with customer consumption, determines bill savings via FiT vs. consumption	1	Assumed constant
Average System Size	PWC Annual RIN Reporting (Historical) PWC BTM PV Installation Reporting (Historical) Energeia Modelling (Forecast)	Interacts with solar profile and consumption, determines bill savings via FiT vs. consumption	8	15

Source: Energeia

4.2.1. Embedded Generation Connection History

PWC's embedded generation connection history as reported in their latest RIN was used to calculate its statistical relationship to ROI. Figure 9 displays the rise and then plateauing of embedded generation connections in recent years.

Figure 9 – Historical Embedded Generation Gross Connections



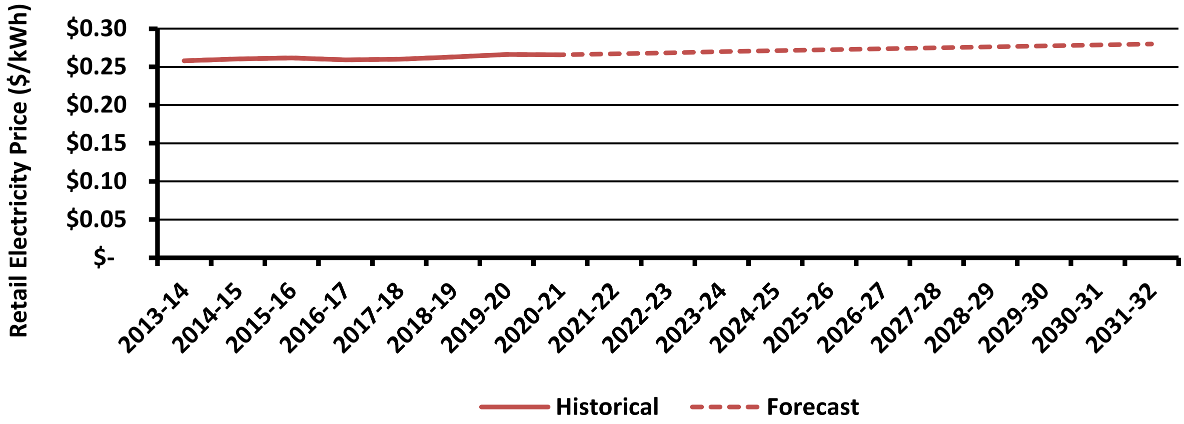
Source: PWC Category Analysis RIN Response

4.2.2. Retail Electricity Price

Figure 10 displays the historical and forecast retail electricity price used to calculate the cost of electricity, which was used to calculate a customer's avoided energy value due to rooftop PV.

Historical retail electricity prices have grown steadily. Energeia utilised a trend forecast method to extend this into the forecast years in the absence of published forecasts.

Figure 10 – Historical and Forecast Residential Retail Electricity Price



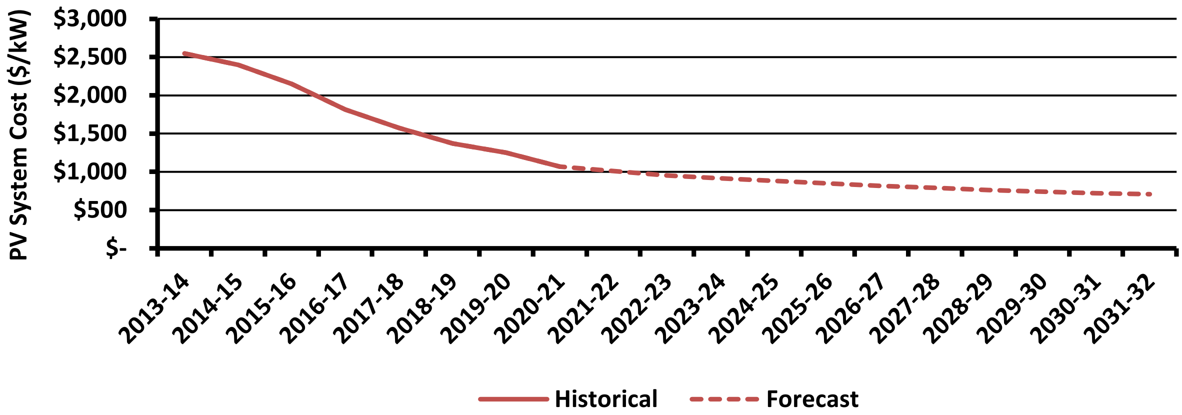
Source: AEMC, Energeia Analysis

4.2.3. Solar PV System Price

Figure 11 displays historical and forecast rooftop PV system prices, used to determine the capital costs of new installations, which is the key denominator for calculating first year ROI.

PV systems showed strong reductions in cost historically, whilst CSIRO's forecast predicts continued cost reductions but at a lower rate.

Figure 11 – Northern Territory Historical and Forecast Solar PV System Price



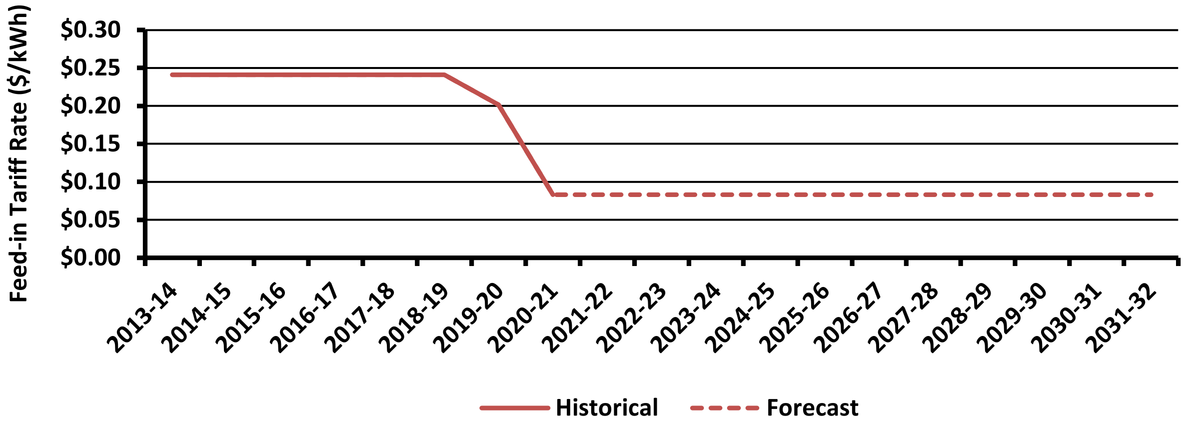
Source: CSIRO GenCost (2021), Solar Quotes (2021), Energeia Analysis

4.2.4. Feed-in Tariff Price

Figure 12 displays the historical and forecast Feed-in Tariff (FiT) rates, used to calculate the prices received by customers for exported PV electricity.

Historical FiT rate were constant for some time, before dropping rapidly in 2019-20 onward. This occurred as the NT moved away from the premium FiT which reflected the standard electricity tariff, to a rate more aligned with other jurisdictions. Energeia assumed a flat FiT price moving onward.

Figure 12 – Northern Territory Historical and Forecast Feed-in Tariff Rate



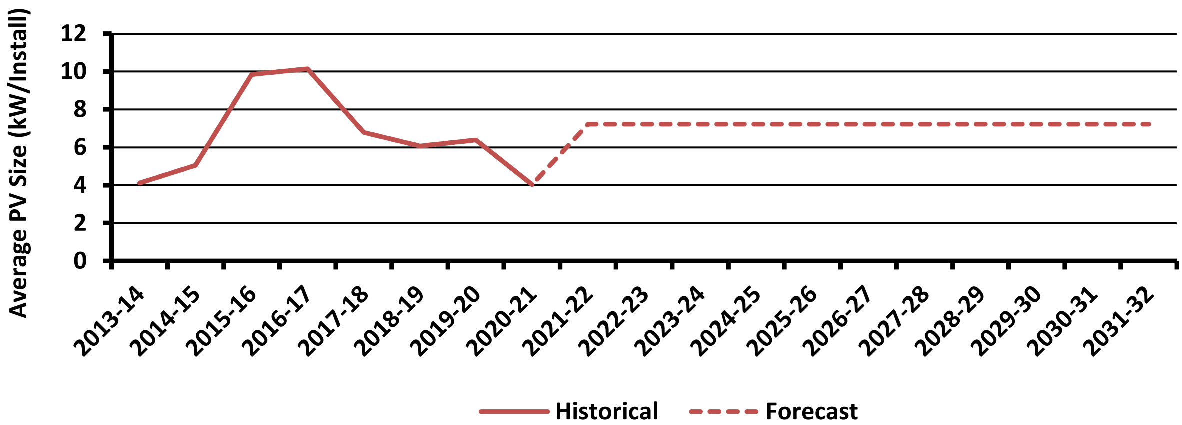
Source: NT Government (2021), Energeia Analysis

4.2.5. Average PV System Size

Figure 13 displays the historical and forecast average PV system size, which were used as the assumption for the average customer PV system size, and hence informed their exports and bill savings.

Historical PV system sizes varied each year without a clear trend. Energeia assumed that the average size of the last 6 years would remain the average for the forecasted duration period.

Figure 13 – Historical and Forecast Average PV System Size

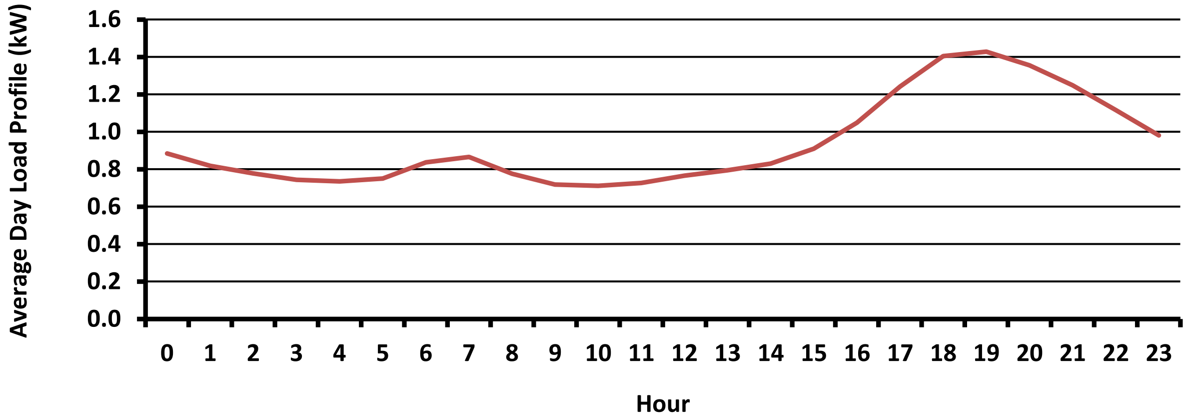


Source: PWC Category Analysis RIN Response, PWC BTM PV Installation Reporting, Energeia Analysis

4.2.6. Average Customer Consumption Profile

Figure 14 displays the average customer load profile used to model customer consumption and the electricity costs associated. Note that this was assumed constant for historical and forecast calculations.

