METHODOLOGY ANNEX

TOXIC FOOTPRINTS

EXPLANATION

This report should be read in conjunction with the main report Toxic Footprints: Exposing the investors behind petrochemical toxicity in the US Gulf States as well as the Toxic Footprint dashboard available on the Planet Tracker website.

This paper provides the definition and methodology used in the main report, allowing Planet Tracker's analysis to be replicable.

This paper provides a guidebook for users of two important EPA datasets:

1. Toxics Release Inventory (TRI)
2. Risk-Screening Environmental Indicators (RSEI)

DEFINING PETROCHEMICALS

Chemicals Derived from Petroleum (Oil & Gas) Products

Petrochemicals are a subset of industrial chemicals. They are defined as chemicals derived from petroleum (oil) products (for instance ethane and naphtha) or from natural gas. Using this definition, petrochemicals account for 90% of the total feedstock demand in chemical production.

High-value chemicals (HVCs) such as light olefins (ethylene and propylene) and aromatics (benzene, toluene and mixed xylenes [BTX]), are often co-produced in a process such as steamcracking.[1] Demand for HVCs tends to be driven by the consumption of plastics, synthetic fibres and rubber.

Ammonia is an example of a chemical that, though it can be produced from oil, is more commonly produced today from natural gas or coal. Methanol, an important industrial alcohol, is similar to ammonia in this regard.

The production of primary chemicals - such as HVCs, ammonia, and methanol - account for close to two-thirds of the total energy demand in the chemical sector.

Removing the 'Petro' One Day?

The RSEI dataset builds upon the TRI data by providing two main metrics to users – RSEI Hazard and RSEI Score. The former provides an indication of the relative potential toxicity of the chemical release, which is specific to the method of release (air, land, or water). The latter goes one step further and estimates the potential relative risk-related impact on human health by modelling how these chemicals travel through the environment and accounts for the size and locations of potentially exposed people - see Figure 1.

[1] Steamcracking takes place in large, complex units at the heart of petrochemical complexes, producing the important bulk building blocks of ethylene, propylene, butadiene, aromatics, and acetylene. It involves cracking hydrocarbon feedstocks in the presence of steam and at temperatures of between 800 and 860°C. The resulting cracked gas is separated into valuable products such as ethylene, propylene, acetylene, butadiene, pyrolysis gasoline and BTX, all according to the specifications for downstream processes. (Source: Linde Engineering).

Today, many petrochemicals can be technically produced from a variety of different products and substances, including forms of renewable energy such as biomass, water and carbon dioxide or other carbon sources. In time, this could result in an elimination of the 'petro' prefix.

However, the vast majority of industrial chemicals use oil, natural gas, or coal both as feedstocks and as a source of energy for fuelling the production processes. These commodities are often easy to acquire and process in comparison to their alternatives, but some atomic building blocks required for chemical products such as plastics and fertilisers (primarily carbon and hydrogen) are present in adequate quantities.

DEFINING PETROCHEMICALS

Types of Petrochemical Facilities

Petrochemical sites have been identified using the activities disclosed in the Toxic Release Inventory (TRI) dataset. Facilities are required to report their business activities according to the North American Industry Classification System (NAICS). These sectors are assigned to facilities based on the quantity or value of the products produced at each site. The sectors that we have included in our definition of petrochemical activities are:[2]

1. Petroleum Refineries
2. Petrochemical Manufacturing
3. All Other Basic Organic Chemical Manufacturing
4. Plastics Material and Resin Manufacturing
5. Synthetic Rubber Manufacturing
6. Nitrogenous Fertiliser Manufacturing

For the list of products that are included in each of these descriptions, please see the NAICS website. None of the feedstock and the technology used for the products are a factor in assigning a NAICS sector to the facility.

Three types of petrochemical activities were identified and used to characterise facilities. The NAICS codes used to create these categories were:

1. **Pure** - facilities where only one of the petrochemical activities takes place on-site. No other production activities take place at these facilities.
2. **Major** - a petrochemical activity is the main activity on-site, but other petrochemical or non-petrochemical activities also take place.
3. **Minor** - the main activity is not one of those listed above, but petrochemical production does take place on-site.

As each facility can assign up to six NAICS codes for each site, this can limit the way in which chemical releases are analysed. The creation of these categories helps to overcome this problem.

