Assessment and Analysis of Incident Data Held by Energy Safe Victoria

Final Report, Version 0.4.1

Andrew Robinson and Steve Lane[1]

[1]CEBRA, the University of Melbourne

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Centre of Excellence for
Biosecurity Risk Analysis

Executive Summary

This report is the final deliverable for a Centre of Excellence for Biosecurity Risk Analysis (CEBRA) project concerning the data collected by Energy Safe Victoria (ESV) on electricity and gas incidents and fire starts. The report contributes to the "Review of Victoria's Electricity and Gas Network Safety Framework", a broader review of electrical and gas network safety undertaken under the lead of Dr. Paul Grimes on behalf of the Department of Environment, Land, Water and Planning (DELWP). The CEBRA project comprised two stages; this report combines both.

ESV is heading in a fruitful direction in terms of data capture and analysis, developing productive partnerships with third parties such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and shifting their processes to deliver more efficient regulation. There is a considerable amount of work to be done, but ESV are well positioned to do it, taking account of the recommendations made in this report.

The motivating question for this report was: is the risk of fire starts that arise from network assets increasing or decreasing in time, after taking account of other sources of variability? At this point, *ESV is not positioned to make a convincing claim about the effect of network assets upon fire starts*, because it is not possible to take account of other sources of variability. This report makes recommendations that, if followed, would develop the data resources necessary to address the question.

This report's contents and recommendations should be taken as recommendations to the Review, and are not independently directed to ESV. The recommendations arising are as follows, along with the page number in which their context may be found.

List of Recommendations

1 Historical fire incident data are held by ESV but only at an aggregate level. ESV should try to obtain incident-level historical fire data in order to improve models of the network effect on fire risk. 4

2 The weekly fire report to the minister is a valued service for the emergency management sector. ESV should consider adding value by providing extra summaries, such as a graphical region-specific summary of fire starts and other incidents. 5

3 The value of some of the contents of the weekly fire report, such as self-reported BMI by electricity DBs, are undermined by uncertainty about their meaning and oversight by ESV. ESV should provide stakeholders with assurance as to the impact, regulatory value, and neutrality of these measures. For example, does a sustained BMI of 0 correlate to a empirically lower fire risk? Alternatively, ESV could consider the inclusion of more informative measures of performance. . . . 5

4 ESV should consider circulating the weekly fire report — or a similar report with sensitive material omitted — to the contributing electricity DBs in order to close the data capture loop and provide a valuable tactical service to its stakeholders. This is not, strictly speaking, ESV's role, but regardless may lead to improvements in data quality and overall outcomes. ESV should discuss the content and mechanism with the stakeholders. 5

5 Presently, fire extent data are reported to OSIRIS as a five-class ordinal variable. ESV should consider requiring that submitted fire records be linked to CFA or MFB data in order to provide a further check on data quality and more detailed fire incident information. 6

6 The Electricity division should consider the use of KPIs to enhance the level of self-reporting and communication in the electricity sector. 6

7 Contextual information about the overall fire risk, such as the total number of fire ignitions by region, would provide a useful background against which to compare the number of fire incidents for each company. ESV should source total fire ignition data from CFA and MFB to enable a relatively simple context-sensitive analysis. 6

8 Contextual information is critical for assessing the performance and risk of the network. ESV should convene a multi-stakeholder working group, including the DBs, CSIRO, EMV, CFA, and MFB, to determine the best indicators of contextual fire risk and how they might be best used in the analysis of network performance. 7

9 ESV recognises that its information capture for gas network incidents only permits manual data entry, and the system is not fit for purpose to support strategic analysis of its data holdings. ESV should investigate the availability of, and implement, a comparative analysis tool that best addresses the demands of monitoring multiple industry groups with differing reporting requirements. 9

10 ESV should identify the needs of stakeholders that use the monthly report. This includes establish, and report on indicators that provide a reflection of gas network integrity and shortfalls. 9

11 Quarterly reports of gas network KPIs are emailed to ESV, but there is no strategic framework for auditing these data. ESV should implement random audits of network KPI records, to form an impression of the compliance rates of the data contributing stakeholders. The random audits should then be weighted towards stakeholders with a history of non-compliance and towards activities that are material to reducing catastrophic incident risk. 10

12 ESV should continue the review of the collection, use, and analysis of gas network KPI data. This review should be expanded to include the handling of the KPI data, which is presently manual. A modest investment in a high-level programming language such as Python or R would deliver great efficiencies in terms of data handling and reduce errors. 10

13 ESV should consider collecting lead indicators of gas network risk such as asset maintenance data and network pressure data, and for reported incidents should ask the stakeholder to identify the causal risk and the planned tactical and strategic remedies. 11

14 ESV should convene a working group that includes representatives from CSIRO, CFA, and MFB to develop standards for the statistically appropriate analysis of spatio-temporal fire incident data. This should include consideration of how best to represent the processes and what data to use as a source of background risk. Such models could use contextual information that ranges from empirical (such as the total number of fire ignitions in each region) through to mechanistic (including consideration of meteorology, fuels, suppression efforts, and so on). . 17

15 That ESV develop a strategic dataset of gas incidents that includes indication of whether or not the incident involved fire, and subject the dataset to similar analytic scrutiny as developed and recommended for the electricity network. . . 17

16 There was insufficient overlap between the AER data and the ESV fire incident data to enable a comparison. ESV should attempt an analytical comparison when the AER data are available that overlap sufficiently with the fire incident data held within OSIRIS or source historic fire incident data as per Recommendation 1. 18

17 ESV should collaborate with CFA, MFB and EMV to engage CSIRO to undertake a study on how fire data could be better captured to meet the needs of all four agencies. This should include electricity DB data on fires from the networks. This data definition and collection exercise should also include considerations of empirical and mechanistic measures of fire risk. 20

18 ESV should engage with the stakeholders that provide data to determine what high-level cross-company analyses would provide value to them, building on the suggestions here. ESV should undertake to develop and provide these analyses on an ongoing basis as a service, with appropriate caveats in place to ensure that such reporting does not impinge upon the electricity DBs' responsibility to manage their risks. 21

19 ESV should develop and invest in a community of practice for risk-based analytics among the major DBs in order to better apprehend the opportunities for regulatory network monitoring and intervention. 21

20 (Outside report scope): That ESV consider imposing the responsibility for reporting network risk upon the DBs. The DBs have the needed data, are already undertaking the necessary analyses and activities, and are best positioned to implement actionable outcomes. ESV should develop and retain the needed analytical capability to audit the DBs data collection, analysis, and reporting for (i) appropriateness to detect risk, and (ii) fidelity to accepted standards. 23

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Introduction

This report is the final deliverable for a CEBRA project concerning the data collected by ESV on electricity and gas incidents and fire starts. The report contributes to a broader review of electrical and gas network safety undertaken under the lead of Dr. Paul Grimes on behalf of DELWP. This report's contents and recommendations should be taken as recommendations to the Review, and are not independently directed to ESV.

The motivating question was: is the risk of fire starts that arise from network assets increasing or decreasing in time, after taking account of other sources of variability?

The deliverables for the CEBRA project were:

Stage 1: provision of a report that includes: A high-level review of the type, quality, integrity and consistency of the data (including consideration of any data gaps) collected by ESV on electricity and gas distribution and transmission incidents and fire starts to determine if the data collected is appropriate to conduct statistically sound analysis of the safety performance of electricity and gas networks, and to identify any data types not being collected that should be; and

Stage 2: Subject to Stage 1 concluding that data is suitable to analyse as determined by both the supplier and the Department — provision of a report which includes: Analysis of trends in the safety performance of electricity and gas networks using the available current and historical data sets provided by ESV and the Australian Energy Regulator (AER, electricity) and a comparison of the ESV data and AER data.

This reports covers both Stage 1 and Stage 2. The report is structured as follows. Chapter 2 provides an overview of the incident data that ESV collects for the electricity network. Chapter 3 covers the transmission and distribution incident data that ESV collects for the gas network. Data analyses that cover (i) the electricity network incidents, (ii) the transmission and distribution incidents in the gas network, and (iii) the AER electricity network data are provided in Chapter 4. Chapter 5 reviews two significant opportunities for ESV to consider different ways of using incident data. Conclusions are presented in Chapter 6.

Acknowledgments

The authors are grateful to Peter Greilach, Ian Burgwin, and William Hajjar of ESV for their patient engagement and generous and thoughtful review comments, and to the individuals identified in Appendix B for their illuminating and forthright contributions.

2

Electricity Network

ESV is responsible for monitoring and regulating the safety of Victoria's power line network. As part of its regulatory function, ESV requires that stakeholders report network incidents. This chapter describes the data collection processes.

2.1 Background

Briefly, the environment in which the data are collected is as follows. ESV's incident register comprises reports that are contributed by five major distribution businesses (DBs), namely Powercor, United Energy, Jemena, AusNet Services, and CitiPower. Each DB has different risk profiles and a different focus.

Incident data for the electricity network comes to ESV by two means, namely (i) serious incidents are reported through the organization's OSIRIS web portal, and (ii) not-serious incidents are reported quarterly using a template developed by ESV [3].

ESV reports to, among other stakeholders, the Minister for Energy, Environment and Climate Change on network-related bushfire status during the fire season. ESV also undertakes the annual network safety performance reporting, which has a broader set of stakeholders.

2.2 Incident Data Being Collected by ESV

This section outlines the process of data capture for incidents (Section 2.2.1), describes the data types (Section 2.2.2), and reports an assessment of the data quality, integrity and consistency (Section 2.2.3).

2.2.1 Data Capture

Incidents are classified as *serious* or *not serious* based on criteria documented in the Electrical Incident and Safety Performance Reporting Guidelines [3]. Any ground or vegetation fires, or fires of transmission assets that are caused by transmission assets, are considered serious.

Serious incidents are recorded manually by the DBs on ESV's OSIRIS incident reporting portal. Certain serious incidents must be reported within 48 hours (Schedule 1 incidents), whereas others may be reported within 20 days (Schedule 2 incidents). Incident records can be augmented and edited as new information arises.

Many of the data items are recorded by means of pull-down menus, which simplifies analysis and data checking by trammeling the outcome into a small number of easily summarized classes, but also imposes a fixed palette of choices. Some of the pull-down menu items permit a record of "Other", accompanied by a free text field. Geographical location can be provided by street address or latitude and longitude coordinates. The former is converted into latitude and longitude; this can be challenging in newly developed areas.

Incidents that are not classified as serious are provided to ESV in a quarterly report. Quarterly reporting previously included Schedule 1 and 2 incidents, but ESV is instigating changes to this reporting to separately identify Schedule 1 and 2 incidents (reported through OSIRIS) from other incidents incidents just reported on a statistical basis.

Opinions vary as to the level of information requested by ESV. At least one DB representative noted that there is considerable information that is not requested; another that the reporting is already too burdensome, and that there appears to be little justification for the required level of reporting in the data products by ESV.

2.2.2 Data Description

Incident records submitted through the portal are very detailed, within the limits of of manual portal-based data capture. The provided data comprise some 129 fields. Here, we focus on the data that are germane to the question of fire starts (Table 2.1).

Table 2.1: OSIRIS data types germane to analysis of fire incidents.

Variable	Type	Notes
Submission Date	Continuous	To the nearest minute
Network	Categorical	Name of DB owning the assets
Description	Free text	Narrative description of incident
Address	Geo-coded text	
Latitude	Continuous	Coded from address or separately entered
Longitude	Continuous	Coded from address or separately entered
Location type	Categorical	
Incident Date	Continuous	To the nearest minute
Assets involved	Categorical	Multiple selections can be entered sufficient to detail the incident
Incident consequence	Categorical	Multiple selections can be entered sufficient to detail the incident
Incident fire size/severity	Categorical	Four categories
Incident cause	Free text	Narrative description of the causes of the incident
Incident cause	Categorical	Multiple selections can be entered sufficient to detail the incident. Selections are separately made against major cause types of technical, environmental, work practices and community.