Figure 14 – Average Customer Daily Load Profile

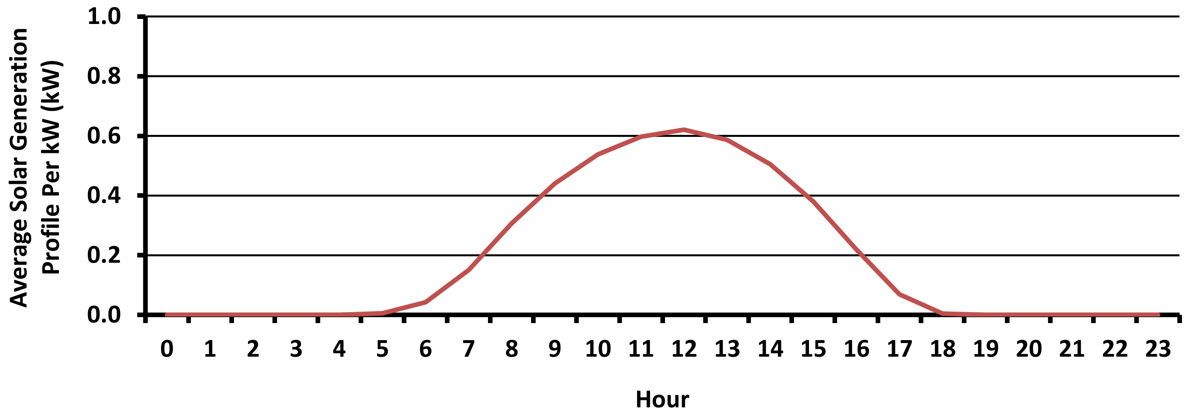


Source: PWC Sample Load Profiles, Energeia Analysis

4.2.7. Solar Generation Profile

Figure 14 displays the assumed average solar generation profile, per kW, of solar PV system installation size. This was used to model the generation profile of customer PV systems and its impact on exports and customer bill savings, via reduction of imported electricity expenditure and the addition of export revenue. Note that this was assumed to be constant for historical and forecast calculations.

Figure 15 – Northern Territory Average Solar Generation Profile, Per kW



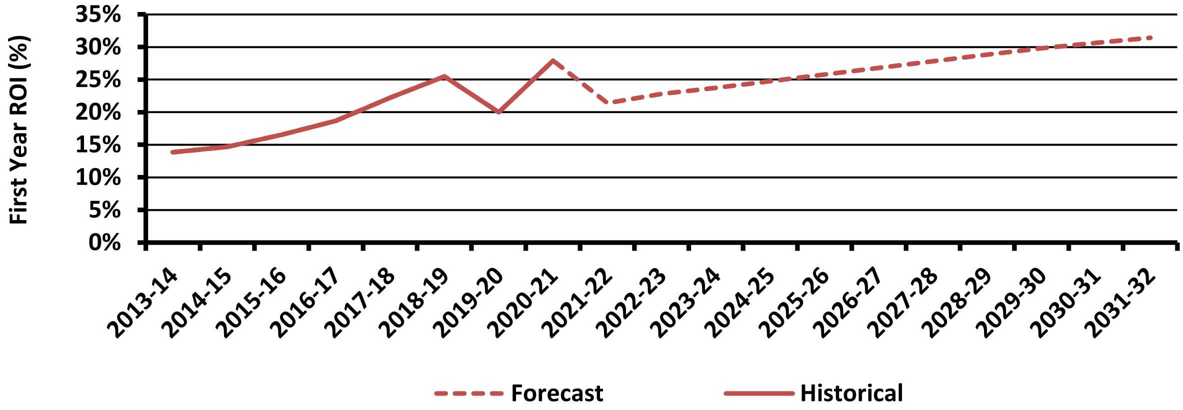
Source: NREL PVWatts, Energeia Analysis

4.2.8. First-Year ROI

Figure 16 displays the historical and forecast first-year ROI that was used to drive annual PV uptake in Energeia's model. It predicts a relatively constant upward trend surpassing 30% by 2030-31. A 30% first year ROI is almost a three-year payback, compared to the current 6 to 7-year payback of a 15% first year ROI.

The calculated historical first-year ROI fluctuates in recent historical years, primarily due to changes in the FiT rate and fluctuating average PV system sizes.

Figure 16 – Historical and Forecast First-Year Return on Investment



Source: Energeia Analysis

5. Results

This section covers the results Energeia's forecast of premise and embedded generation connections, both gross and new. Major connection types (those with >30 connections historically) are covered individually, with the other minor connection types grouped together.

5.1. Premise Connections

A summary of the optimised forecasts used for each of the major premise connection types is shown in Table 12. This includes the years of history (actual and back-casted) that were used, whether a trend or regression was used for the final result and, where applicable, the independent variables used.

See Appendix A – Gross Connections Regressions for the results of the model optimisation process resulting in these selections.

Table 12 – Forecast Method Summary by Major Premise Connection Type

Connection Type	Years of History	Trend or Regression	Regression Variables
Residential – Simple Connection LV	10	Trend	-
Residential – Complex Connection LV	10	Trend	-
Commercial – Simple Connection LV	10	Regression	Total Building Activity
Commercial – Complex Connection LV (minor HV)	5	Trend	-
Commercial – Complex Connection LV (upstream)	10	Regression	Wage Price Index, Residential Building Activity
Commercial – Complex Connection HV	10	Trend	-
Subdivision – Complex Connection LV	5	Average Trend	-

Source: Energeia

As mentioned in Section 3.1.1 the other minor connection types used a flat forecast set to the final historical year's value. These connection types are:

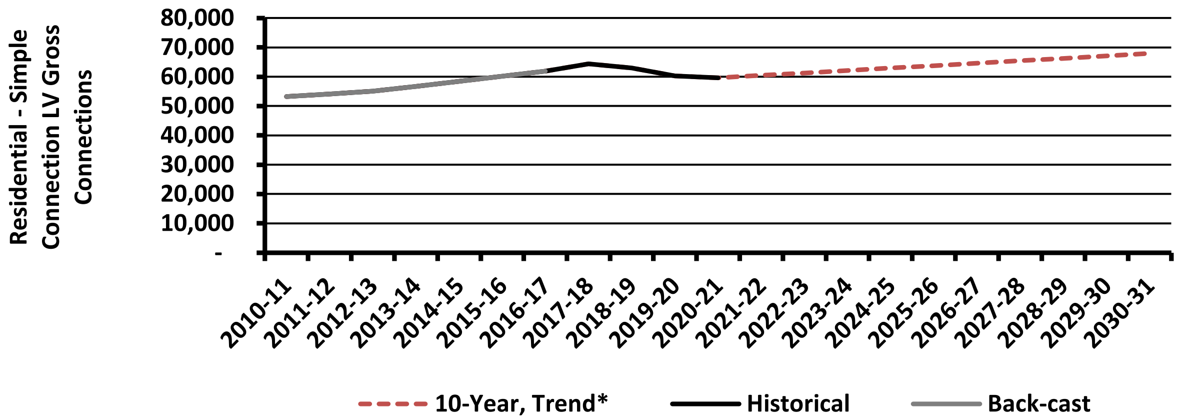
- Residential – Complex HV
- Commercial – Complex Sub-transmission
- Subdivision – Complex HV (no upstream)
- Subdivision – Complex HV (with upstream)

The following sections report on the resulting forecasts by connection type.

5.1.1. Residential – Simple LV

A 10-year trend was recommended for the Residential – Simple LV gross connection forecast, shown in Figure 17. It shows a steady growth in connections, breaking from the recent, COVID-driven fall in historical connections. It also predicts the 2017-18 historical peak to be exceeded in 2026-27, reaching 67,932 gross connections in 2030-31.

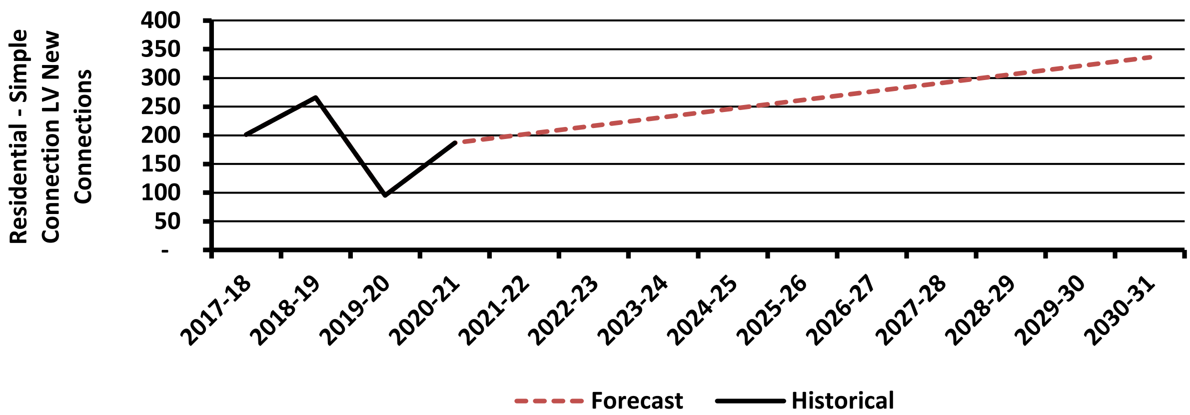
Figure 17 – Back-Cast, Historical and Forecast Residential - Simple Connection LV Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

Likewise, annual new connections are forecasted to increase steadily. As shown in Figure 18, the 2018-19 peak is exceeded in 2026-27 and predicted to reach 336 new connections in 2030-31.

Figure 18 – Historical and Forecast Residential - Simple Connection LV New Connections

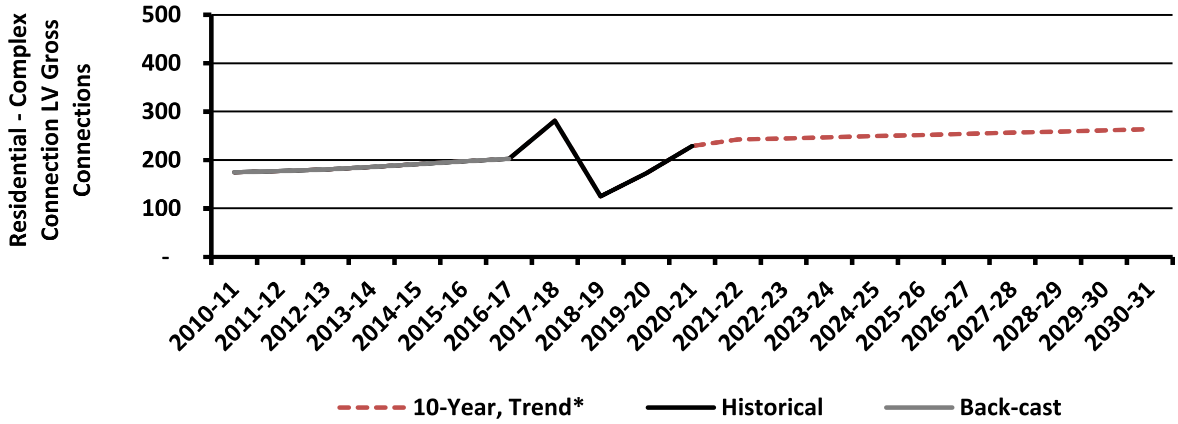


Source: Energeia Analysis, PWC Category Analysis RIN Response

5.1.2. Residential – Complex LV

A 10-year trend was recommended for the Residential – Complex LV gross connection forecast, shown in Figure 19. It predicts a slight growth in connections over time that reaches 264 gross connections in 2030-31.