[2] NAICS codes corresponding to the descriptions provided are 324110, 325110, 325199, 325211, 325212, and 325311

NAICS Sector Contributions

Table 1 shows the share of the chemical hazard that is contributed by each NAICS sector in the Pure and Major Petrochemical categories. It shows that most of hazardous releases in both categories come from All Other Basic Organic Chemical Manufacturing (325199). Nitrogenous Fertiliser Manufacturing (325311) contributes the least in both categories.

Table 1: Share of Total Releases by Petrochemical NAICS Codes per Petrochemical Category. Source: US EPA. [i, ii] Metric: Chemical Hazard.

	Pure Petrochemical	Major Petrochemical
324110	33.62	9.08
325110	17.12	3.24
325199	43.62	82.90
325211	1.66	1.48
325212	2.70	0.39
325311	1.28	0.19
Other	0.00	2.72

DATA SOURCES

Overview

This study analyses the toxic releases from petrochemical facilities in Louisiana and Texas in the United States. Greenhouse gas emissions are excluded.

We have sourced data from three United States Environmental Protection Agency (EPA) sources:

1. Toxic Release Inventory (TRI)[i]
2. Risk Screening Environmental Indicators (RSEI)[ii]
3. Enforcement and Compliance History Online (ECHO)[iii]

Toxic Release Inventory (TRI)

The TRI dataset comprises facility-level disclosures of toxic releases from 1987 to 2019, the latest dataset available at the time of the analysis. Facilities have to report to the TRI when they meet certain disclosure requirements, for example whether they use, process, or dispose of TRI listed toxic chemicals. The TRI contains release data on approximately 600 chemicals, which are classified according to their method of release, where they are released, and the waste management route - see Figure 1.

At a high-level, toxic releases in the TRI are categorised as going to one of the following seven ways:

On-site releases to...
- Air
- Land
- Water

Off-site transfers for...
- Disposal
- Energy Recovery
- Recycling
- Treatment

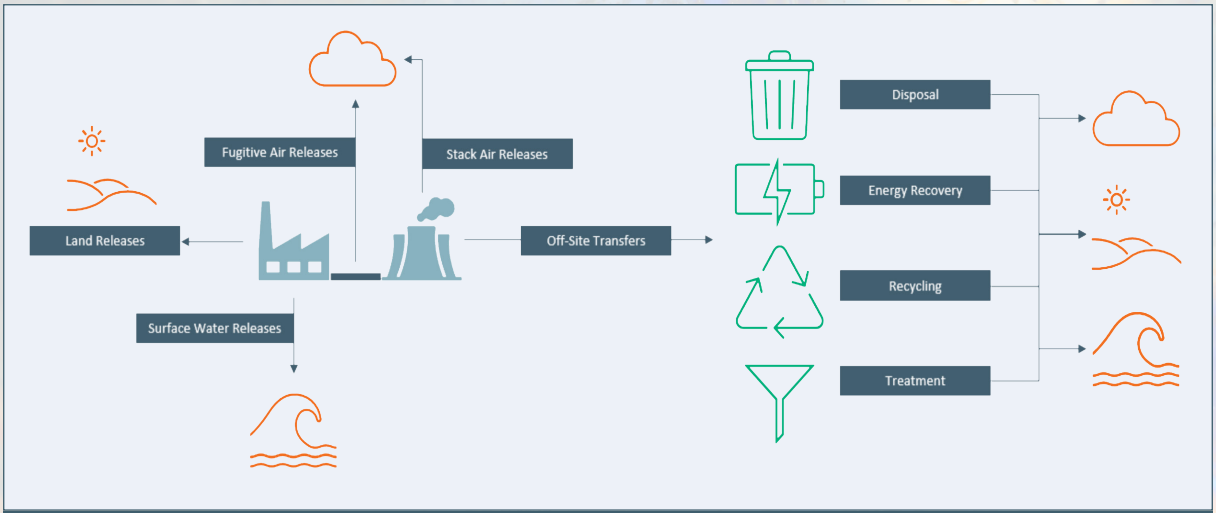

Figure 1: Classifications of Toxic Chemical Releases in the Toxic Release Inventory. Source: U.S. EPA and Planet Tracker.