2.2.3 Assessment

A formal assessment of the quality, integrity, and consistency of the data would require a substantial investment of effort on behalf of the reviewers and also ESV. That exercise would involve a rigorous comparison of the data holdings within the DBs and the data submitted to ESV, and a tracing of the data capture and development processes within the DBs back to the original incidents.

This section of the current review will describe and assess the data curation processes that ESV has developed that should mitigate against failures of data capture. There are two primary risks in the analysis of incident data provided by third parties, namely (i) missing or inaccurate fields, and (ii) missing records.

2.2.3.1 Risk: missing or inaccurate fields

The first risk concerns the fidelity of the submitted records. These records may have fields that have missing or inaccurate data. OSIRIS performs some testing as the data are entered.

This risk is addressed by ESV in the following ways:

- The OSIRIS system has been set up to require that those fields necessary to define the incident are mandatory and that an incident report cannot be submitted without the information provided being complete.
- Once the incident report is received by ESV, it is subject to review by an incident investigator before the report is accepted by ESV. The OSIRIS system allows reports to be referred back to the distribution business for clarification or addition of information before it is accepted and transferred to the Conduit system for analysis.
- The review of incident reports by ESV's incident investigators (see above) includes the review of submitted responses of categorical fields against the free-text descriptions of the incident and the causes of the incident.
- A review of the data quality is independently undertaken to identify and correct anomalies before ESV prepares its network safety performance report each year. Any systematic anomalies are fed back to incident investigators to improve the oversight practices or captured as improvements to the OSIRIS portal (see Appendix E).

Although ESV is addressing data completeness as part of its ongoing data capture processes, there are historical incident data that lack useful information for analyzing the change in fire risk. Incident data that were submitted to ESV before OSIRIS was implemented are available as ignition counts in broad asset categories but not by location or DB.

Recommendation 1. *Historical fire incident data are held by ESV but only at an aggregate level. ESV should try to obtain incident-level historical fire data in order to improve models of the network effect on fire risk.*

2.2.3.2 Risk: missing records

The second risk is concerned with whether the database is missing records. This may happen when incidents are misclassified. This risk is addressed by ESV in the following ways.

- A triage process has been developed to better clarify the types of incidents that are reportable to ESV and the timeframes for such reporting. This is currently being reviewed in consultation with the DBs.

- Guidelines are being developed, including photographic examples, to better clarify the nature of fire-related events that are reportable to ESV.
- Discussions are underway with the Metropolitan Fire Brigade (MFB) and Country Fire Authority (CFA) to improve data sharing between the agencies. One of the advantages of this would be that ESV will be able to triangulate the details of fire-related incidents to provide verification and supplementary data to inform investigations.

2.3 Incident Data Uses by ESV

ESV reports weekly to the Minister for Energy, Environment and Climate Change's office during the fire season. The weekly report is a pro-forma that includes routine information such as the Bushfire Mitigation Index (BMI), vegetation management components such as electric line clearance, and event descriptions. There is genuine interest in the report.

The report provides situational awareness, detailing what is happening and what information ESV is receiving that the stakeholders do not. ESV's report provides a more direct route to the information, that is, more depth, than is provided by CFA and MFB. However, few decisions are made directly as a consequence of the report. If a sustained upshift in non-compliance were observed then ESV would be questioned, and there would be implications for operational readiness, including resource planning implications.

Recommendation 2. *The weekly fire report to the minister is a valued service for the emergency management sector. ESV should consider adding value by providing extra summaries, such as a graphical region-specific summary of fire starts and other incidents.*

The specification and reporting of BMI by the MECs (Major Electricity Companies) was a concern. Stakeholders commented that it was unclear whether the reported BMI had undergone any checking or audit for accuracy by ESV, and the dimensionless nature of the index made it difficult to interpret. ESV is currently reviewing the contents of the fire start report in order to provide better quality information that has been reviewed. This review may see the replacement of snapshot details (such as BMI and non-compliant vegetation spans) with graphs of DB performance (e.g., actual clearance by region vs planned program). The report quality also depends on the accuracy and completeness of the event descriptions, including fire starts. The report is used to cross-reference subsequent incident reporting for computing the F-factor.

Recommendation 3. *The value of some of the contents of the weekly fire report, such as self-reported BMI by electricity DBs, are undermined by uncertainty about their meaning and oversight by ESV. ESV should provide stakeholders with assurance as to the impact, regulatory value, and neutrality of these measures. For example, does a sustained BMI of 0 correlate to a empirically lower fire risk? Alternatively, ESV could consider the inclusion of more informative measures of performance.*

A number of the DB representatives noted that they would value a high-level analysis of the incident data, such as starts, causes, and so on, to help them anticipate potential trends in their own regions.

Recommendation 4. *ESV should consider circulating the weekly fire report — or a similar report with sensitive material omitted — to the contributing electricity DBs in order to close the data capture loop and provide a valuable tactical service to its stakeholders. This is not, strictly speaking, ESV's role, but regardless may lead to improvements in data quality and overall outcomes. ESV should discuss the content and mechanism with the stakeholders.*

2.4 Data Not Being Collected by ESV

This section addresses the question of whether ESV should be collecting other data types. The question of what data *should* be collected rests more in the nature of the use and interpretation of outputs from analyses of the data than it does in the database itself. Therefore it is necessary to determine who are the stakeholders of the data outputs, what are the uses and interpretations placed upon them, and the statutory directions underpinning the uses and requirements.

It is reasonable to believe that a more nuanced idea of the risk of fires can be achieved through reporting the total size or damage of the fire upon its conclusion. Presently, ESV requests fire size as an ordinal variable (namely: *Negligible*: no ground fire; *Localised*: less than 10 sq.m; *Small*: 10 – 1000 sq.m; *Medium*: 1000 sq.m – 10 ha; and *Large*: more than 10 ha). However, the DBs would be able to report more exact area and damage. An ordinal summary is arguably sufficient for the tactical response, but greater strategic value may arise from more precise information about fire impact. This is because splitting a continuous variable, such as fire extent, into an ordinal variable, creates a reduction of statistical information.

More detailed fire information is held by the fire authorities, CFA and MFB. Requiring DB fire records to be linked to CFA or MFB data will provide a further check on data quality and more detailed fire information, although these data are recognized as having their own flaws (see Section 5.1). ESV accepts the need for triage to add value to and to challenge the reporting by the DBs.

Recommendation 5. *Presently, fire extent data are reported to OSIRIS as a five-class ordinal variable. ESV should consider requiring that submitted fire records be linked to CFA or MFB data in order to provide a further check on data quality and more detailed fire incident information.*

The DBs hold considerable information that is relevant to the risk of incidents but are not obliged to report this information, and it is not clear that ESV is currently resourced to be able to use these data constructively were they made available. However the data provide a potentially substantial source of information about the risk to the network, both when incidents are occurring and when they are not, such as (i) asset inspection outcomes, (ii) faults on systems that could cause fire, or (iii) smart meter readings. Such information could be used as lead indicators of risk to assist ESV and the DBs in identifying areas of the network that most need remediation activity. Analysis on these data resources may be undertaken by the DBs already, in which case ESV could implement a safety case regime. Some DBs are informally reporting some of these measures.

Recommendation 6. *The Electricity division should consider the use of KPIs to enhance the level of self-reporting and communication in the electricity sector.*

Contextual information is critical for assessing the performance and risk of the network. The number of fire starts and the total damage — however it be defined — would be placed in context better if background information were available about the vulnerability of the systems in which the networks are embedded. For example, the overall fire risk can be represented by proxy variables such as the number of bushfires in each region. A simple analysis would include the total number of fire starts in each region, to show whether the relative contribution by the DB networks is increasing or decreasing. This would permit a statistical correction to fire start numbers.

Recommendation 7. *Contextual information about the overall fire risk, such as the total number of fire ignitions by region, would provide a useful background against which to compare the number of fire incidents for each company. ESV should source total fire ignition data from CFA and MFB to enable a relatively simple context-sensitive analysis.*

Further information may be valuable about the relative risk of different incidents. For example, fire starts that occur during locations and durations of total fire ban could be reported separately. Likewise, there are smaller incidents that have the potential to ignite fires but from which, for some reason, fires or even near-misses do not result. Other stakeholders, such as Emergency Management Victoria (EMV), may also find value in these data. Such indicators are collected, for example, in New South Wales [4]. These may be considered lead indicators of risk, and again, could be cross-referenced with regional days of total fire ban.

Recommendation 8. *Contextual information is critical for assessing the performance and risk of the network. ESV should convene a multi-stakeholder working group, including the DBs, CSIRO, EMV, CFA, and MFB, to determine the best indicators of contextual fire risk and how they might be best used in the analysis of network performance.*

3

Gas Network

ESV is responsible for monitoring and regulating the safety of Victoria's gas pipeline network. As part of its regulatory function, ESV requires that stakeholders report network incidents. This chapter describes the data collection processes.

3.1 Background

The gas network includes natural gas transmission pipelines, gas mains and services. This includes in excess of 5,000km of licensed pipelines and 30,000km of gas mains servicing nearly 2 million Victorians.

The primary stakeholders providing data are three DBs, namely: Multinet and United Energy, AusNet Gas Services and Australian Gas Networks. There are also ten Natural Gas Transmission Licensees.

The development of gas intelligence capability as per the current organisation structure is about 30 months behind the electricity arm of ESV. Thinking about analytics is now moving to the front and centre. Having recorded no gas deaths for over 10 years, it is reasonable to believe that system is arguably safe, however, the regulator cannot be complacent.

3.2 Data Being Collected by ESV

3.2.1 Data Capture

On the gas side of ESV, incidents are classified as being reportable or not reportable. Incident reporting is free form; some companies submit their data by email, and some send spreadsheets. There are presently no tight definitions for the data; development of these definitions is continuing.

Incident data are transcribed to the Complaints and Incident Management System (CIMS) database by ESV personnel. There is no automated error checking. The degree of subsequent communication between ESV and the company that reported the incident depends on the seriousness of the incident. Some organizations will triage incident reporting, with multiple stages.

Stakeholders questioned the kind of information that was requested. For example, the DBs can record the level of emergency and ESV attendance, but stakeholders expressed uncertainty as to whether this information was being used, and its value. ESV recognises that its current system is not fit for purpose and is in the process of reviewing its data capture procedures and policies for the gas network.

Recommendation 9. *ESV recognises that its information capture for gas network incidents only permits manual data entry, and the system is not fit for purpose to support strategic analysis of its data holdings. ESV should investigate the availability of, and implement, a comparative analysis tool that best addresses the demands of monitoring multiple industry groups with differing reporting requirements.*

Non-reportable incidents are captured in the KPIs. KPIs are reported to ESV quarterly using a template sent by email. Industry groups have KPI spreadsheets that they are required to report within 20 business days after end of quarter. These indicators include information about risk mitigation exercises such as Cathodic protection and emergency response exercises.

Upon arrival, the KPIs are manually sorted to folders and assessed, but there is no strategic framework and limited analysis. The KPIs are presently under review, and it was not clear who were the stakeholders for the reporting.

Recommendation 10. *ESV should identify the needs of stakeholders that use the monthly report. This includes establish, and report on indicators that provide a reflection of gas network integrity and shortfalls.*

3.2.2 Data Description

As the incident data are delivered free form to ESV, there is no fixed reporting or format. Table 3.1 describes the incident data as it was made available for this review. The data are stored on CIMS, which is a PEGA-6 style database that is designed for case management and does not facilitate strategic analysis.

Table 3.1: Gas network data types germane to analysis of fire incidents.