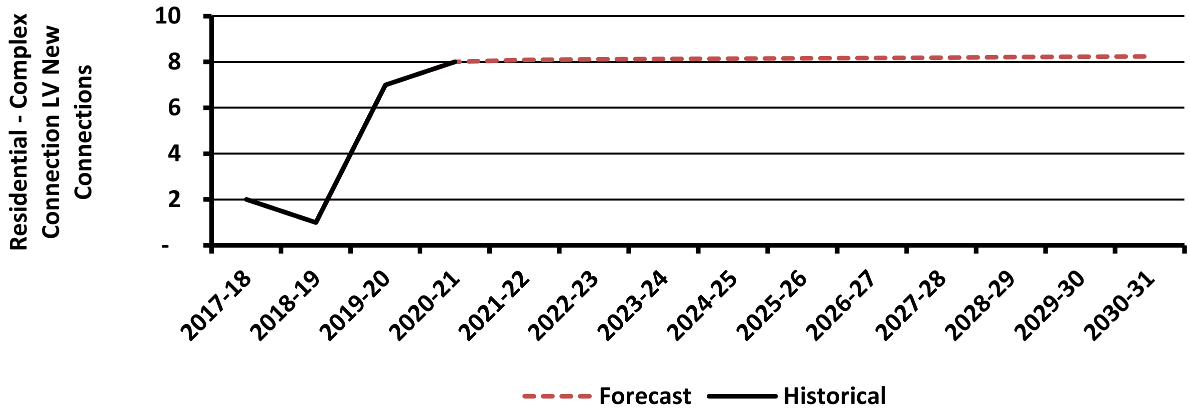
Figure 19 – Back-Cast, Historical and Forecast Residential - Complex Connection LV Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

Consequently, Figure 20 displays the forecasted annual new connections to be almost flat at 8 new connections each year.

Figure 20 – Historical and Forecast Residential – Complex Connection LV New Connections

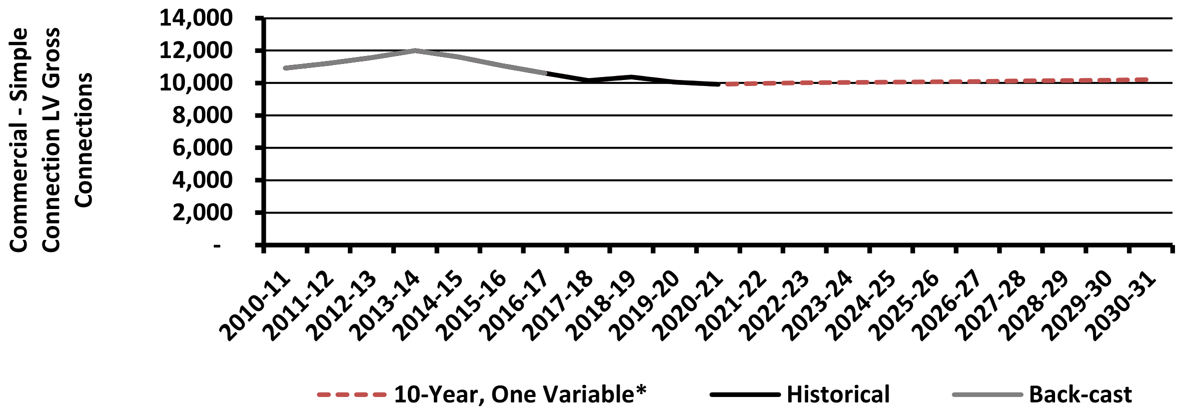


Source: Energeia Analysis, PWC Category Analysis RIN Response

5.1.3. Commercial – Simple LV

Figure 21 displays the forecasted Commercial – Simple LV gross connections, which predicts a very slight increase in connections amounting to 10,203 gross connections in 2030-31, counter to the slight decrease in recent history due to COVID-19. This forecast was based on a 10-year regression model using total building activity as the independent variable.

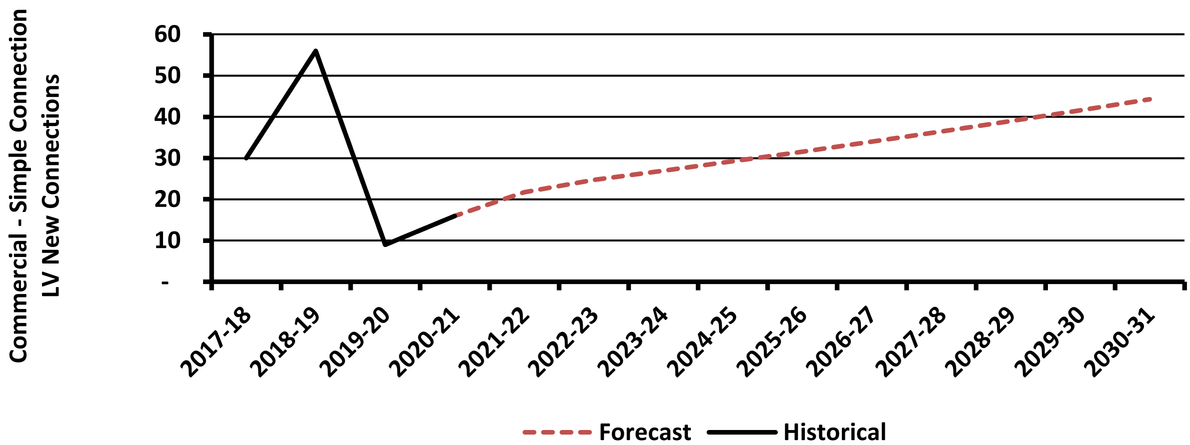
Figure 21 – Back-Cast, Historical and Forecast Commercial - Simple Connection LV Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

The forecast in Figure 22 depicts future annual new connections to increase steadily to 44 new connections in 2030-31.

Figure 22 – Historical and Forecast Residential Commercial - Simple Connection LV New Connections

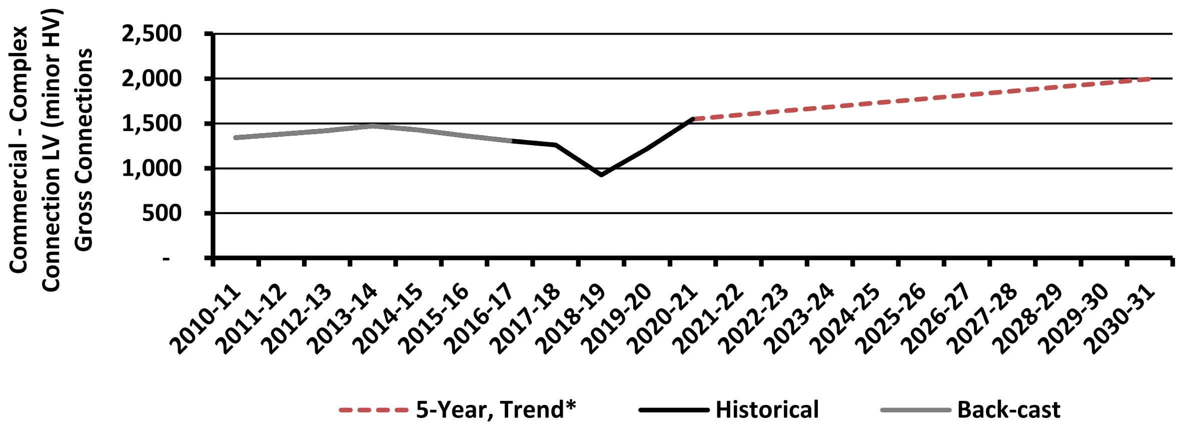


Source: Energeia Analysis, PWC Category Analysis RIN Response

5.1.4. Commercial – Complex LV (minor HV)

A 5-year trend was selected for the Commercial – Complex Connection LV (minor HV) gross connection forecast. This resulted in steady growth in future connections, which reaches 1,996 gross connections in 2030-31.

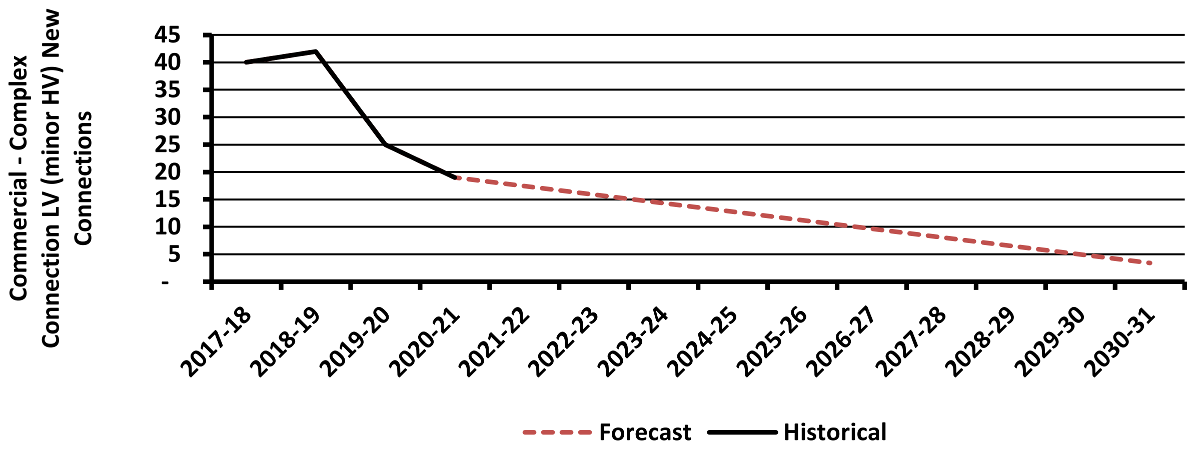
Figure 23 – Back-Cast, Historical and Forecast Commercial - Complex Connection LV (minor HV) Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

The new connections forecast in Figure 24 conflicts with this result, showing annual new connections to fall in future. The cause of this is related to the historical sharp growth in gross connections from 2018-19 to 2020-21, whilst new connections sharply fell in this time.