Risk Screening Environmental Indicators (RSEI)

The RSEI dataset builds upon the TRI data by providing two **main metrics to users - RSEI Hazard and RSEI Score**. The former provides an indication of the toxicity of the chemical release, which is specific to the method of release (air, land, or water). The latter goes one step further and estimates the impact on human health by modelling how these chemicals travel through the environment and enter the human body - see Figure 2

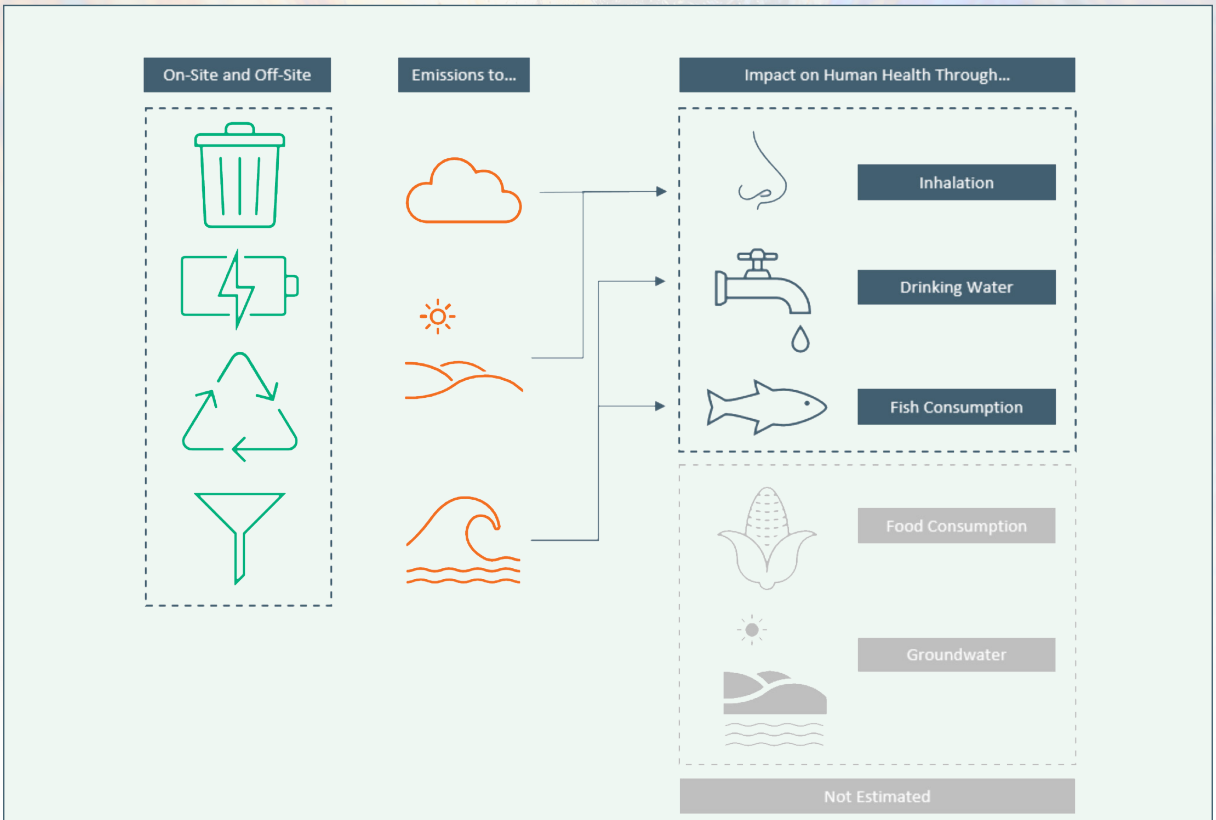

Figure 2: How Chronic Human Health Impacts of Toxic Releases are Modelled to produce RSEI metrics. Source U.S. EPA and Planet Tracker.

Enforcement and Compliance History Online (ECHO)

The ECHO dataset provides information on the fines imposed on the operators of facilities across various regulatory regimes. In this study we have taken all data for facilities that have a TRI identity number.

This dataset outlines the number of fines, inspections and penalties given to facilities within the last five-years. To find out more information on what fines were given for, we used the Detailed Facility Report (DFR) which gives more granular information on a case-by-case basis.

Measuring Chemical Releases

There are three main metrics provided by the EPA that we use to measure the impact of chemical releases:

- the physical **quantity** of the chemical released - called TRI Pounds
- the **hazard** posed by that release - called RSEI Hazard
- the estimated **risk** it poses to human health - called RSEI Score.