Variable	Type	Notes
Event ID	String	Identifier
Status	Categorical	Incident status with levels such as Resolved, Review, Investigation Underway, and so on.
Category	Categorical	Gas, for example
Sub-category	Categorical	Distribution or Transmission
Summary	Free text	Brief narrative description of incident
Description	Free text	Narrative description of incident
Event Occurred	Continuous	Time to the nearest minute
Assigned Operator	Free Text	ESV personnel
Street No.	Free Text	Address portion
Street	Free Text	Address portion
Suburb	Free Text	Address portion
Postcode	Integer	Address portion
Company Name	Free Text	Where relevant, the company at which or upon whose assets the incident occurred.

A more detailed work-up of data was provided for the 2016–17 FY, which included extra fields, namely gas type, environment, equipment type, cause, incident type, consequence, injury type, property damage, and incident notification. There were six such incidents in transmission and 66 in distribution, five of which had incident type of "Fire, explosion".

3.2.3 Assessment

3.2.3.1 Risk: missing or inaccurate fields

ESV audits the KPI data on an ad-hoc needs basis. There are no formal systems for verification of all KPIs reported. Some KPIs can be validated, e.g., emergency response exercises, as ESV can ask for reports. Previously, audits were driven by what ESV had seen in field inspection. There is no general systemic check or strategic analysis of outcomes to form a view of more or less compliant companies.

Recommendation 11. *Quarterly reports of gas network KPIs are emailed to ESV, but there is no strategic framework for auditing these data. ESV should implement random audits of network KPI records, to form an impression of the compliance rates of the data contributing stakeholders. The random audits should then be weighted towards stakeholders with a history of non-compliance and towards activities that are material to reducing catastrophic incident risk.*

3.2.3.2 Risk: missing records

There are no formal mechanisms for checking incident data with the data provider. However, KPI data that are not submitted (within 20 business days at end of quarter) are followed up by Gas and Pipeline Infrastructure Safety (GPIS) directly via email to the responsible stakeholder. This ensures entities are accountable for submitting the KPI reports.

3.3 Incident Data Uses by ESV

The CIMS database is a PEGA 6 system, which is a work management system that focuses on independent transactions. CIMS is searchable but exporting is limited, which impedes strategic analysis of incident data. For example, it is very difficult to search by category and nature of incident. We note a recommendation above (Recommendation 9) that ESV continue its review of incident data capture and handling systems and replace the PEGA-6 system with a system that enhances strategic analysis instead of hampering it.

ESV constructs a monthly report that includes high-level tabled statistics and some case data. This report covers case management. Constructing the report involves extracting data from transactional systems, and is therefore effortful. In addition to the CIMS database noted above, the KPI data are held in spreadsheet templates and data extraction is manual.

Recommendation 12. *ESV should continue the review of the collection, use, and analysis of gas network KPI data. This review should be expanded to include the handling of the KPI data, which is presently manual. A modest investment in a high-level programming language such as Python or R would deliver great efficiencies in terms of data handling and reduce errors.*

3.4 Data Not Being Collected by ESV

The uses for ESV's gas data reports are less clear, and the stakeholders that rely upon the reporting were not identified. Therefore it was difficult to form an opinion about whether or not all the data that should be collected are being collected. A recommendation has been made above that ESV should identify the stakeholders that use the monthly reports and, when these stakeholders have been identified, tailor the KPI data collection and reporting to enhance the value of the reports (Recommendation 11).

However, interviews with stakeholders undertaken for this report showed that useful data that could potentially be collected were not being collected. For example, asset maintenance data and network pressure data are not routinely required, and these could be used as lead indicators of incident risk. Furthermore, in incident data collection, ESV could ask for causal factors and remedies, both tactical (for this incident) and strategic (for this kind of incident).

Recommendation 13. *ESV should consider collecting lead indicators of gas network risk such as asset maintenance data and network pressure data, and for reported incidents should ask the stakeholder to identify the causal risk and the planned tactical and strategic remedies.*

4

Data Analysis

This chapter focuses on our analysis of the incident data that were kindly provided by ESV personnel. The analysis is presented in two sections: the electricity network, which is also represented in the appendices, and the gas network.

4.1 Electricity Network

For the purposes of this report, we categorised an incident as being a fire incident if any severity fire was recorded (`incidentFireSeverity`).

4.1.1 Incident Characteristics

This section provides a breakdown on the characteristics associated with reported incidents. The provided data covered the dates February 2015 to June 2017 inclusive.

The OSIRIS system was launched by ESV in October 2015, to enable electricity distributors to report incidents online. As the data provided covered dates earlier than the system start date, we restrict the analysis to dates after September 2015; there were 2877 incidents reported between October 2015 and June 2017.

Table 4.1 displays the number of incidents over the whole period by the electricity distributor, and by whether the incident was a fire incident or not. Figure 4.1 shows the number of incidents per quarter, by electricity distributor, for the two years of data available in OSIRIS. Powercor has the highest number of each kind of incident. Figure 4.2 shows the relative occurrence rates of fires by distributor across time.

Table 4.1: Number of incidents, fire and non-fire, by distributor. The Percentage column reports the percentage of all incidents that were fire incidents.

Distributor Name	Non-fire incidents	Fire incidents	Percentage
AusNet Services	264	235	47
CitiPower	163	35	18
Jemena	205	60	23
Powercor	845	521	38
United Energy Distribution	377	172	31

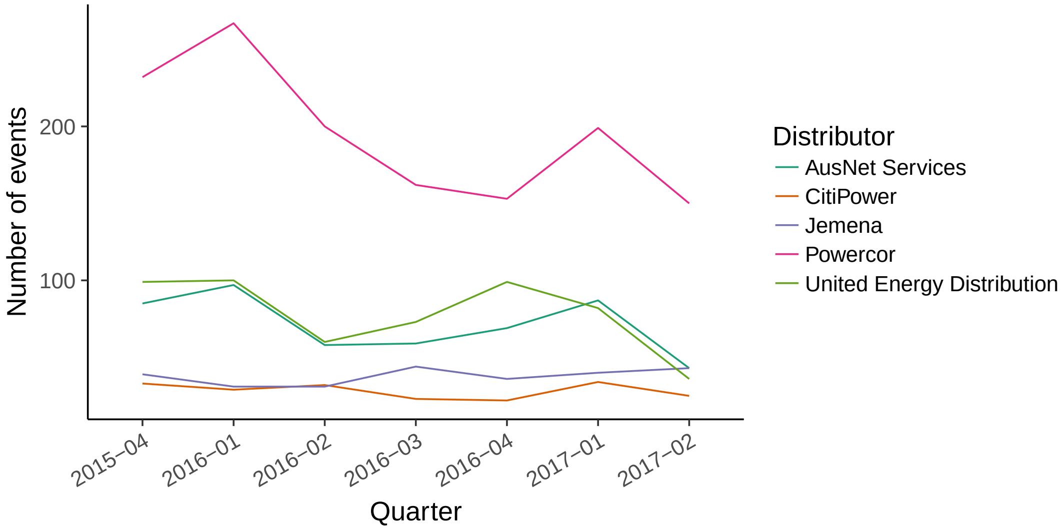

Figure 4.1: Number of incidents per quarter by distributor.

4.1.2 Modelling Energy Safe Victoria Incident Data

In this section we construct statistical models of the ESV incident data to assess whether there have been any changes in the rate of incidents over time and analyze the rate of incidents within distributors. This analysis should be treated as preliminary and indicative only because there are presently insufficient data to take account satisfactorily of other potential risk factors.

We assume here that the incidents are independent; that is, the location, timing and/or number of previous incidents does not increase the risk of any future incident. This assumption is a simplification, but it permits an analysis of the data that is descriptive and more readily understandable than models relaxing that assumption. A complete analysis would need to verify whether this assumption is reasonable.

Figure 4.3 displays the observed time between fire incidents by distributor.

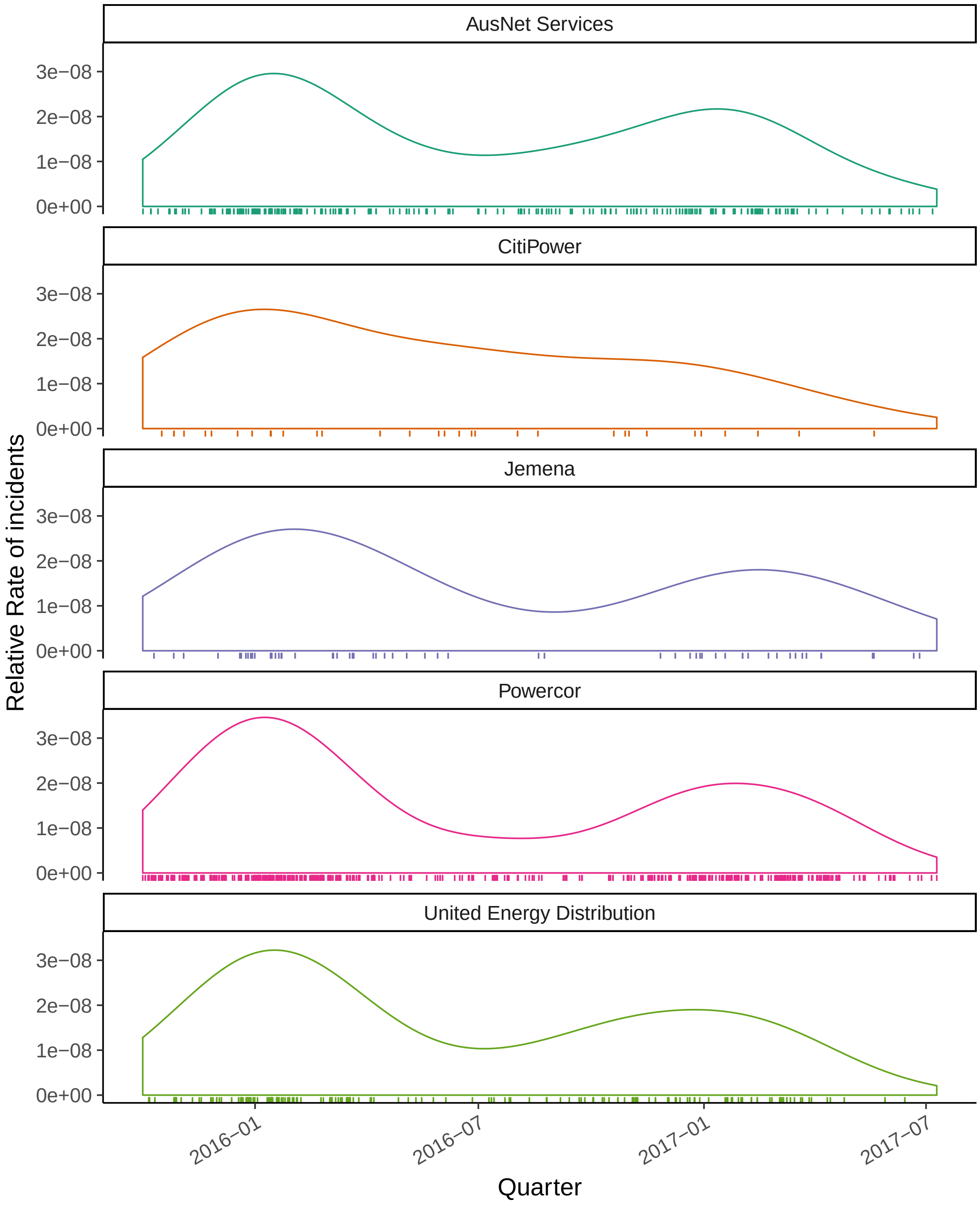

Figure 4.2: Relative rate of fire incidents by time by distributor. The rate is computed from a smoothed moving window. Fire size is ignored. The area under each polygon is set to be identical.