Figure 24 – Historical and Forecast Commercial - Complex Connection LV (minor HV) New Connections

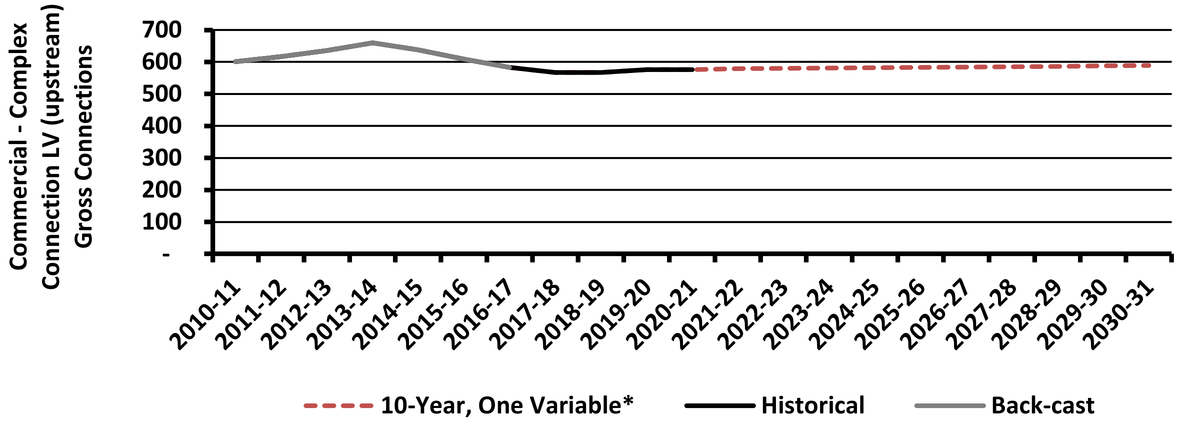


Source: Energeia Analysis, PWC Category Analysis RIN Response

5.1.5. Commercial - Complex LV (upstream)

Commercial – Complex LV (upstream) gross connections were forecasted in Figure 25 from multi-factor regression results, with WPI and total building activity used as the two independent variables. The forecast predicts a very slight upward incline in gross connections, reminiscent of historical connections, to 589 gross connections in 2030-31.

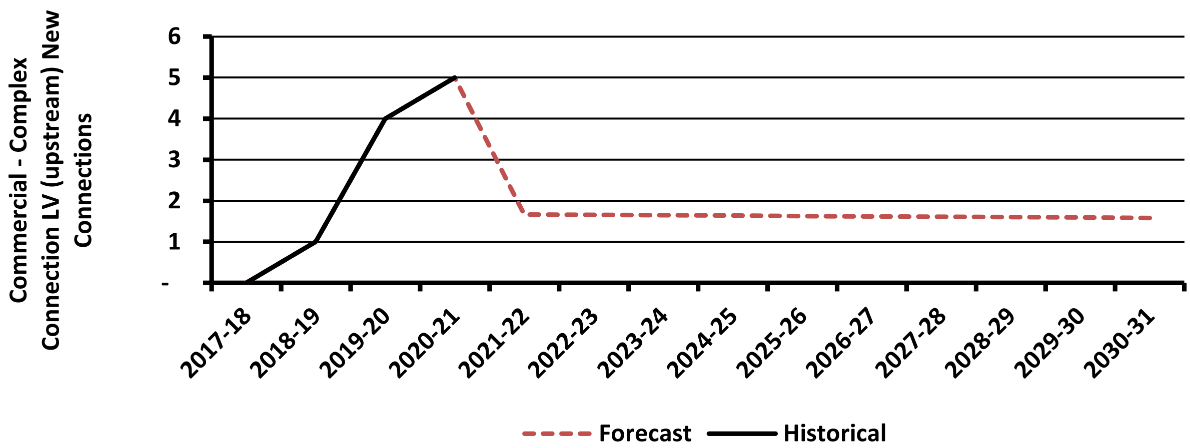
Figure 25 – Back-Cast, Historical and Forecast Commercial - Complex Connection LV (upstream) Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

The subsequent new connections forecast, shown in Figure 26, displays a mostly flat forecast of between 1 to 2 new connections each year.

Figure 26 – Historical and Forecast Commercial - Complex Connection LV (upstream) New Connections

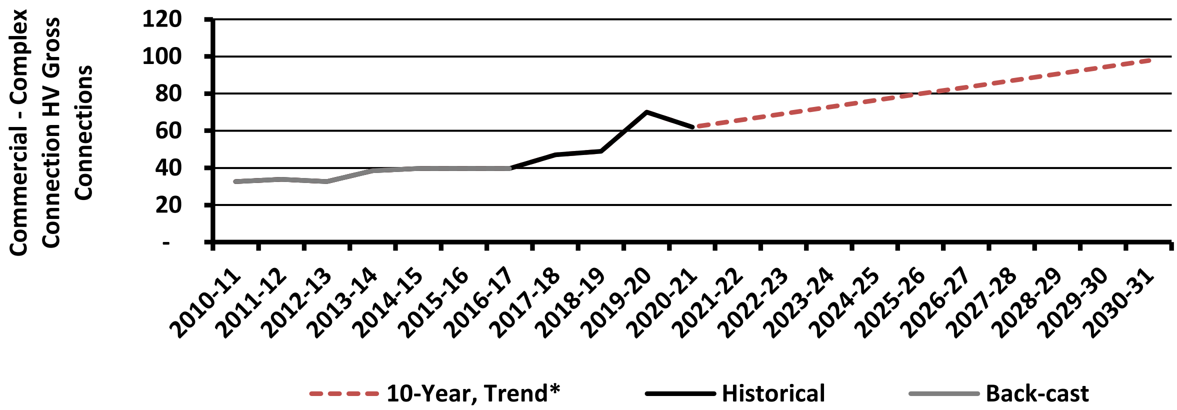


Source: Energeia Analysis, PWC Category Analysis RIN Response

5.1.6. Commercial – Complex HV

A 10-year trend was recommended to forecast Commercial – Complex HV gross connections, leading to a steady upward trend in future connections, peaking in 2030-31 at 98 gross connections. This result largely reflects general historical trends, as can be seen in Figure 27.

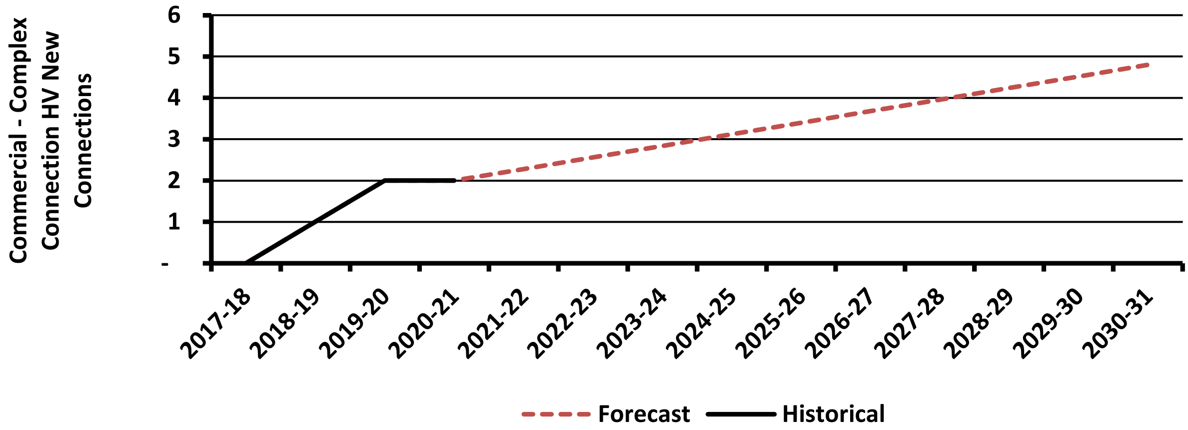
Figure 27 – Back-Cast, Historical and Forecast Commercial - Complex Connection HV Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

Figure 28 displays the new connections forecast, which rises steadily in a similar fashion, approaching 5 new connections annually in 2030-31.

Figure 28 – Historical and Forecast Commercial - Complex Connection HV New Connections

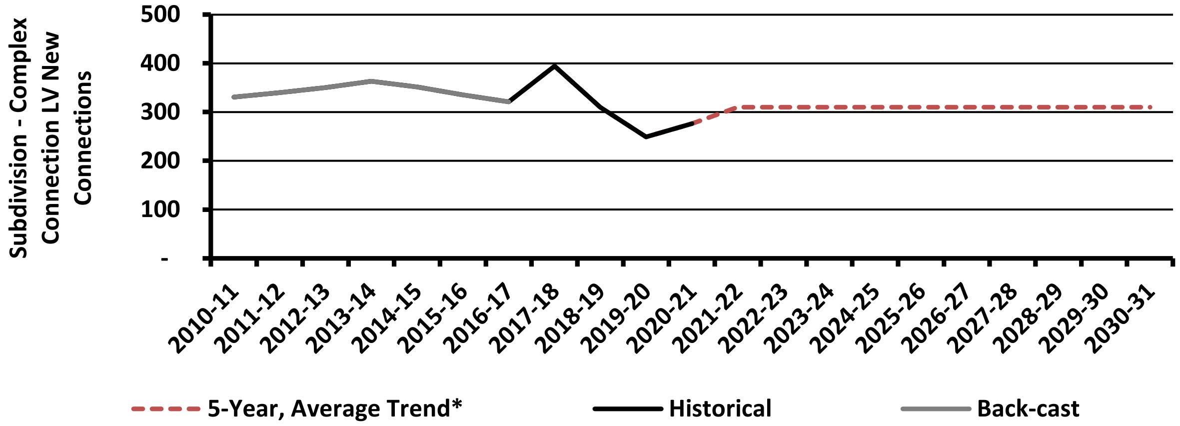


Source: Energeia Analysis, PWC Category Analysis RIN Response

5.1.7. Subdivision – Complex LV

The new connections forecast for Subdivision – Complex LV connections can be seen in Figure 29, based on the average of the past 5-years of history. It thus predicts[31] a flat forecast of 310 new connections each year.