Each metric tells us something different. Please note that a more detailed discussion of these datasets is discussed below in the EPA Data Guidebook.

Comparing the physical quantities of different chemical releases can be done using TRI Pounds, which we refer to as "chemical quantity" in the main Toxic Footprints report.

However, this is of limited use as one pound of mercury released to water causes a very different impact compared to one pound of asbestos sent to landfill, for instance. But when we examine the RSEI Hazard, which we also call the "chemical hazard" in the main report, it provides an idea of the potential impact on human health from the release. RSEI Score, referred to as "chemical risk" in the report, models how that chemical release travels through the environment and impacts human health.

However, there are trade-offs to be made. For instance, chemical quantities are available for all chemical releases, whereas the chemical hazard and risk data covers approximately two-thirds of chemicals, or less. Table 2 outlines the advantages and disadvantages of using each metric.

Table 2: Metrics Provided by the US EPA to Assess Toxic Chemical Releases. Source: Planet Tracker.

	Chemical Quantity (TRI Pounds)	Chemical Hazard (RSEI Hazard)	Chemical Risk (RSEI Score)
+	• 1987 to 2019 • Available for all chemicals	• 1988 to 2019 • Meaningful comparison between chemical releases • Can differentiate between cancer and non-cancer effects	
−		• RSEI release categories do not match TRI release categories • The location of the impact is not always known	
−		• Available for 67% of chemicals	• Available for less than 67% of chemicals • Does not consider acute human toxicity or ecotoxicity • Does not consider impact from food consumption • Not calculated for all media

Throughout this study we have used chemical hazard as the main metric for our analysis. This allows us to identify chemicals that would not appear using chemical risk, because the EPA does not estimate the impact of all releases on human health via all release pathways. Chemical risk is used at various points throughout the study when assessing human health impacts. The metrics used to generate each table and figure are provided in the corresponding description and labelled as either chemical quantity, chemical hazard, or chemical risk throughout the report.

IMPORTANT DATA CONSIDERATIONS

Merging Environmental Data

The analysis is focused on releases that occurred between 2007 and 2019 (the latest year of data at the time of writing). 2007 is chosen as the starting year as this is the first year that RSEI released metrics on chemical hazard and chemical risk. Also, facilities were consistently reporting their activity data in-line with NAICS codes, rather than Standard Industrial Classification (SIC) codes, which makes the comparison between petrochemical categories more consistent.

The TRI categorises chemical releases in 72 different ways. The categories provided include means in which the chemical has been released, how and where the chemical has been disposed. Chemical hazard and chemical risk data are placed into eight and five categories respectively. The coverage of these releases has been mapped to the three metrics being used in this report in Figure 3.