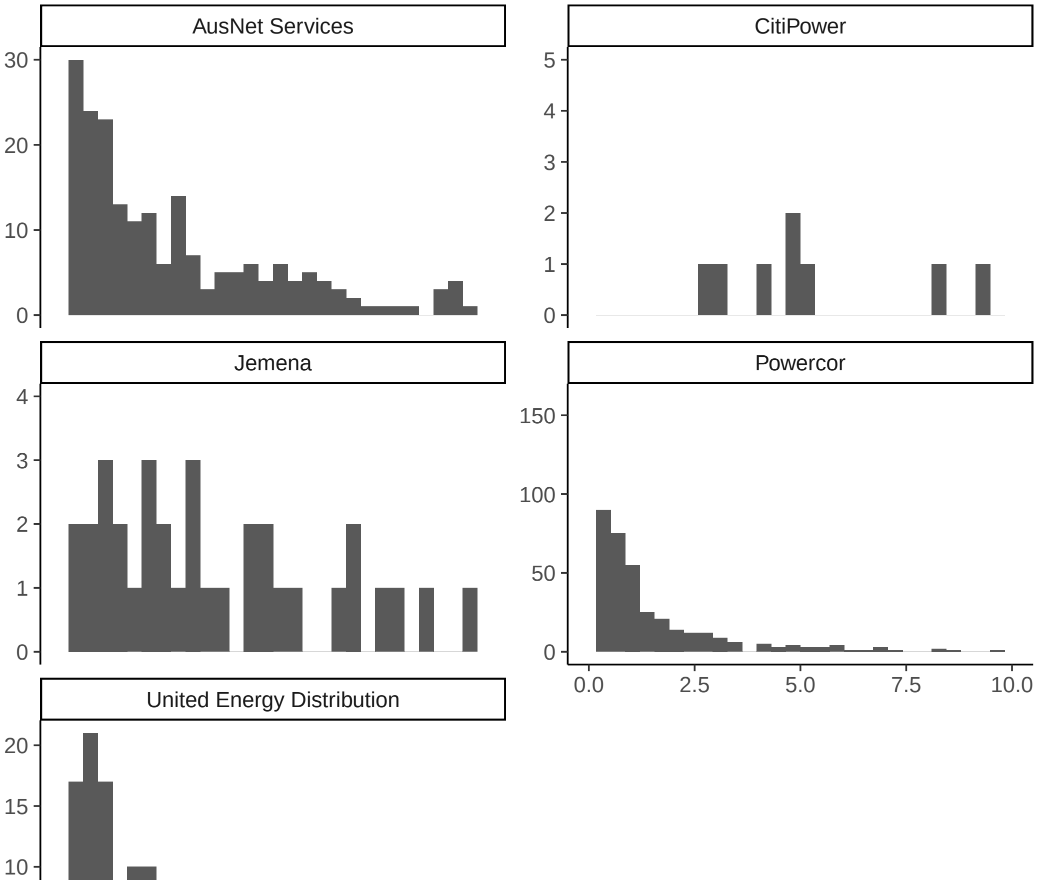

Figure 4.3: Observed time (in days) between fire incidents, by distributor.

4.1.3 Model Specification

There are a number of outcomes (response variables) that could be considered for modelling. Here we focus on two: (i) the time between all incidents, and (ii) the time between incidents involving fire.

As predictor variables we consider (i) the distributor, and (ii) the year of the event. These variables allow us to make comparisons between distributors, as well as assessing whether the rate of incidents seems to be increasing or decreasing over time.

In particular, we investigated four different model specifications:

M0 A model that includes a grand average term only. That is, no distributor or time effects are modelled.

M1 A model that estimates distributor-specific effects. No accounting for the period of the incident is estimated in this model.

M2 A model that estimates both distributor-specific effects, and period (year of incident) effects; these two effects are modelled independently of each other.

M3 A model that estimates distributor by period effects; i.e., there is a *different* effect of the period within each distributor (the so-called interaction model).

This analysis is for the purposes of demonstration only; the specification of time by years is unsatisfactory because of the different time periods involved. It would be preferable to split the data into financial years in order to not cut across the fire season, however, we only have one complete FY in the data.

4.1.4 Results

The model results show that there is a difference between distributor but not between year (see Appendix C.2). Figure 4.4 displays the fitted values for each distributor; the lines show 90% probability intervals. These results are not interesting in and of themselves because the model lacks information about the context, specifically, the background risk in the regions that are occupied by each DB.

Results of a similar analysis applied to all the incidents are presented in Appendix C.3.

Appropriate analysis of fire incident data is a complex statistical challenge. Incident data are most faithfully captured by a statistical model called a *point process* [see, e.g., 5]. The application and interpretation of such models would be a substantial undertaking. Ideally, we would also have information on the background fire risk, for example as might be captured by the total number of fires in each of the regions.

It is possible to represent the data as the number of occurrences per unit time, but the disadvantage of such a representation is the necessity of an arbitrary choice of time period duration and start. For example, analyzing fire incident data using an annual time step (as we have above, forced by time) creates an unnecessary and deleterious boundary between incidents that occur on June 30 and July 1. Further, the interpretation of time periods as independent observations is arbitrary and questionable.

Recommendation 14. *ESV should convene a working group that includes representatives from CSIRO, CFA, and MFB to develop standards for the statistically appropriate analysis of spatio-temporal fire incident data. This should include consideration of how best to represent the processes and what data to use as a source of background risk. Such models could use contextual information that ranges from*

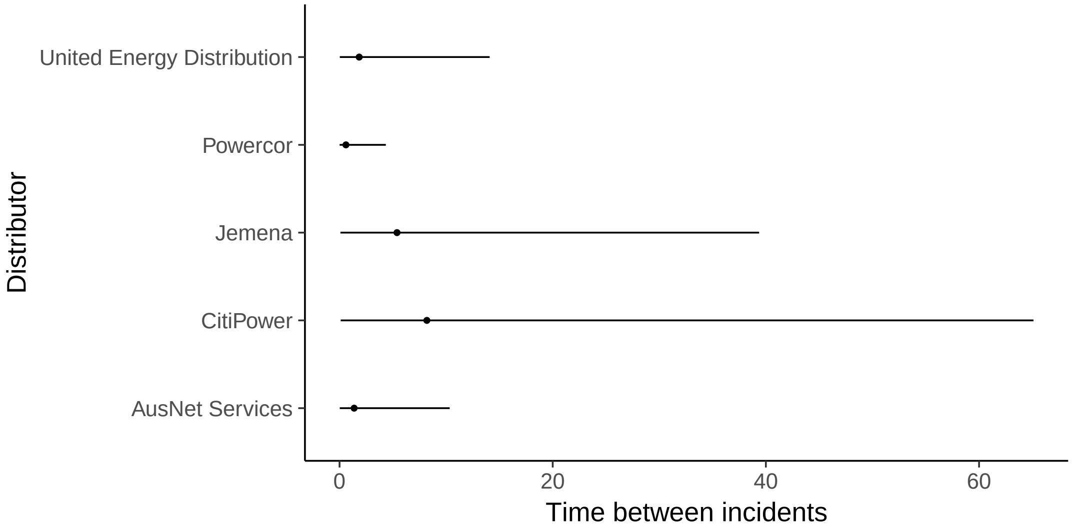

Figure 4.4: Overall estimated time between fire-related incidents by distributor. The intervals are 90% probability intervals for the estimated values.

empirical (such as the total number of fire ignitions in each region) through to mechanistic (including consideration of meteorology, fuels, suppression efforts, and so on).

4.2 Gas Network

This section provides a summary of the Gas Network data provided by Energy Safe Victoria (ESV) for analysis.

4.2.1 Incident Characteristics

This section provides a breakdown on the characteristics associated with reported incidents. The provided data covered the dates March 2013 to May 2017 inclusive. Over this period, there were 470 incidents related to distribution, and 55 related to transmission. Figure 4.5 displays the number of incidents per quarter, by category (distribution/transmission).

As only five of the incidents in the last financial year resulted in fire, and we do not presently have information on the number of fire incidents in other years, we do not advocate further analysis of these data at this time.

Recommendation 15. *That ESV develop a strategic dataset of gas incidents that includes indication of whether or not the incident involved fire, and subject the dataset to similar analytic scrutiny as developed and recommended for the electricity network.*

4.3 AER Data (Electricity)

The Australian Energy Regulator (AER) determines an annual target number of fire starts for distributors, which is used as a performance benchmark. The AER data were sourced from the AER website.

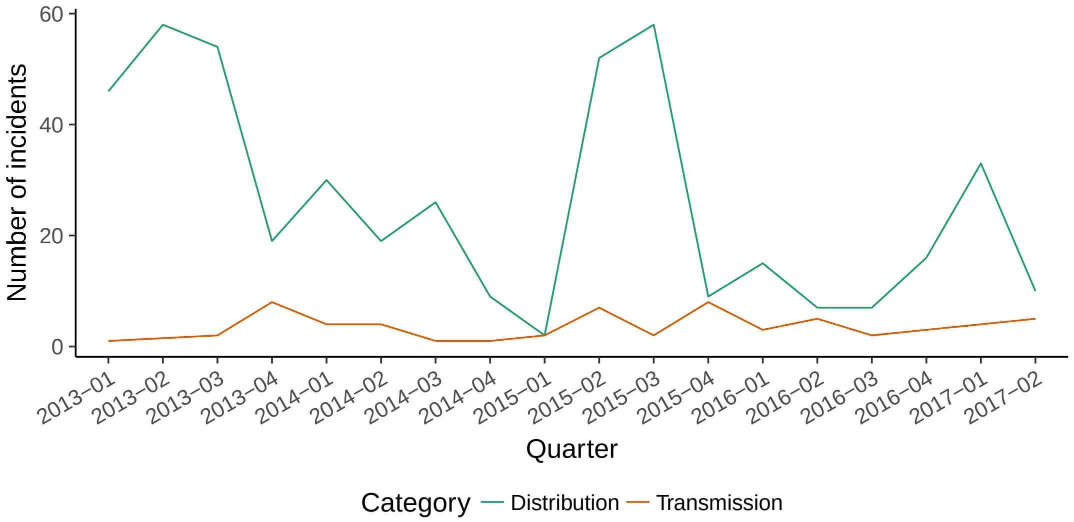

Figure 4.5: Number of incidents on the gas network per quarter by category.

The AER data is contained within PDF documents as reported by the DBs, and is thus not amenable to an in-depth analysis without significant data processing. For this reason, we present the aggregated total number of fire starts by distributor for years 2014 and 2015.

Unfortunately we were not able to compare the AER data to the ESV data; this is because the DB-specific ESV data were only available from February 2015. We do not have data from the AER for 2016, which is the first full year for which we have ESV data.

4.3.1 Fire Starts by Distributor

In this section we present the number of fire starts by distributor as reported to the AER. Note that for these reports, there is no distinction made between the distribution and transmission networks of AusNet Services; the counts shown are the sum of both networks.

The definition of *fire* used by the AER is narrower than that used by ESV. The AER definition primarily considers whether there was a flame. ESV's definition includes blackening, charring and melting. These additional factors are considered as lead indicators, whereas appearance of flame is a lag indicator.

Figure 4.6 shows the total number of fire starts by distributor, for each of 2014 and 2015, with the F-factor added as an extra field. All distributors have reduced the number of fire starts they are responsible for between 2014 and 2015. Ausnet was below its F-factor both years; the other DBs were above their F-factor in 2014 and below in 2015.