Figure 29 – Back-cast, Historical and Forecast Subdivision - Complex Connection LV New Connections



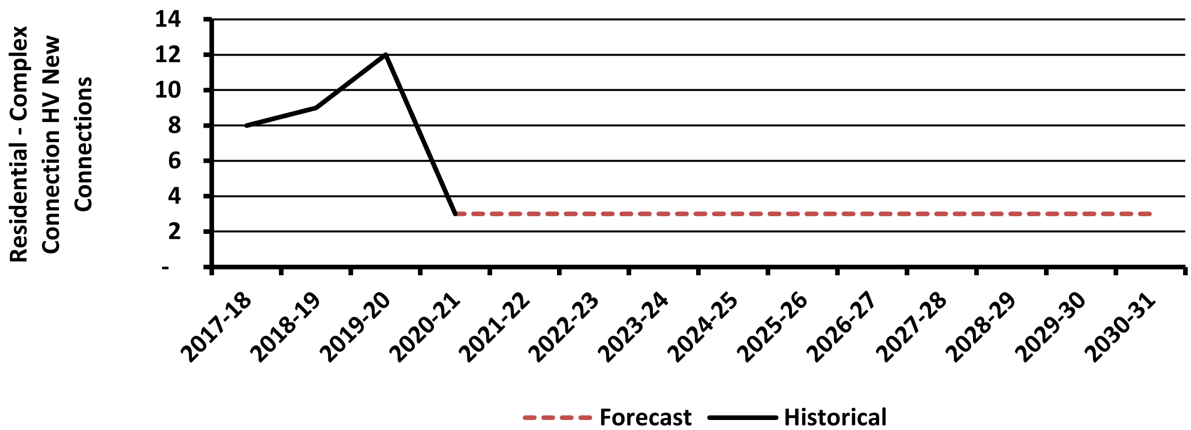
Source: Energeia Analysis, PWC Category Analysis RIN Response

5.1.8. Other Minor Connection Types

As previously discussed, these connection types had no existing connection history, so only new connections forecasts were produced using the final year of historical new connection data. Additionally, Commercial – Complex Sub-transmission was not forecasted, as there were no reported historical new or existing connections.

Figure 30, Figure 31, and Figure 32 display these forecasts and show 3, 2 and 1 new connections annually for the Residential - Complex Connection HV , Subdivision - Complex HV (no upstream), and Subdivision - Complex HV (with upstream) connection types, respectively.

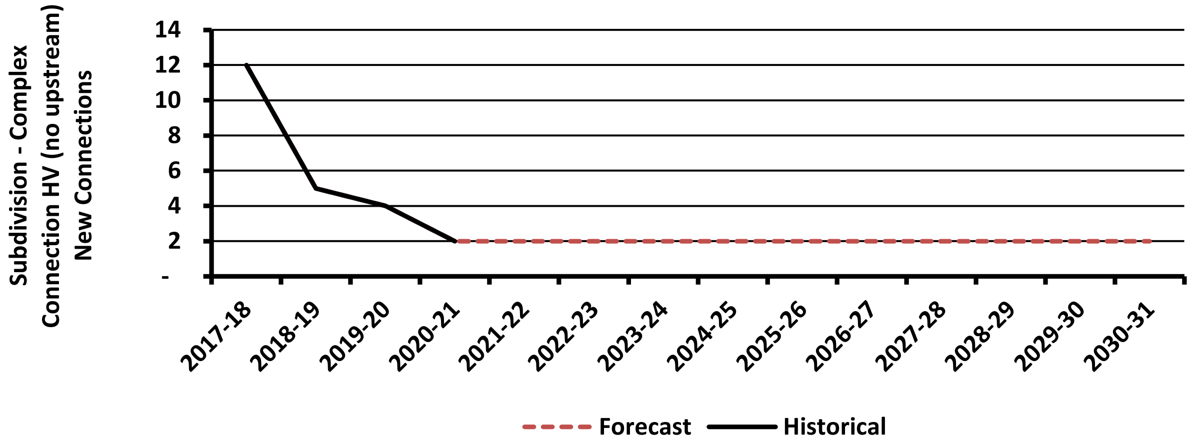
Figure 30 – Historical and Forecast Residential - Complex Connection HV New Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

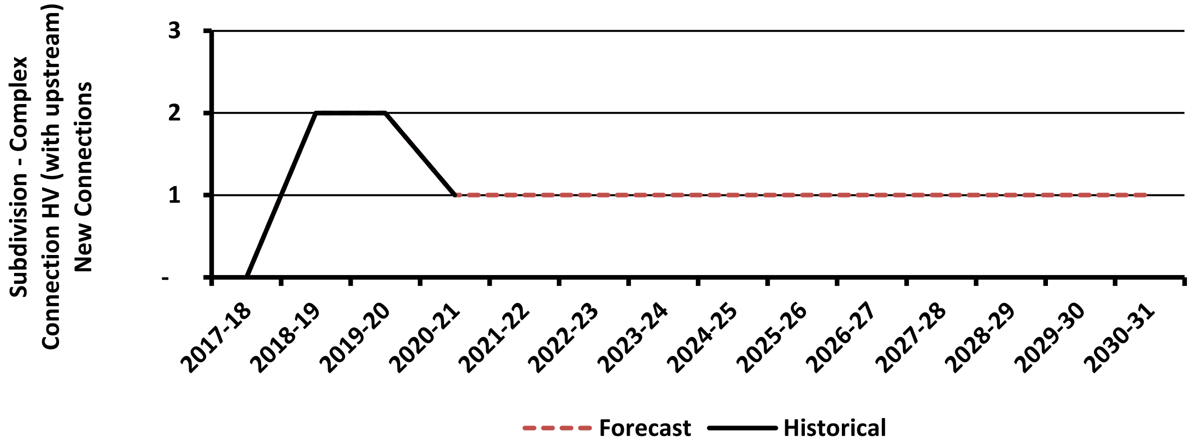
[31] Refer to Section 3.1.1 for why there was no gross connection forecast for this connection type.

Figure 31 – Historical and Forecast Subdivision - Complex Connection HV (no upstream) New Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

Figure 32 – Historical and Forecast Subdivision - Complex Connection HV (with upstream) New Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

5.2. *Embedded Generation Connections*

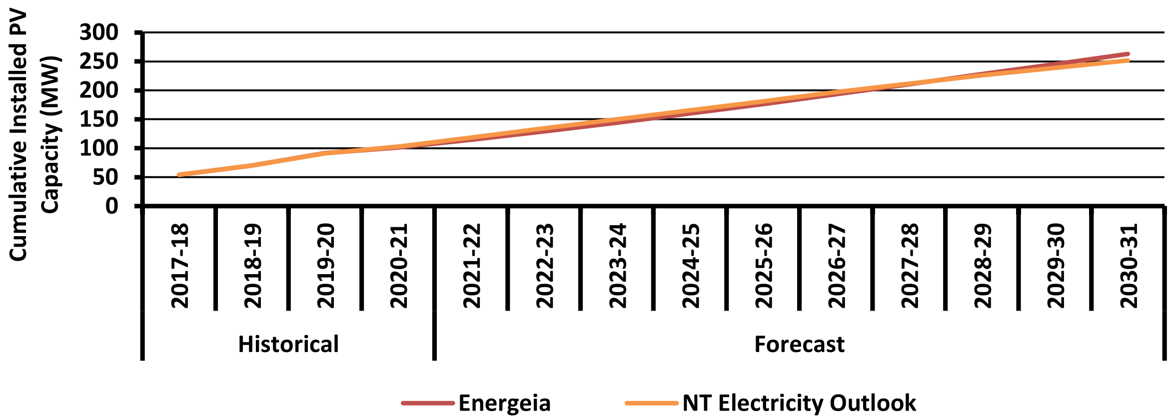
The major embedded generation connection type (Embedded Generation - Simple Connection LV) was forecasted using the PV uptake model described in Section 3.3.2, whilst the minor Embedded Generation - Complex HV (small capacity) and Embedded Generation - Complex HV (large capacity) connection types were assumed constant to the final historical year's value.

5.2.1. Forecast Benchmarking

Energeia's uptake model also produced an array of other PV-related results that could be used to compare to external forecasts for validation. In this instance, forecasted cumulative installed PV capacity was compared to the NT Utilities Commission's forecast.

Figure 33 displays this comparison and shows that both forecasts were very similar in the first five forecast years but diverge slightly in the latest years, with increasing ROI driving Energeia's slightly higher uptake. This comparison provides evidence for the reasonableness of Energeia's PV uptake forecast.

Figure 33 – Historical and Forecast Cumulative Distributed PV Capacity by Energeia and Utilities Commission

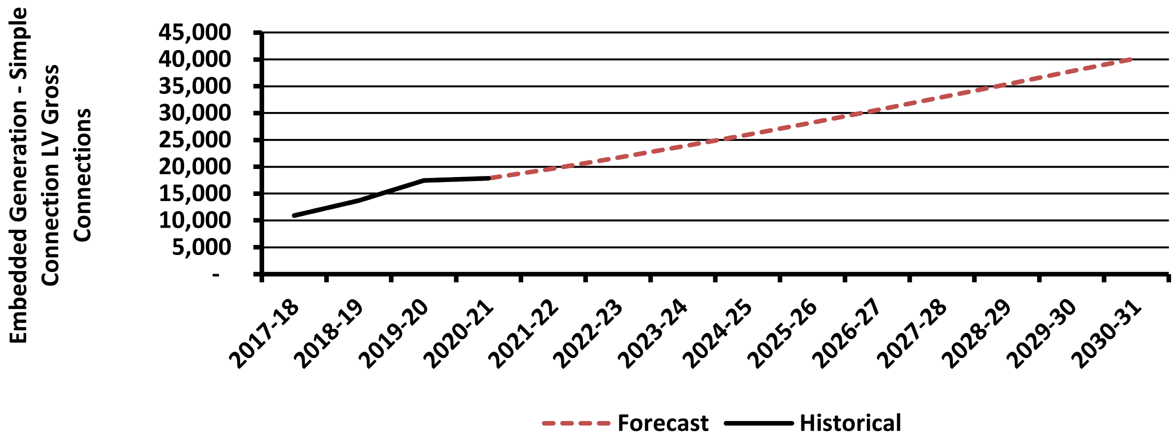


Source: Energeia Analysis, NT Utilities Commission (2022)

5.2.2. Embedded Generation – Simple LV

The Embedded Generation - Simple LV gross connections forecast is shown in Figure 34. It predicts a consistent growth in connections at a rate comparable to that of historical gross connections prior to their plateauing in 2021-22. The forecast reaches 40,213 gross connections in 2030-31.

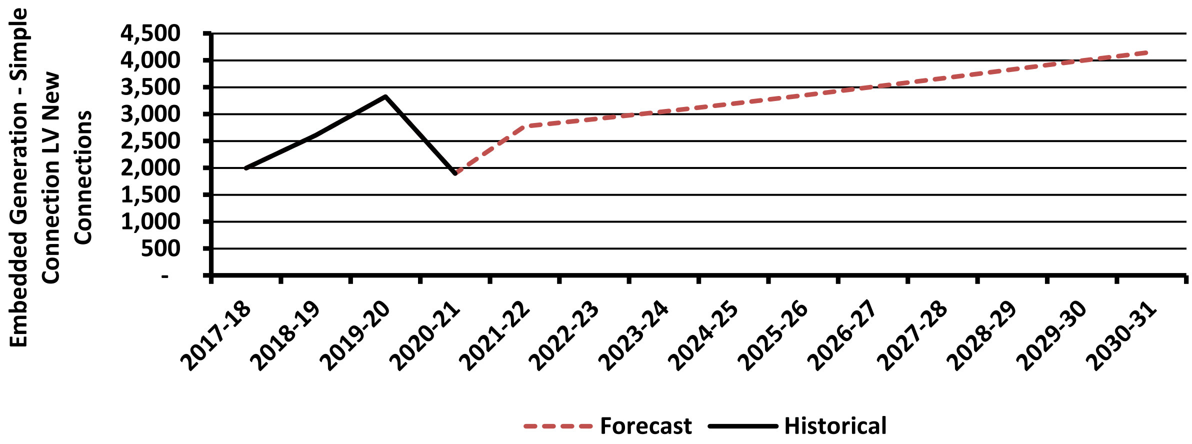
Figure 34 – Historical and Forecast Embedded Generation - Simple Connection LV Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

Likewise, the forecast new connections depicted in Figure 35 predicts steady growth in annual new connections which approaches 3,500 new connections in 2030-31.