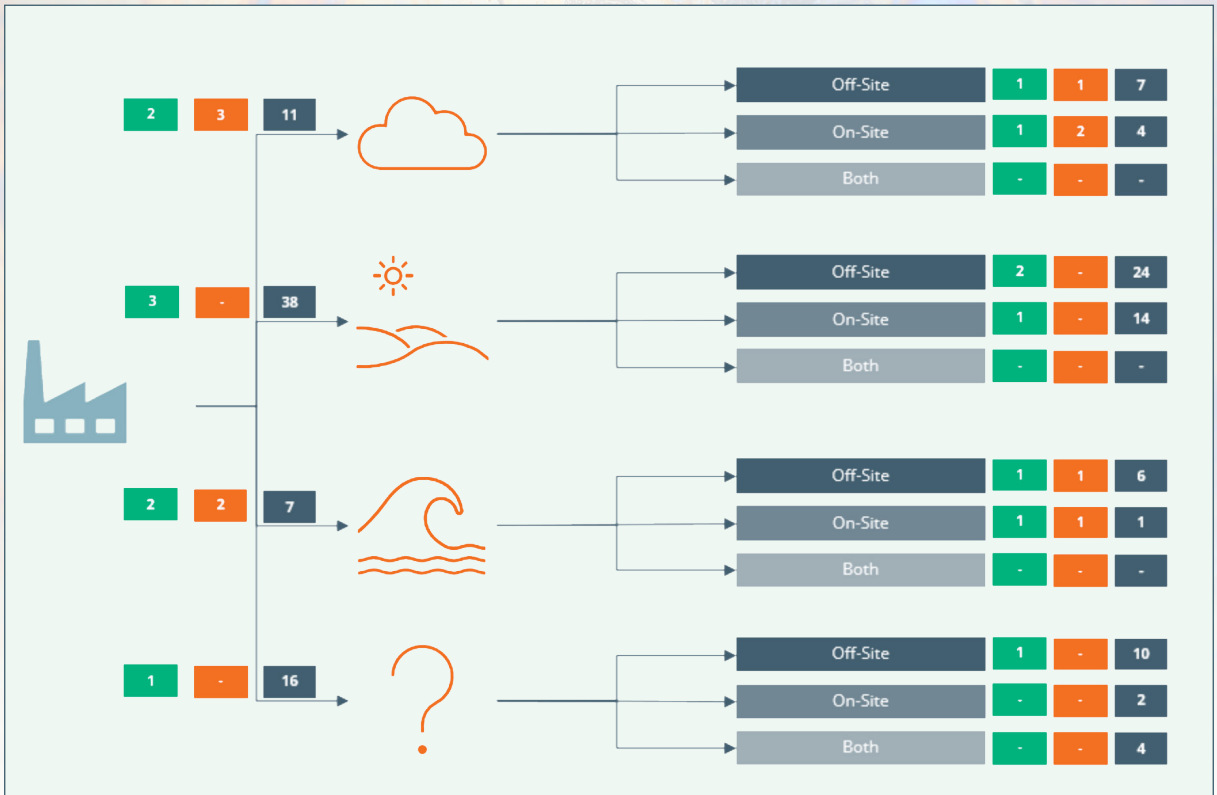

Figure 3: The Number of Categories of Toxic Chemical Releases to Air, Land, Water and Unknown Media Mapped to the Following Metrics: Chemical Hazard (green); Chemical Risk (orange); Chemical Quantity (blue/grey).

To quantify production and non-production waste[3] using the chemical hazard metric, the TRI and RSEI datasets needed to be combined in various ways. Due to this limitation, it means that we are not able to use the chemical hazard or risk metrics in accordance with the categories in the TRI. To go into this level of detail we have used the chemical quantity metric instead.

When is Production, Non-Production?

The split of production and non-production waste is also important, as the latter is infrequent, and often from one-off occurrences.[4] For instance, hurricane damage that causes a spill of plastic pellets into local waterways would be classified as a non-production release, as would the same spill resulting from a catastrophic failure plant equipment due to poor management or negligence. Production-related releases occur due to the day-to-day running of the facility and are a constant, expected source of toxic releases. Figure 3 shows that production-related chemical releases from Pure Petrochemical plants in Texas increased five-fold between 2015 and 2018, whereas Major Petrochemical plants releases increased six-fold over the same period in Louisiana - see Figure 3.