Recommendation 16. *There was insufficient overlap between the AER data and the ESV fire incident data to enable a comparison. ESV should attempt an analytical comparison when the AER data are available that overlap sufficiently with the fire incident data held within OSIRIS or source historic fire incident data as per Recommendation 1.*

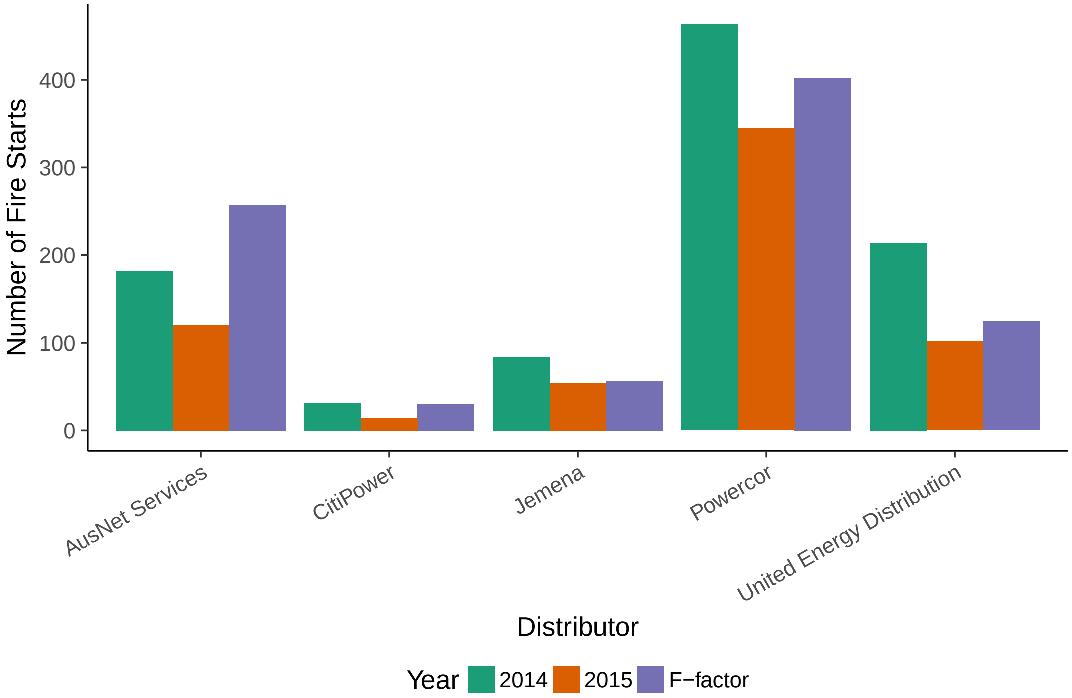

Figure 4.6: Number of fire starts per year by distributor, as reported to the AER.

5

Opportunities

This chapter provides an overview of other opportunities that arose during our discussions with ESV and its stakeholders.

5.1 Fire Incident Data Analysis

Some attempts have been made by various parties to analyze fire incident data in the light of fire risk [10, 9, 6, 2]. These analyses usually apply a process-based approach, including, for example, meteorological data. A more complete analysis would include asset information, threat to asset, impact at point, surrounding fuel, and so on. This leads to a better understanding of fire in the landscape and the role of the power network. This kind of analysis would be a very substantial investment, requiring cooperation across numerous agencies and the analysis of significant volumes of data.

An advantage of developing such a model is that it would pinpoint the increase in fire incident risk due to different network assets and enable a clear prediction of local risk, which would in turn enable optimised or at least risk-based investments in network intervention. Therefore it would enable more efficient regulatory intervention, as well as reporting the urgency of such intervention. It would also enable a comparison with simpler empirical models that might be cheaper to deploy across space and time. It would enable a clearer answer to the motivating question, which is whether the fire risk arising from electricity networks is increasing, decreasing, or stable. However, such a model would require substantial ongoing investment in data capture from the Bureau of Meteorology (BOM) and other parties.

However, there are further complications. It is easy to capture conditions at the time of the incident, but some common events such as crossarm fires are postulated to be due to aggregated conditions over a period leading to the fire (i.e., dust deposition over period, no rainfall to wash away deposition plus high humidity (mist/fog) to wet the deposit and create a medium for voltage transfer). Collection of meteorological data for the preceding period is difficult because the duration over which data needs to be collected is uncertain; for example the length of the needed period could depend upon rainfall patterns.

Recommendation 17. *ESV should collaborate with CFA, MFB and EMV to engage CSIRO to undertake a study on how fire data could be better captured to meet the needs of all four agencies. This should include electricity DB data on fires from the networks. This data definition and collection exercise should also include considerations of empirical and mechanistic measures of fire risk.*

Bushfire data are in general of low quality — they are error prone and vague, and the agencies (CFA/MFB) lack data quality control systems. The agencies would value better data but there is a capability gap. Data capture protocols have changed in time, and they vary by source — e.g., there are differences between records kept by DBs, CFA, and MFB. Bushfire data are collated by AFAC (Australasian Fire and Emergency Service Authorities Council) but there are no reconciliation exercises. Recommendation 5 suggests that ESV should require that the DBs link the fire incident data records with records held by the fire agencies.

Further complication is added by the coding of *fire complexes* — the agencies typically identify one fire to carry the complex record, but this creates confusion when a complex has multiple causes. Fire data lack the needed framework to capture a hierarchy of ignitions, which is key to interpreting complex fire behaviour. Poor data quality prohibits answering important questions such as: why are fires caused by the electricity network the deadliest [8]?

5.2 Enhance Strategic Value

ESV could provide a strategic analysis of DB data back to the DBs. This undertaking would (i) close the loop on data provision, thereby enhancing data quality; (ii) provide feedback on data usage; and (iii) provide valuable tactical information to the DBs about generic network risks. Causal trends that are specific to a network may be relevant to another network in which they are yet to be evidenced. DBs that experience encroachment by third parties might appreciate information on the number of repeat offenders, or an analysis on the effectiveness of Dial Before You Dig (DBYD).

Recommendation 18. *ESV should engage with the stakeholders that provide data to determine what high-level cross-company analyses would provide value to them, building on the suggestions here. ESV should undertake to develop and provide these analyses on an ongoing basis as a service, with appropriate caveats in place to ensure that such reporting does not impinge upon the electricity DBs' responsibility to manage their risks.*

Safety is a cooperative undertaking. No DB benefits when other DBs fail, and the success of each depends upon the success of the others. ESV is well placed to provide an opportunity for the DBs to learn from one another in terms of monitoring the safety and compliance of their networks.

Recommendation 19. *ESV should develop and invest in a community of practice for risk-based analytics among the major DBs in order to better apprehend the opportunities for regulatory network monitoring and intervention.*

6

Conclusions

6.1 The Effect of Network Assets on Fire Risk

The motivating question for this report was: is the risk of fire starts that arise from network assets increasing or decreasing in time, after taking account of other sources of variability? At this point, ESV is not positioned to make a convincing claim about the effect of network assets on fire starts, because it is not possible to take account of other sources of variability. This report makes recommendations that, if followed, would develop the data resources necessary to address the question.

The push by ESV to assess changes in the fire incident risk of the electricity and gas networks is hampered by the lack of information about the background risk of fire incidents. Without this information it is impossible to tell whether changes in fire incident rates reflect ameliorative efforts or systemic changes in the underlying fire risk. There are two overarching strategies that can be used to try to compare the observed network fire incident rate against some kind of index: *empirical* and *mechanistic*, each covered briefly here.

An example of the empirical approach to estimating a background risk involves comparing network fire incident rates (or damages, etc.) against the overall rates of fires experienced in the state. This comparison could be made a variety of ways, by region or across the state, and so on, by fitting a suitable statistical model. All it would require is the state-level fire incident data. These data are not perfect, but they may well be good enough. This kind of model cannot be used to predict fire risk in advance, but it can be used to assess whether the realized risk of fire incidents due to the networks is increasing, decreasing, or constant. Recommendation 7 concerns this direction.

An example of the mechanistic approach to estimating a background risk involves a process model of fire ignition, which requires detailed meteorological data, fuel data, asset status, and so on. This kind of model can be used to predict fire risk in advance as well as to assess whether the realized risk of fire incidents due to the networks is changing. However, it requires a great deal of data. This kind of approach has been used with some success by local fire scientists [see, e.g., 8].

6.2 ESV

It is fair to say that the current assessment finds ESV in a development phase. ESV was criticized by the 2009 Victorian Bushfires Royal Commission [11], and has been developing and refining its data capture and curation processes since. The vast majority of this report's comments and recommendations are already known by ESV, and many reflect work that is already underway.

The electricity side of ESV is maturing rapidly but still has plenty of scope for improvement. The recommendations arising from this report may provide some suggestions for fruitful strategic directions.

The gas side of ESV is lagging behind the electricity side by a substantial distance. Although superficially this lag present advantages — being able to learn from the electricity side's mistakes, for example — the significant disadvantage is that inefficient data capture and data processing are consuming a substantial amount of personnel time.

There is a recognition within the organization about the importance of developing and using lead indicators of risk — that is, indicators that can be used to predict the risk of incidents before they happen — as well as lag indicators, which can only be used to explain incidents after the fact.

To sum up, ESV is heading in a fruitful direction in terms of their data capture and analysis, developing productive partnerships with third parties such as CSIRO, and shifting their processes to deliver more efficient regulation. There is a considerable amount of work to be done, but ESV are well positioned to do it, taking account of the recommendations made in this report.

6.3 A Safety Case Approach

The final recommendation is outside the scope of the current report, although it is reflected in some of the discussions that we have had during this project. It is clear that the DBs already invest considerably in data capture and analytics to manage the risk of their networks, although the motivations may be primarily economic. The DBs know much more about their networks than ESV reasonably could. Furthermore, the DBs manage a variable palette of risks based on the environments in which their networks are located. A complete regulatory analysis — a deep dive — into each DB's network risk would create considerable duplication of effort.

Rather than have ESV try to assess the network risk across the diverse range of different activities, it seems preferable for the responsibility of risk management to fall upon the DBs, and for ESV to set performance requirements and audit performance. This is the *safety case regime*, whereby the operator outlines their safety proposition for what safety means, and a plan for achieving it, and conduct assurance activities to demonstrate that risk is controlled to the specified performance standards and as per the proposed plan. The regulator requires assurance program outputs that are relevant to demonstrating compliance with the Safety Case, and would also conduct auditing activities to test this directly.

Recommendation 20. *(Outside report scope): That ESV consider imposing the responsibility for reporting network risk upon the DBs. The DBs have the needed data, are already undertaking the necessary analyses and activities, and are best positioned to implement actionable outcomes. ESV should develop and retain the needed analytical capability to audit the DBs data collection, analysis, and reporting for (i) appropriateness to detect risk, and (ii) fidelity to accepted standards.*

Bibliography

[1] *2016 Safety Performance Report on Victorian Electriciy Networks*. Energy Safe Victoria. Sept. 2016.

[2] Simon Dunstall et al. *PBSP Risk Reduction Model Overview and Technical Details*. Tech. rep. CSIRO, 2017.

[3] *Electrical Incident and Safety Performance Reporting Guidelines*. 1st ed. Energy Safe Victoria. June 2016.

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[5] David Harte. “PtProcess: An R Package for Modelling Marked Point Processes Indexed by Time”. In: *Journal of Statistical Software, Articles* 35.8 (2010), pp. 1–32. ISSN: 1548-7660. DOI: `10.18637/jss.v035.i08`.

[6] Carolyn Huston et al. *Catastrophic Fires Hypotheses 1 & 2: Investigating why bushfires started by power transmission systems disproportionately cause a loss of human life*. Tech. rep. CSIRO, Australia, 2015.

[7] *Information Specification Performance Indicators Requirements For Reporting By Victorian Gas Distribution Companies*. Essential Services Commission and Energy Safe Victoria. Jan. 2009.

[8] Claire Miller et al. “Electrically caused wildfires in Victoria, Australia are over-represented when fire danger is elevated”. In: *Landscape and Urban Planning* 167 (2017), pp. 267–274. ISSN: 0169-2046. DOI: `http://dx.doi.org/10.1016/j.landurbplan.2017.06.016`.