Figure 35 – Historical and Forecast Embedded Generation - Simple Connection LV New Connections



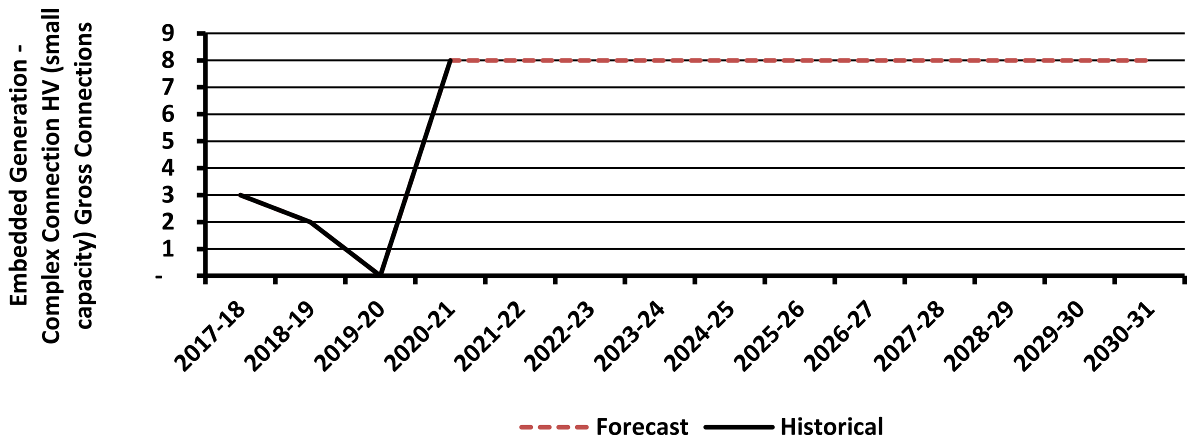
Source: Energeia Analysis, PWC Category Analysis RIN Response

5.2.3. Other Minor Connection Types

Figure 36 and Figure 37 display the respective gross connection forecasts for the Embedded Generation – Complex HV (small capacity) and Embedded Generation – Complex HV (large capacity) connection types.

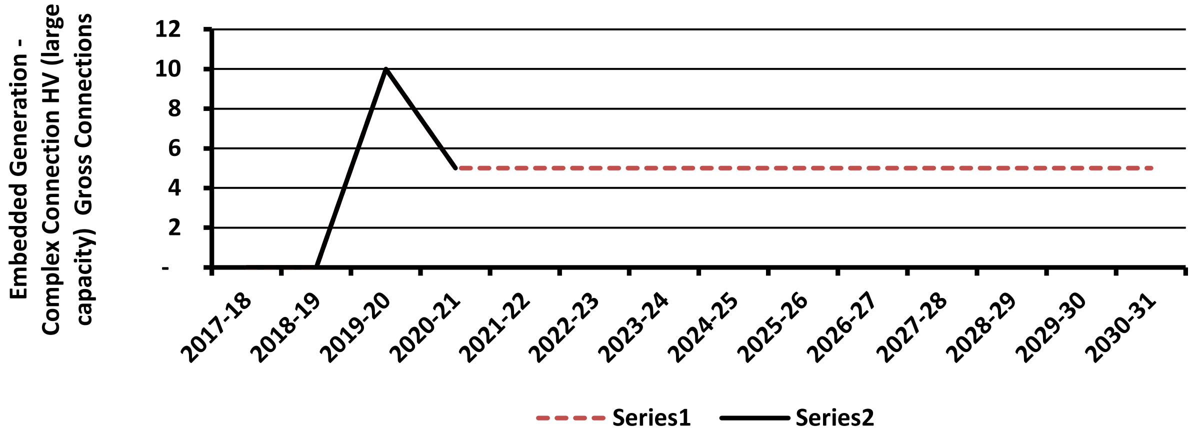
The Embedded Generation – Complex HV (small capacity) new connection forecast was zero, due to zero new connections reported in the historical data and is hence not plotted graphically here.

Figure 36 – Historical and Forecast Embedded Generation - Complex Connection HV (small capacity) Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

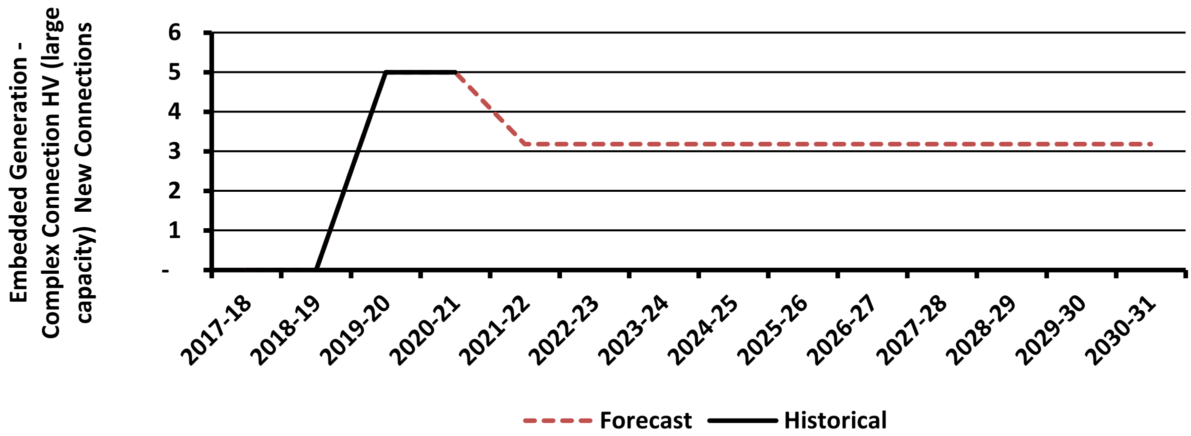
Figure 37 – Historical and Forecast Embedded Generation - Complex Connection HV (large capacity) Gross Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

Figure 38 displays the Embedded Generation – Complex HV (large capacity) new connections forecast, which sits at just over 3 annual new connections over the forecast period.

Figure 38 – Historical and Forecast Embedded Generation - Complex Connection HV (large capacity) New Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

Appendix A – Gross Connections Regressions

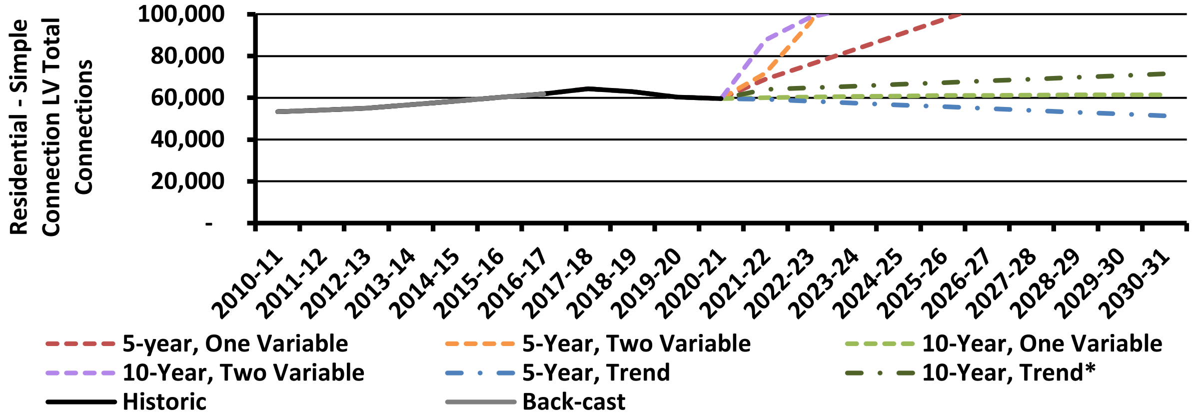
The following series of tables display the set of the best regressions found for each combination of variable counts (one or two) and histories used (5-year or 10-year). The graphs that follow them plot these best regressions, the trend lines considered, and the recommended forecast for each regression – denoted by an asterisk.

Table A1 – Regression Summary, Residential - Simple Connection LV Gross Connections

Residential - Simple Connection LV	One Variable		Two Variables	
Parameter	5 Year	10 Year	5 Year	10 Year
Best R2	0.36	0.82	0.93	0.87
Variable 1	Population	Lagged Connections (N-1)	Lagged Connections (N-1)	Population
Variable 2			Population	Lagged Connections (N-1)
Slope 1	2.61	0.78	0.95	0.34
Slope 2			4.54	0.48
Intercept	-580,303	13,326	-1,115,801	-51,954
R2	0.36	0.82	0.93	0.87
P1	0.28	0.00	0.06	0.13
P2			0.04	0.06

Source: Energeia

Figure A1 – Regression Results, Residential - Simple Connection LV Gross Connections



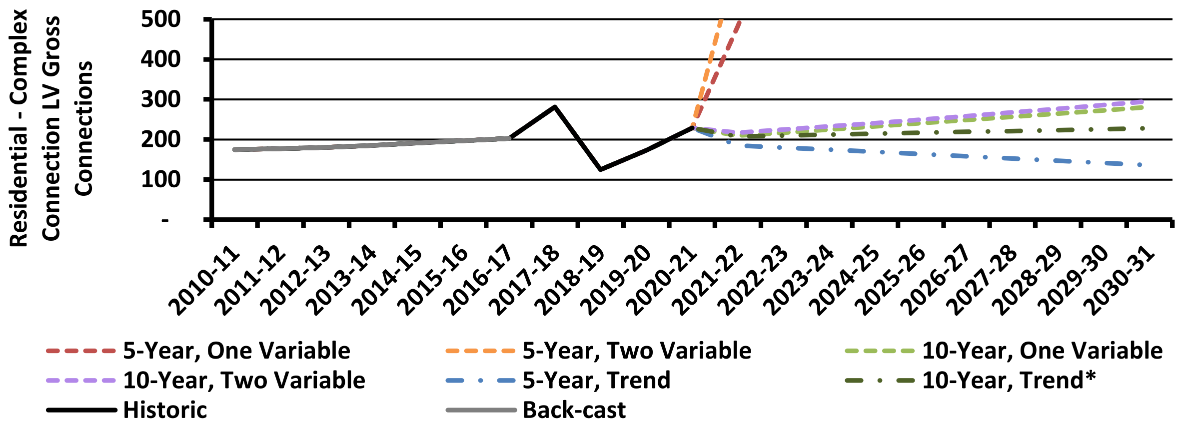
Source: Energeia Analysis, PWC Category Analysis RIN Response