[9] Matt Plucinski et al. *Links between bushfires from powerlines and catastrophic fire events*. Tech. rep. EP142591. CSIRO, Australia, 2014.

[10] *Safety Performance Report on Victorian Electricity Distribution and Transmission Businesses 2012*. Energy Safe Victoria. June 2013.

[11] Bernard Teague, Ronald McLeod, and Susan Pascoe. *2009 Victorian Bushfires Royal Commission Final Report Summary*. Online document. `http://www.royalcommission.vic.gov.au/finaldocuments/summary/HR/VBRC_Summary_HR.pdf`, last accessed 21/7/2017. July 2010.

Appendix A

Acronyms

Table A.1: Acronyms used in report.

Acronym	Meaning
AER	Australian Energy Regulator
AFAC	Australasian Fire and Emergency Service Authorities Council
BMI	Bushfire Mitigation Index
BOM	Bureau of Meteorology
CEBRA	Centre of Excellence for Biosecurity Risk Analysis
CFA	Country Fire Authority
CIMS	Complaints and Incident Management System
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBs	Distribution businesses (e.g., Powercor, United Energy, Jemena, AusNet Services, and CitiPower)
DBYD	Dial Before You Dig
DELWP	Department of Environment, Land, Water and Planning
EMV	Emergency Management Victoria
ESV	Enery Safe Victoria
GPIS	Gas and Pipeline Infrastructure Safety
LOOIC	Leave-One-Out Information Criterion, a statistical device
MEC	Major Electricity Companies
MFB	Metropolitan Fire Brigade

Appendix B

Methods and Materials

This report is based on the following activities.

B.1 Electricity Network

- Interviews
    - Paul Fearon (Director of Energy Safety & CEO, ESV),
    - Ian Burgwin (General Manager, Electrical Safety and Technical Regulation, ESV),
    - Peter Greilach (Acting Manager, Analytics & Intelligence, ESV),
    - Brendon Frost (Head of Risk and Regulatory Practice, ESV),
    - Mike Tshaikiwsky (United Energy and Multinet Gas)
    - Phillip Bryant (Manager, Network Safety, AusNet Services)
    - Luke Farrugia (Network Safety Manager – Electricity Networks, Powercor)
    - Alan Shu (Assurance Manager Electricity, Jemena)
    - Simon Dunstall (Research Director, Decision Sciences Program, Data61, CSIRO)
    - Ashley Hunt (Director, Powerline Bushfire Safety Program and Energy Emergency Management, DELWP)
    - Lee Miezis (Deputy Secretary Forest, Fire and Regions DELWP)
- Review of materials
    - Electrical Incident and Safety Performance Reporting Guidelines [3]
    - 2016 Safety Performance Report on Victorian Electricity Networks [1]
    - 2009 Victorian Bushfires Royal Commission Final Report Summary [11]
    - ESV's OSIRIS incident reporting portal
    - ESV's Conduit analytics dashboard
    - Example Weekly fire start report to the Minister
    - Electricity Networks Reporting Manual of the Independent Pricing and Regulatory Tribunal of New South Wales [4].

- Examination of resources (provided in Excel format)
    - OSIRIS/Conduit data
        - extract of all submissions
        - extract of final copies of all incident reports, and
        - analyses underpinning the 2016 Safety Performance Report on Victorian Networks.
    - AER Fire report data.

B.2 Gas Network

- Interviews
    - Paul Fearon (Director of Energy Safety & CEO, ESV),
    - Steve Cronin (General Manager of Gas and Pipeline Safety, ESV)
    - Darren Tilley (Team Leader, Gas Intelligence, ESV)
    - William Hajjar (Engineer, Gas and Pipeline Infrastructure Safety Team, ESV)
    - Michael Weber (Data Analyst Gas Operations, ESV)
    - Liz Brierley (Head of Asset Management, SEA Gas)
    - Sam Pitruzzello (Engineering Services Manager, AusNet Services)
    - Sam Maloney (Pipeline Integrity Engineer, Lattice Energy)
    - Mark Beech (General Manager Network Operations, Multinet/AGIG)
- Review of materials
    - Information Specification Performance Indicators Requirements For Reporting By Victorian Gas Distribution Companies, Essential Services Commission and Energy Safe Victoria [7].
- Examination of resources
    - Gas Transmission and Distribution Incident data

Appendix C

Modelling Details

In this appendix we provide the statistical details of the models used in Chapter 4.1.2.

Modeling these data appropriately is a substantial undertaking, as noted earlier. The canonical statistical approach is to model the fire incident data using a *point process*, which relies on an underlying intensity function similar to that seen in Figures 4.2 and D.1, which itself is a function of candidate predictor variables. Alternative approaches include survival analysis, although the definition of the unit is questionable, and modeling the time between incidents, which is the approach taken here.

C.1 Model Setup

Recall from Section 4.1.3 that we have the distributor and the year of the event at our disposal as predictor variables. We fit three different model specifications; letting μ be the shape of a Gamma distribution these models are specified by:

$$\log(\mu_i) = \alpha \tag{M0}$$

$$\log(\mu_i) = \alpha + \beta_{d[i]} \tag{M1}$$

$$\log(\mu_i) = \alpha + \beta_{d[i]} + \gamma_{y[i]} \tag{M2}$$

$$\log(\mu_i) = \alpha + \beta_{d[i]} + \gamma_{y[i]} + \delta_{dy[i]} \tag{M3}$$

where $\beta_{d[i]}$ is the effect of the d^{th} distributor (relative to the base category, which we set as AusNet Services Distribution); $\gamma_{y[i]}$ is the effect of the y^{th} year (relative to 2015); and $\delta_{dy[i]}$ is a product term between distributors and years — Model (M3) allows us to investigate whether the time between incidents is increasing/decreasing dependent on the distributor.

We used a Bayesian regression to estimate the posterior distribution of the parameters. We chose a Bayesian regression due to the ease of estimating the scale parameter of the Gamma distribution simultaneously with the shape parameters (those in Equations (M0)–(M3)). A standard frequentist regression would estimate the scale parameter via profile likelihood, after fixing the shape parameters at their maximum likelihood estimates; the error in estimating these parameters is thus not accounted for under the frequentist regression framework.

To complete the specification, we require prior distributions for the parameters in Equations (M0)–(M3), and for the scale parameter. We chose weakly informative priors to minimise the effect of the prior on posterior estimation:

$$
\begin{aligned}
\alpha &\sim \text{student t}_7\\
\beta_d &\sim \text{student t}_7\\
\gamma_y &\sim \text{student t}_7\\
\delta_{dy} &\sim \text{student t}_7\\
\sigma &\sim \text{half-Cauchy}(0,5)
\end{aligned}
$$

where student t_7 is the student t distribution with 7 degrees of freedom; half-Cauchy$(0,5)$ is a folded (i.e. restricted to the positive real line) Cauchy distribution with scale 5; and σ is the scale of the Gamma distribution.

C.2 Results: Time Between Fire Incidents

Table C.1 compares the models using the leave-one-out information criterion (LOOIC)[1]. The reduction in the LOOIC is large when moving from Model (M0) to Model (M1), negligible moving from Model (M1) to Model (M2) and is positive from Model (M2) to Model (M3); from this we conclude that Model (M1) provides a satisfactory fit to the data.

Table C.1: LOOIC comparison of Models (M0)–(M3); restricted to fire related incidents. Eff. P shows the effective number of parameters in the model, and ΔLOOIC shows the change in LOOIC; se(·) denotes standard error.

Model	LOOIC	Eff. P	se(Eff. P)	ΔLOOIC	se(ΔLOOIC)
M0	3744	3	0.7		
M1	3410	6	0.9	−334	33
M2	3385	8	1.0	−25	7
M3	3393	15	1.6	9	3

Table C.2 shows the coefficients from the model; there is a clear distributor effect.

Table C.2: Estimated multiplicative effect of predictor variables on the time between events, from Model (M1); fit to fire-related incidents.

Variable	Estimate	90% CI
Intercept	2.7496798	(2.3986309, 3.1637267)
CitiPower	6.2797235	(4.3167429, 9.4331157)
Jemena	3.8813734	(2.8651457, 5.3440637)
Powercor	0.4534008	(0.3810879, 0.5341998)
United Energy Distribution	1.3218568	(1.0719954, 1.6398077)
shape	1.7653659	(1.7057052, 1.8269752)

C.3 Results: Time Between all Incidents

Figure C.1 displays the observed time between incidents by distributor.

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[1] LOOIC is interpreted as follows: a smaller LOOIC indicates a better fitting model.

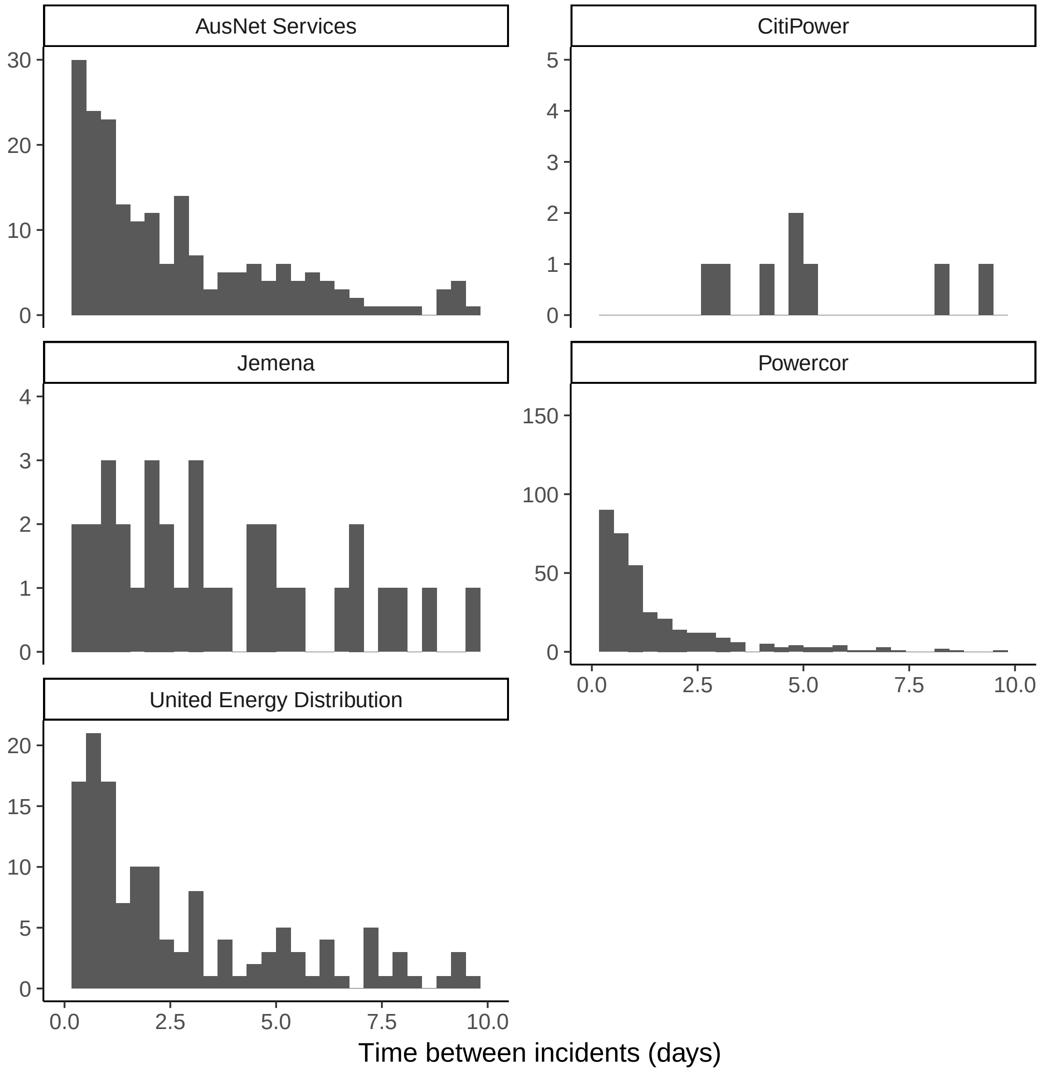

Figure C.1: Observed time (in days) between incidents, by distributor.