Table A2 – Regression Summary, Residential - Complex Connection LV Gross Connections

Residential - Complex Connection LV	One Variable		Two Variables	
Parameter	5 Year	10 Year	5 Year	10 Year
Best R2	0.64	0.08	0.96	0.09
Variable 1	Population	Population	Population	GSP
Variable 2			GSP	Residential Building Activity
Slope 1	0.10	0.00	0.14	0.01
Slope 2			0.05	0.00
Intercept	-25,628	-492	-36,161	-100
R2	0.64	0.08	0.96	0.09
P1	0.10	0.42	0.02	0.46
P2			0.06	0.74

Source: Energeia

Figure A2 – Regression Results, Residential - Complex Connection LV Gross Connections



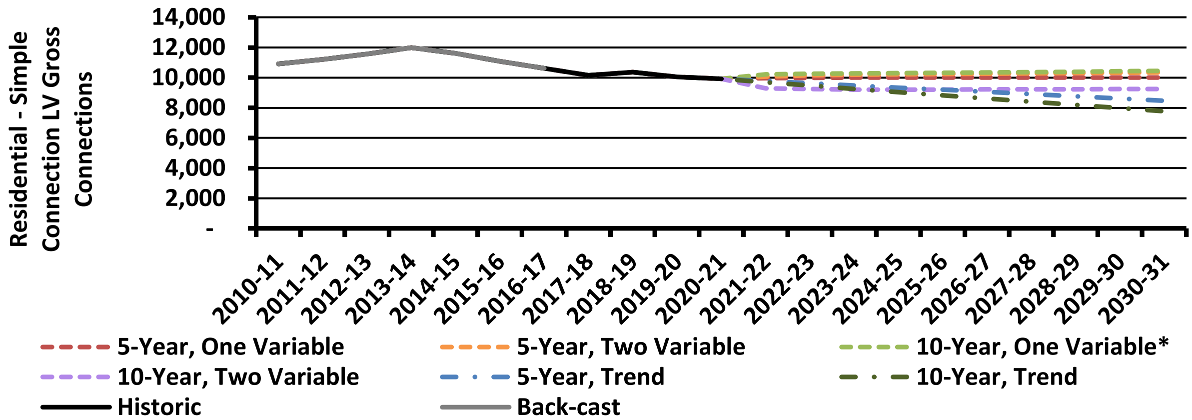
Source: Energeia Analysis, PWC Category Analysis RIN Response

Table A3 – Regression Summary, Commercial - Simple Connection LV Gross Connections

Commercial - Simple Connection LV	One Variable		Two Variables	
Parameter	**5 Year**	**10 Year**	**5 Year**	**10 Year**
Best R2	0.51	0.93	0.53	0.96
Variable 1	Lagged Connections (N-1)	Total Building Activity	Residential Building Activity	Wage Price Index
Variable 2			Lagged Connections (N-1)	Residential Building Activity
Slope 1	0.47	0.00	0.00	253.24
Slope 2			0.33	0.00
Intercept	5,295	9,398	6,454	8,867
R2	0.51	0.93	0.53	0.96
P1	0.18	0.00	0.79	0.03
P2			0.63	0.00

Source: Energeia

Figure A3 – Regression Results, Commercial - Simple Connection LV Gross Connections



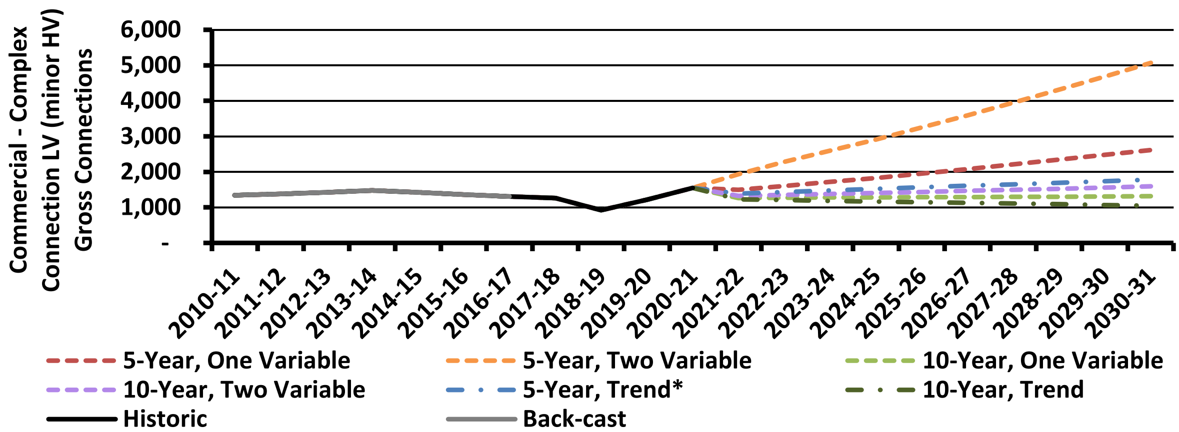
Source: Energeia Analysis, PWC Category Analysis RIN Response

Table A4 – Regression Summary, Commercial - Complex Connection LV (minor HV) Gross Connections

Commercial - Complex Connection LV (minor HV)	One Variable		Two Variables	
Parameter	5 Year	10 Year	5 Year	10 Year
Parameter	5 Year	10 Year	5 Year	10 Year
Best R2	0.30	0.28	0.95	0.31
Variable 1	GSP	Residential Building Activity	GSP	GSP
Variable 2			Residential Building Activity	Residential Building Activity
Slope 1	0.17	0.00	0.41	0.03
Slope 2			0.00	0.00
Intercept	-3,105	1,122	-10,349	293
R2	0.30	0.28	0.95	0.31
P1	0.34	0.12	0.03	0.58

Source: Energeia

Figure A4 – Regression Results, Commercial - Complex Connection LV (minor HV) Gross Connections



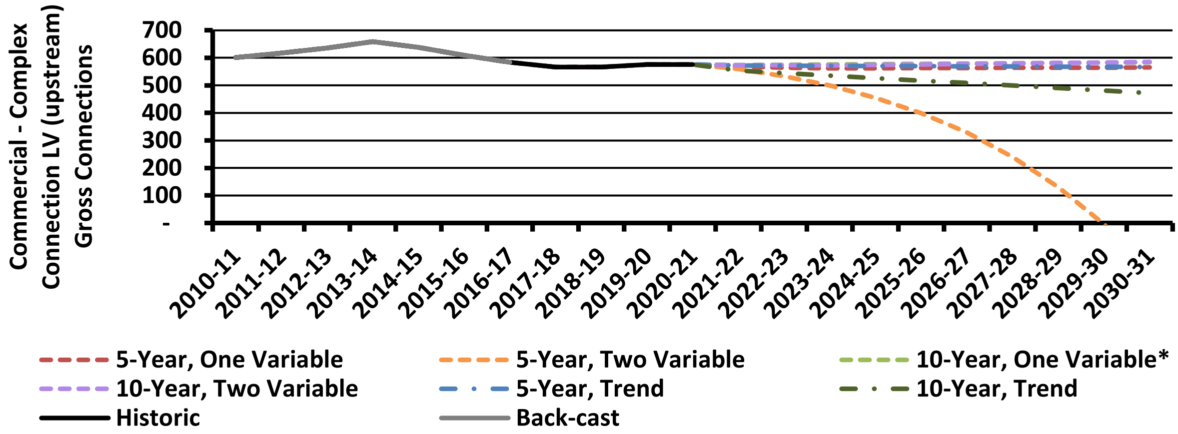
Source: Energeia Analysis, PWC Category Analysis RIN Response

Table A5 – Regression Summary, Commercial - Complex Connection LV (upstream) Gross Connections

Commercial - Complex Connection LV (upstream)	One Variable		Two Variables	
Parameter	5 Year	10 Year	5 Year	10 Year
Best R2	0.62	0.94	0.98	0.97
Variable 1	Wage Price Index	Total Building Activity	Residential Building Activity	Wage Price Index
Variable 2			Lagged Connections (N-1)	Residential Building Activity
Slope 1	19.84	0.00	0.00	13.05
Slope 2			1.20	0.00
Intercept	535	536	-36	510
R2	0.62	0.94	0.98	0.97
P1	0.11	0.00	0.02	0.01
P2			0.01	0.00

Source: Energeia

Figure A5 – Regression Results, Commercial - Complex Connection LV (upstream) Gross Connections



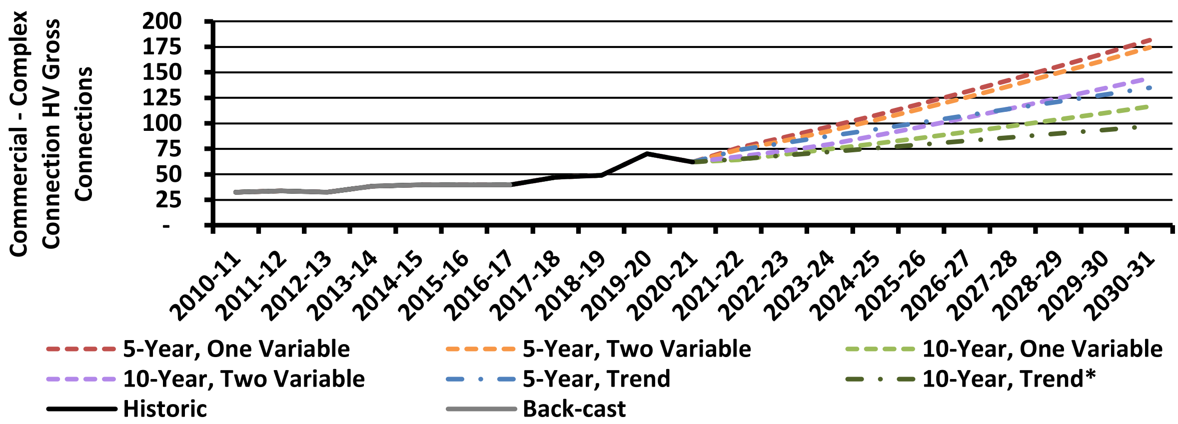
Source: Energeia Analysis, PWC Category Analysis RIN Response

Table A6 – Regression Summary, Commercial - Complex Connection HV Gross Connections

Commercial - Complex Connection HV	One Variable		Two Variables	
Parameter	**5 Year**	**10 Year**	**5 Year**	**10 Year**
Best R2	0.88	0.75	0.89	0.82
Variable 1	GSP	GSP	GSP	GSP
Variable 2			Wage Price Index	Wage Price Index
Slope 1	0.02	0.01	0.02	0.01
Slope 2			4.50	8.58
Intercept	-354	-149	-346	-268
R2	0.88	0.75	0.89	0.82
P1	0.02	0.00	0.07	0.00
P2			0.72	0.13

Source: Energeia

Figure A6 – Regression Results, Commercial - Complex Connection HV Gross Connections



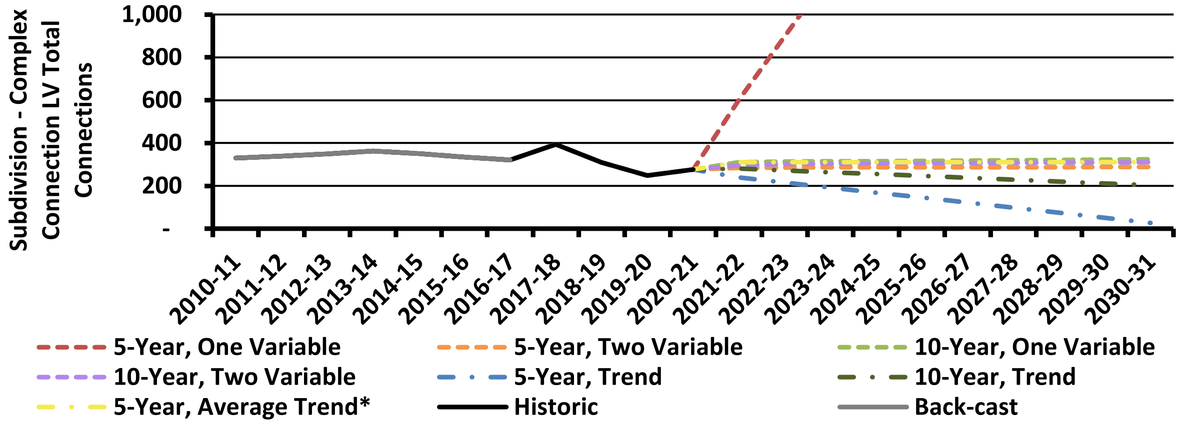
Source: Energeia Analysis, PWC Category Analysis RIN Response

Table A7 – Regression Summary, Subdivision - Complex Connection LV New Connections

Subdivision - Complex Connection LV	One Variable		Two Variables	
Parameter	5 Year	10 Year	5 Year	10 Year
Best R2	0.79	0.34	0.94	0.36
Variable 1	Population	Residential Building Activity	Population	Total Building Activity
Variable 2			Lagged Connections (N-1)	Lagged Connections (N-1)
Slope 1	0.11	0.00	0.11	0.00
Slope 2			0.41	0.26
Intercept	-26,525	272	-27,901	200
R2	0.79	0.34	0.94	0.36
P1	0.04	0.08	0.04	0.19
P2			0.16	0.49

Source: Energeia

Figure A7 – Regression Results, Subdivision - Complex Connection LV New Connections



Source: Energeia Analysis, PWC Category Analysis RIN Response

Appendix B – Industry Practice

Table B1 – DNSP Historical Connection Forecasting Approaches

	NEM	NT	VIC					NSW			QLD		SA	TAS	WA
	AEMO	PWC	Jemena	AusNet	United Energy	CitiPower	Powercor	Essential Energy	AusGrid	Endea-vour	Energex	Ergon	SAPN	Tas-Networks	Western Power
Forecasting Methodology															
Trend	✓				✓	✓	✓	✓							
Projection	✓			✓	✓	✓	✓				✓				
Bottom-up			✓		✓	✓	✓								
Regression		✓	✓									✓		✓	
Auto-Regressive Modelling															✓
Other															✓
Unspecified								✓					✓	✓	
Outputs															
Class (e.g. Residential)	✓	✓		✓	✓	✓	✓	✓			✓	✓		✓	✓
Voltage (e.g. LV/HV)					✓	✓	✓								
Complexity (e.g. Simple/Complex)					✓	✓	✓							✓	
Volume of Connections (e.g. High)					✓	✓	✓								
Customer Size (e.g. Large)			✓										✓		
Supply Area (e.g. Zone Substation)				✓											✓
Hierarchy (e.g. Tariff Group)								✓							✓
Unspecified	✓		✓												
Drivers Used															
Population		✓		✓							✓	✓			
Building Activity/Growth	✓		✓	✓	✓	✓	✓	✓					✓		
GSP		✓									✓	✓		✓	
Unspecified Economic Indicators			✓								✓				✓
Unspecified														✓	
Years of History Used															
10		✓													
4					✓	✓	✓	✓							
5				✓											
Unspecified	✓		✓								✓	✓	✓	✓	✓

Source: Energeia, Various DNSP Sources

Note: AusGrid and Endeavour Energy's methodologies were not found publicly (indicated in grey)

Appendix C – Definitions

This section provides definitions for key connection related terms referenced frequently throughout this report. The most important are the definitions of the two types of connection forecasts Energeia has provided:

- **Gross Connections –** The sum of 'existing' and 'new' connections as named in the Category Analysis Regulatory Information Notice (RIN) response, table 2.5.3.
- **New Connections** – 'New' connections as named in the Category Analysis RIN response, table 2.5.3.

PWC notes in their 2020-21 Category Analysis – Basis for Preparation[32] that:

> *"For new connections, the source of historical information is an internal database for overhead and above ground connections, which have then been assigned manually to different classifications. For existing connections, the source of the information is from internal databases including PV Database, Gentrack RMS and MV90."*

and,

> *"Embedded Generation connections that require an upgrade to PV metering are being considered as new connections for the purpose of this field. It is noted that while including these connections here is technically incorrect there can only be one intended purpose for this field and that is to capture PV connections."*

As these are the source of key historical inputs for connections, Energeia's forecasts reflect these data sources and definitions.

Definitions for forecast connection types are outlined by the AER[33], as shown in Table C1.

Table C1 – AER Connection Type Definitions

Class	Type	AER Definition
RESIDENTIAL	Simple connection LV	*Single/multi-phase customer connection service; and/or:* • *one span of overhead service wire or standard underground service; and/or* • *an overhead road crossing.*
	Complex connection LV	*Single/multi-phase customer connection services which are not simple customer connections and, as an example, may involve the following:* • *greater than one span of overhead service wire;* • *extension or augmentation of the LV feeder, overhead and/or underground;* • *road crossing (overhead or underground).* *Notes: This also includes the reconfiguration of LV network assets (not including any HV asset works) as a result of specific requests for connection specifications.*
	Complex connection HV	*Single/multi-phase customer connection services which are not simple customer connections or complex type low voltage connections and, as an example, may involve the following:* • *extension or augmentation of the HV feeder, overhead and/or underground;* • *installation of a distribution substation (pole mounted, ground types);* • *extension or augmentation of the LV feeder, overhead and/or underground;*

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33 AER Final Category Analysis RIN – Distribution Network Service Providers, 2014

		• *greater than one span of overhead service wire;* • *road crossing (overhead or underground).* *Notes: This also includes the reconfiguration of HV network assets (not including any LV asset works) as a result of specific requests for connection.*
COMMERCIAL / INDUSTRIAL	Simple connection LV	*Single/multi-phase customer service connection and, as an example, may involve the following:* • *one or more spans of overhead service wire;* • *road crossing (overhead or underground);* • *small LV extension or augmentation of overhead and/or underground mains.*
	Complex connection HV (customer connected at LV, minor HV works)	*Multi-phase customer connection service at LV which are not simple connections and, as an example, may involve the following:* • *the installation of a distribution substation (pole mounted, ground types, or indoor types);* • *overhead and/or underground HV feeder extension or augmentation associated with the connection of the substation but excluding major feeder extensions or augmentation;* • *installation of LV mains associated with the new substation.*
	Complex connection HV (customer connected at LV, upstream asset works)	*Multi-phase customer connections which are not simple connections or Complex type connection high voltage and, as an example, may involve the following:* • *large extension or augmentation, overhead and/or underground, of the HV feeder;* • *installation of a distribution substation (pole mounted, ground types or indoor types).* *Notes: Upstream shared asset alterations expected to be required. This also includes the reconfiguration of HV network assets as a result of specific requests for connection.*
	Complex connection HV (customer connected at HV)	*Multi-phase customer connections where the customer is supplied at HV and, as an example, may include the following:* • *large extension or augmentations of the HV feeders;* • *installation of a high voltage switching station or switch room.*
	Complex connection sub-transmission	*Multi-phase customer connections where the customer is connected via feeders operating between 33kV and 132kV inclusive and, as an example, may include any of the following:* • *extension or augmentation of the Sub-transmission network;* • *installation of switching stations, switch rooms or similar facilities.*
SUBDIVISION	Complex connection LV	*Single/multi-phase customer connection and, as an example, may include the following:* • *extension or augmentation of overhead or underground LV feeders including road crossings.*
	Complex connection HV (no upstream asset works)	*Multi-phase customer connection which are not simple connections and, as an example, may include the following:* • *extension or augmentation of HV feeders;* • *installation of one or more distribution substations;* • *installation of LV mains.* *Notes: Each subsequent connection of a residential premises within a new estate will be treated as a connection. The subdivision category excludes civil works (that is, the cost of trenching, excavation, backfilling or re-instatement within the subdivision development).*
	Complex connection HV (with upstream asset works)	*Multi-phase customer connections which are not simple connections and, as an example, may involve the following:* • *extension or augmentation of HV feeders including major upstream works;* • *installation of one or more distribution substations;* • *installation of LV mains.*

		Notes: This category is intended to capture the cost of developing the network to serve new estates and possible upstream shared asset alterations that may be required. Each subsequent connection of residential premises within a new estate will be treated as a simple connection. The subdivision category excludes civil works (that is, the cost of trenching, excavation, backfilling or re-instatement within the subdivision development).
EMBEDDED GENERATION	Simple connection LV	*Single/multi-phase customer connection service, and /or:* • *one span of overhead service wire or standard underground service wire and/or road crossing; and* • *meter upgrade.*
	Complex connection HV (small capacity)	*Multi-phase customer connection which are not simple connections and, as an example, may involve the following:* • *large extension or augmentation, overhead and/or underground, of the distribution HV/LV feeders;* • *installation of a distribution substation (Pole mounted, ground types or indoor types).*
	Complex connection HV (large capacity)	*Multi-phase customer connection which are not simple connections and, as an example, may involve the following:* • *extension or augmentation of HV or sub transmission feeders;* • *installation of switching stations, switch rooms or similar facilities.*

Source: AER

It should also be noted that throughout this report the term "RIN response" was used, which is referring to PWC's past Category Analysis RIN responses[34], most often the connections data from table 2.5.3 of these responses.

[34] PWC 2020-21 Category Analysis RIN Response Workbook