Table C.3 compares the models using the leave-one-out information criterion (LOOIC). The reduction in the LOOIC is large when moving from Model (M0) to Model (M1), slight moving from Model (M1) to Model (M2) and is positive from Model (M2) to Model (M3); from this we conclude that Model (M2) provides a satisfactory fit to the data.

Table C.3: LOOIC comparison of Models (M0)–(M3); fit to all incidents. Eff. P shows the effective number of parameters in the model, and ΔLOOIC shows the change in LOOIC; se(·) denotes standard error.

Model	LOOIC	Eff. P	se(Eff. P)	ΔLOOIC	se(ΔLOOIC)
M0	5518	2.3	0.16		
M1	4727	5.2	0.26	−791.0	37.6
M2	4716	7.2	0.36	−10.4	5.2
M3	4723	13.7	0.81	6.5	3.4

Table C.4 shows the coefficients from the model; there is a clear distributor effect, and a smaller year effect.

Table C.4: Estimated multiplicative effect of predictor variables on the time between events, from Model (M2); fit to all incidents.

Variable	Estimate	90% CI
Intercept	1.0913009	(0.9700928, 1.2320077)
CitiPower	2.4342153	(2.0622605, 2.8848809)
Jemena	1.8716121	(1.6146894, 2.1915461)
Powercor	0.3667460	(0.3308902, 0.4053665)
United Energy Distribution	0.8884429	(0.7868948, 1.0031365)
Year, 2016	1.1821351	(1.0709686, 1.3040767)
Year, 2017	1.3120573	(1.1724049, 1.4708658)
shape	1.9838763	(1.9347814, 2.0351821)

Figure C.2 displays the fitted values for each distributor and year combination; the lines show 90% probability intervals. The time between events is decreasing over time, but this effect does not appear to be strong.

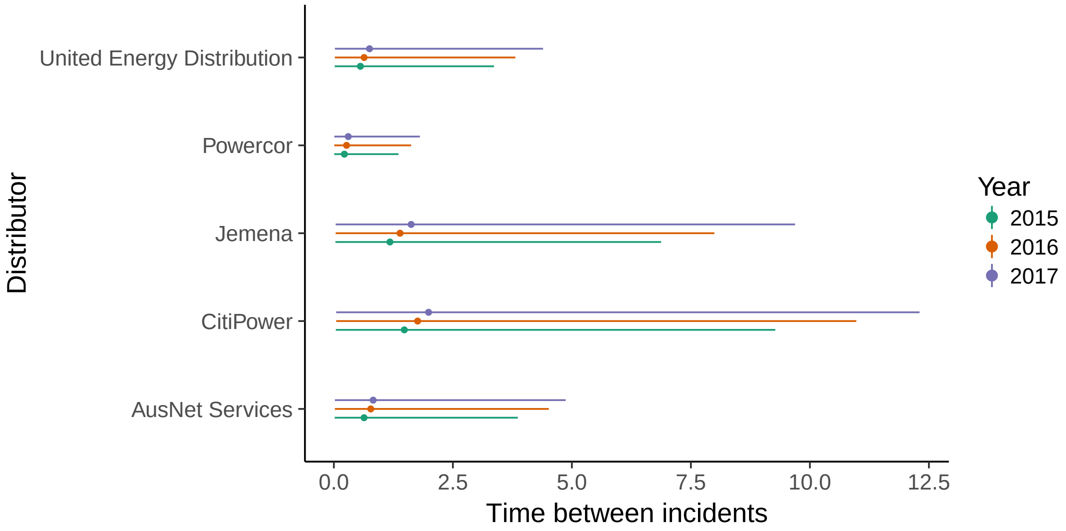

Figure C.2: Overall estimated time between incidents by distributor. The intervals are 90% probability intervals for the estimated values, with year of incident shown by colour.

C.4 Other Details

Figure C.3 shows the relative occurrence rates of incidents by distributor across time from the OSIRIS data.

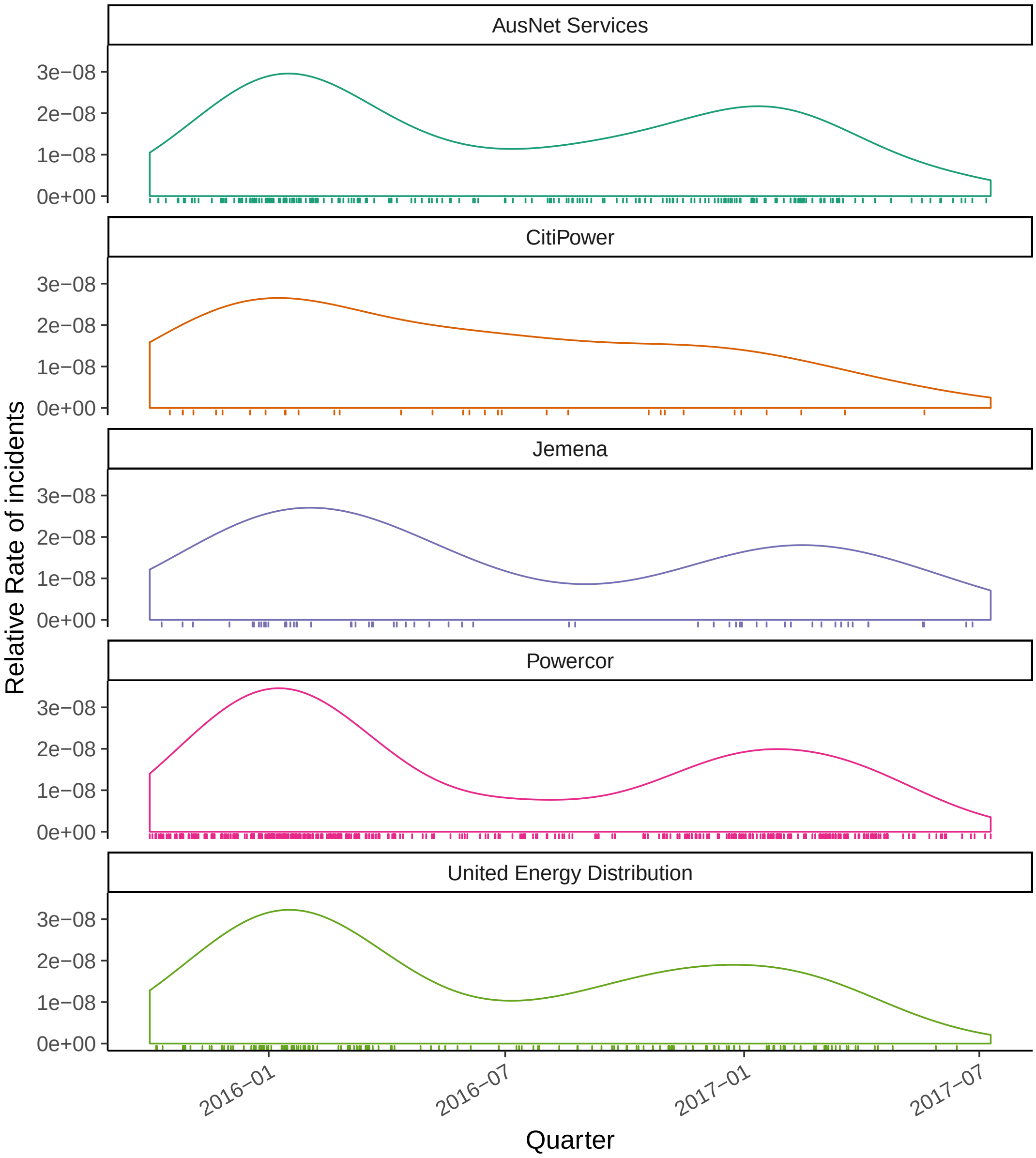

Figure C.3: Relative rate of all incidents by time by distributor.

Appendix D

Fire History

This chapter presents some graphical summaries of the fire history data provided in `All DBs_Ignitions_2012 to 2015_3171 Records_14 10 2016.xlsx`.

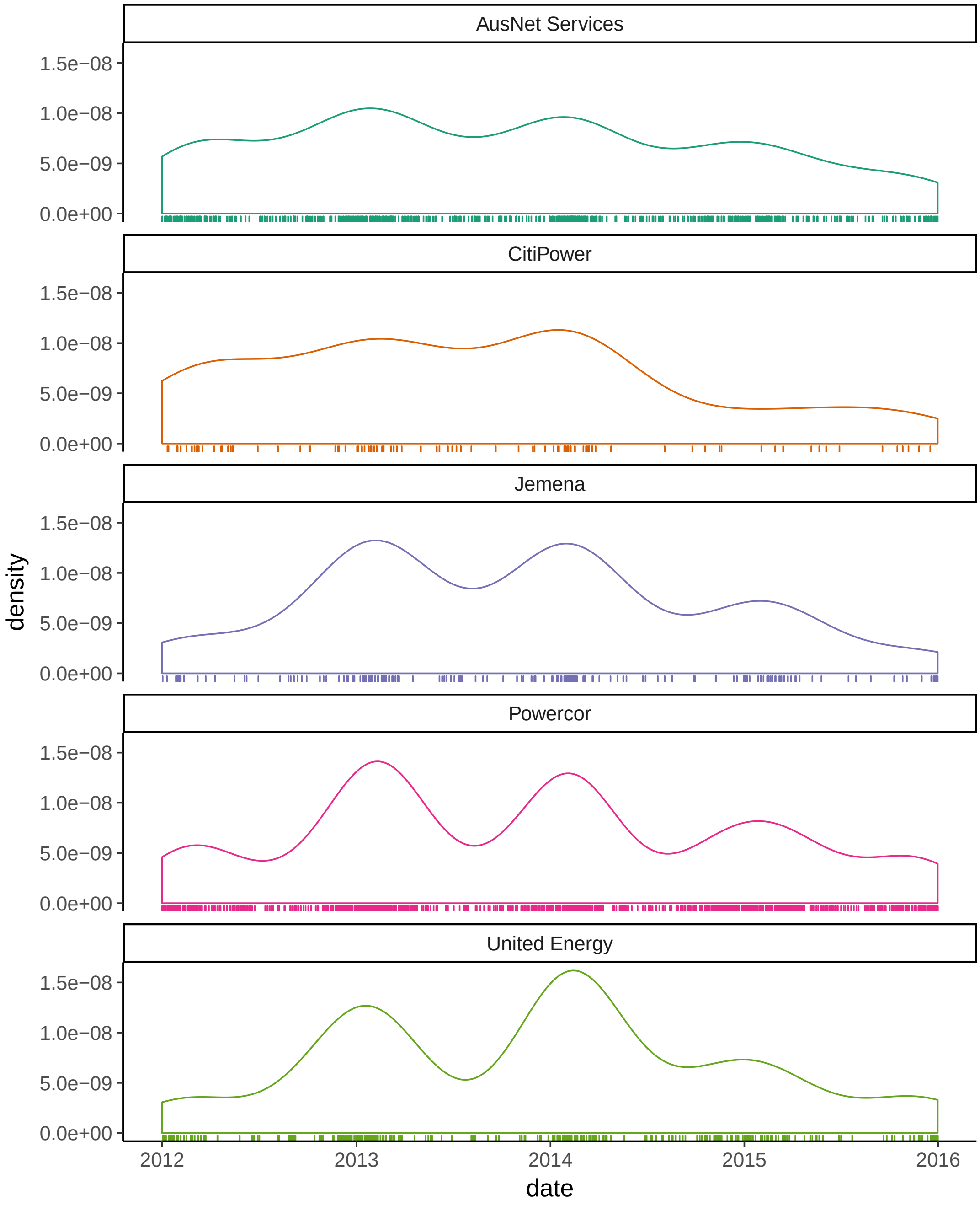

Figure D.1: Relative rates of fires by company, 2012–2015.

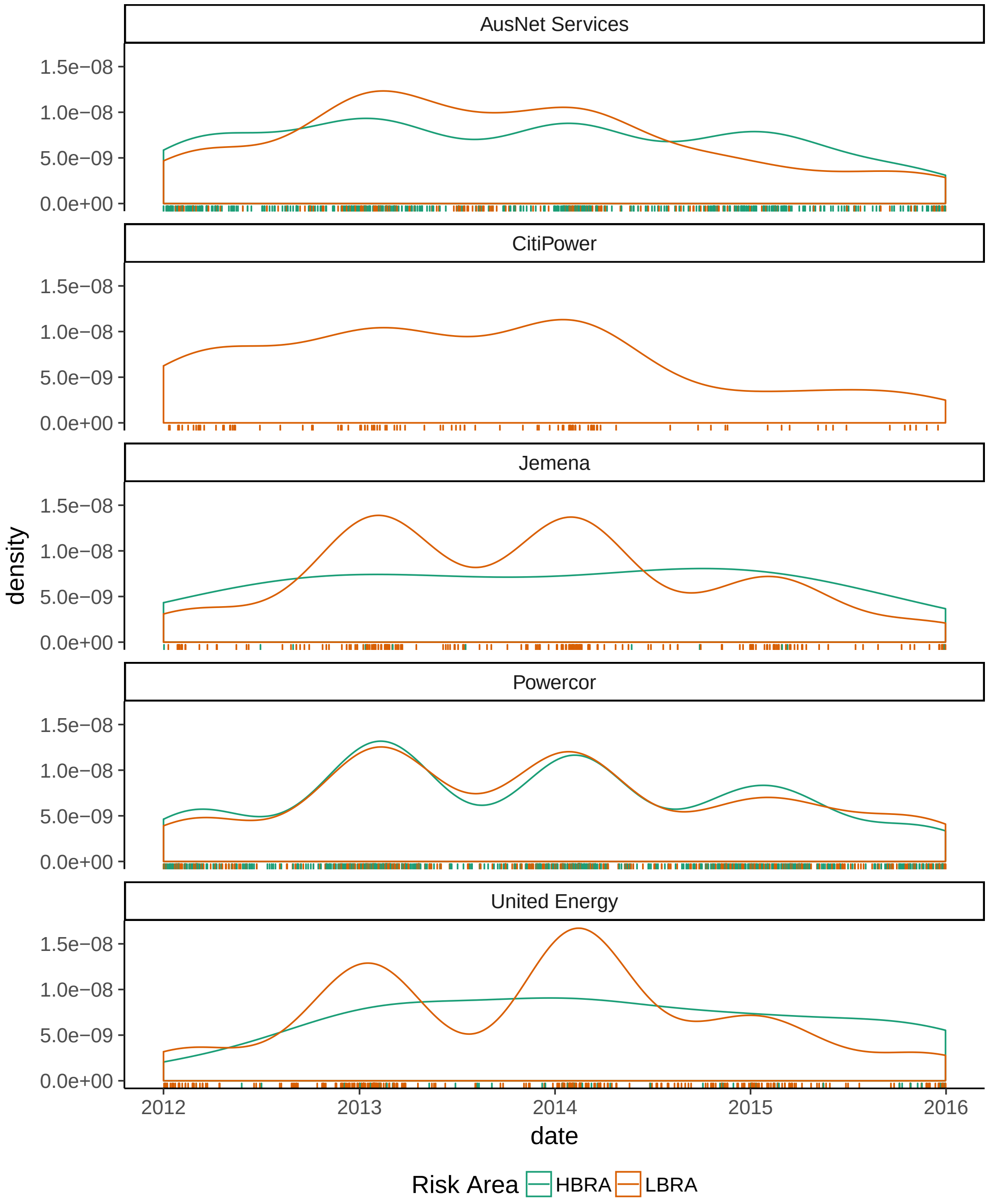

Figure D.2: Relative rates of fires by high- and low-risk areas and company, 2012–2015.

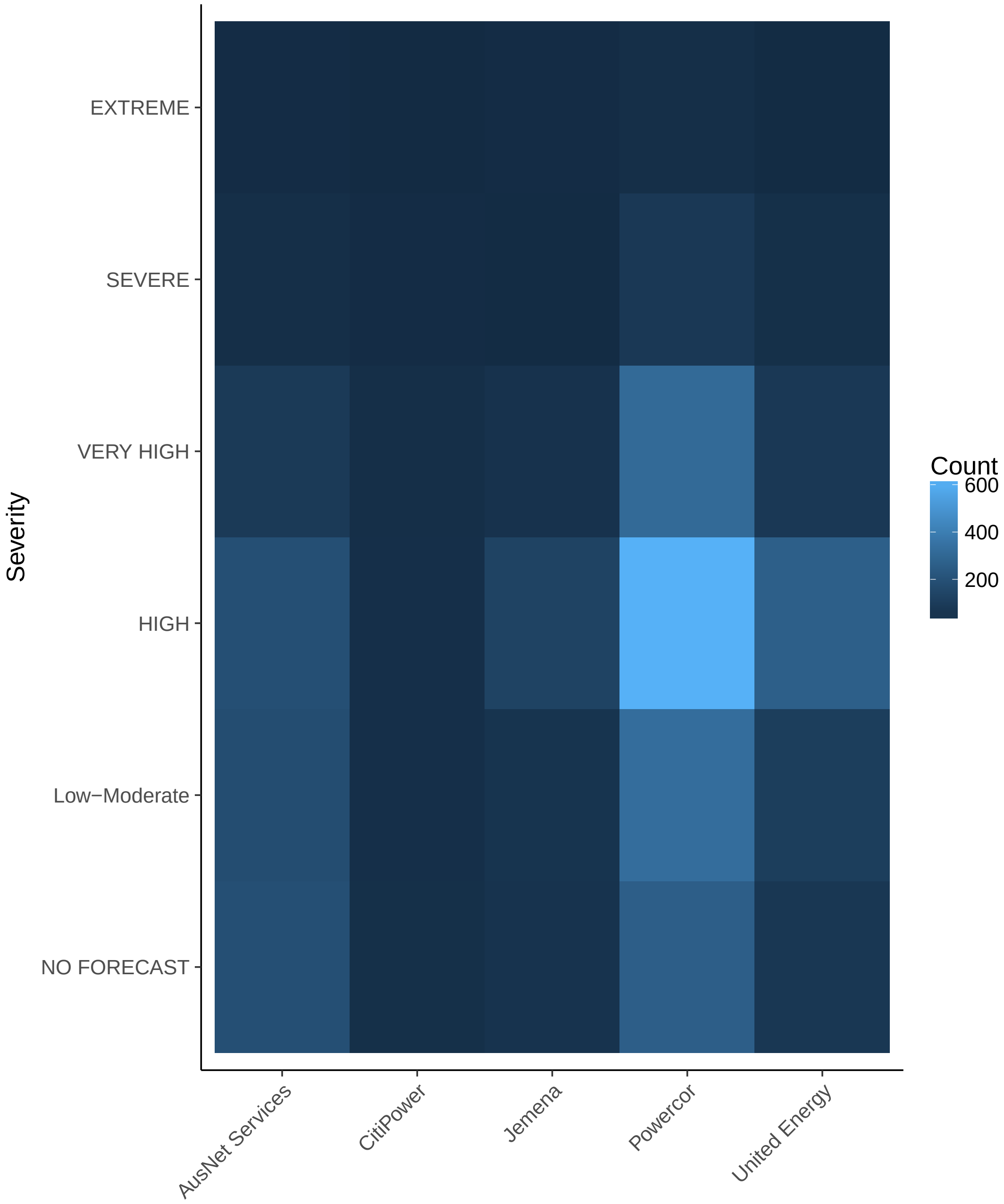

Figure D.3: Tile plot of fire incidents by fire risk and distributor, 2012–2015.

Appendix E

Data-Checking Narrative

The following text is adapted from Peter Greilach to describe the steps that he undertakes annually to assess the quality of ESV electricty network incident data.

E.1 Process

First, review the data in Tableau primarily to look at the data spatially. This identified a number of incidents that were listed against the wrong DB (1 Powercor incident listed as CitiPower and 26 Powercor incidents listed as CitiPower) and three incidents with the wrong coordinates (2 Jemena that popped up in the middle of Port Phillip Bay, the default error location, and 1 AusNet).

Then review the data in Excel, applying filters to look for exceptions.

- Check the contact names and details (address, phone, email) for individual typing errors and standardising address formats.
- Check the incident addresses by looking at the formatting of the addresses.
  - Where the address is generated by OSIRIS it appears in a defined format (upper case; street comma suburb state postcode). Where it was in this format, assume that the lat/longs are ok (i.e. generated by OSIRIS or moved slightly by the user). No overall check of address geo-location vs coordinates provided. Each potentially anomalous address was individually checked against GoogleMaps and OSIRIS, and where there was a disagreement the address is checked against the VicPlan website. Each check of address was done using the lat/longs provided to make sure they matched the address provided.
- Check `incidentLocationType::Other` to ascertain whether these items could be classified against the existing categories or whether new classifications need to be added to the OSIRIS menu.
  - Two additions were identified for consideration; all other items were reclassified.
- Ensure `voltageBetweenPoints` is in numeric format. This is currently not stipulated as numeric (in volts) in OSIRIS. It is not needed for the current performance reporting.
- Examine the free-text provided under `failedAssetsOther`, `failedOtherAssetsOther`, `incidentConcequenceOther`, `causeTechnicalOther`, `causeEnvironmentalOther`, `causeWorkPOther`

and `causeCommunityOther`. This information is reviewed (together with the free-text descriptions of the incident, actions and cause) to determine whether the data had been correctly classified.

Subsequently,

- Issue individualised versions of the spreadsheet to each DB for their review and comment.
- Check the responses provided to compile a master spreadsheet
- Provide the master spreadsheet to Readify to update the records in OSIRIS and Conduit

There is no technical review of the content of the incident reports. Each report is reviewed by incident investigators as they are submitted and ESV assumes that any technical deficiencies have been addressed in this process.

E.2 Outcomes

Following the initial review of 2911 incidents, there were 69 incidents where one of the responses is to be reviewed (2.4%), 81 reports where further clarification is required from the DB (2.8%) and 1 report where further clarification is required by ESV (0.03%). There are 23 reports, mainly overlapping, that were identified a possible extension to the OSIRIS menu options (0.8%).

A total of 2693 reports required minor amendment (92.5%). This largely reflects an amendment to the address format for the business contact details that is not consistent with the addressing for the incident location. All addresses should be in a common format and this will need to be rectified in OSIRIS.

The address problems were generally minor in nature and did not affect ESV's regulatory response. The amendments were mainly made to ensure the ability to properly search on data and undertake analytics in the future.

ESV also identified a few reports that were false alarms and that could be deleted from the records.

Appendix F

Revision History

Revision	**Date**	**Author(s)**	**Description**
0.1.0	21/07/2017	AR	Stage 1 initial draft.
0.2.0	21/07/2017	AR	After ESV comments.
0.3.0	09/08/2017	AR & SL	Stage 2 initial draft.
0.4.0	19/09/2017	AR	Stage 1 & 2 combined report.
0.4.1	19/09/2017	AR	Minor edits and corrections.