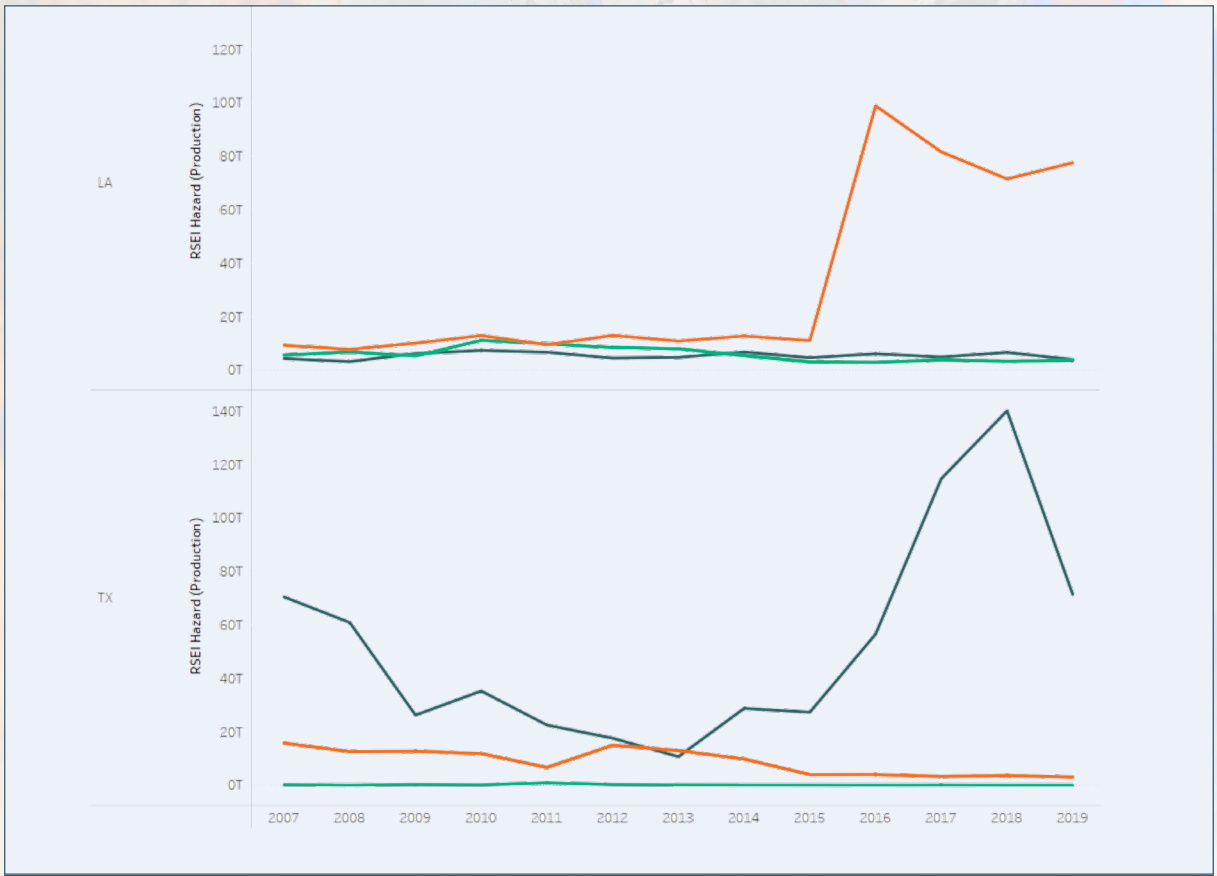

Figure 4: Production-related Waste Flows in Texas and Louisiana, 2007-2019. Source: US EPA. [i, ii]
Metric: Chemical Hazard. Key: Pure (blue-grey); Major (orange); Minor Petrochemical Activities (green).

[3, 4] The EPA differentiate between the production and non-production waste as follows:
Production-related waste is the quantity of chemical waste generated at a facility as a result of normal, routine production processes and reported as managed.
Non-Production-related waste is the quantity of waste containing TRI chemicals resulting from one-time, non-routine events, rather than from standard production activities. Examples include spills and catastrophic events, such as natural disasters.

Imprecise Financial Penalties

The ECHO data that we have used is a subset of a much larger collection of data provided by the EPA. In our dataset, it doesn't inform us about some important aspects of the fines that were levied against companies. For instance, only aggregated fines and inspections over the last five years are provided and we were unable to find out whether a fine was linked to the release of a specific chemical. In order to provide further details on fines, we inspected the data available in the Detailed Facility Report, which provides granular information on enforcement actions at a facility-level.

Missing Data

There is a lack of data in parts of the TRI and RSEI datasets. Omissions included:

TRI

- Sometimes it is not possible to identify to which media off-site releases go because in most instances the location of off-site releases is unknown. In Louisiana and Texas, 98% of production and non-production related toxic emissions are released off-site. Off-site Transfers to Disposal (61%), Recycling (20%) and Energy Recovery (14%) account for most of the releases.
- Changes in facilities' ownership are not considered. Ownership of facilities by parent companies reflect 2019 data.

RSEI

- As mentioned in Table 2, acute human toxicity and environmental toxicity are not included in the calculation of the RSEI metrics. This could significantly impact which chemicals and facilities should be focussed on.
- Leaks of chemicals from land to groundwater are not included in the RSEI calculations.

OWNERSHIP DATA

Ownership and Financing

The corporate ownership of financial flows examines three main areas:

- Equity ownership
- Bond ownership
- Financing of loans and underwriting of debt and equity

The TRI was used to identify 335 unique petrochemical facilities with a total of 149 unique facility parent companies in 2019.

The facility parent companies were researched using Refinitiv and Orbis to ascertain if they were public or private entities. The method used to identify owners is shown in Figure 4.

Planet Tracker scanned the corporate hierarchy in order to identify any publicly traded company, as disclosure requirements mean we were able to find out more about the financials of these companies – steps 1 to 3. When no publicly traded company could be identified in the corporate chain, information was taken from the private company at the top of the hierarchy - step 4.

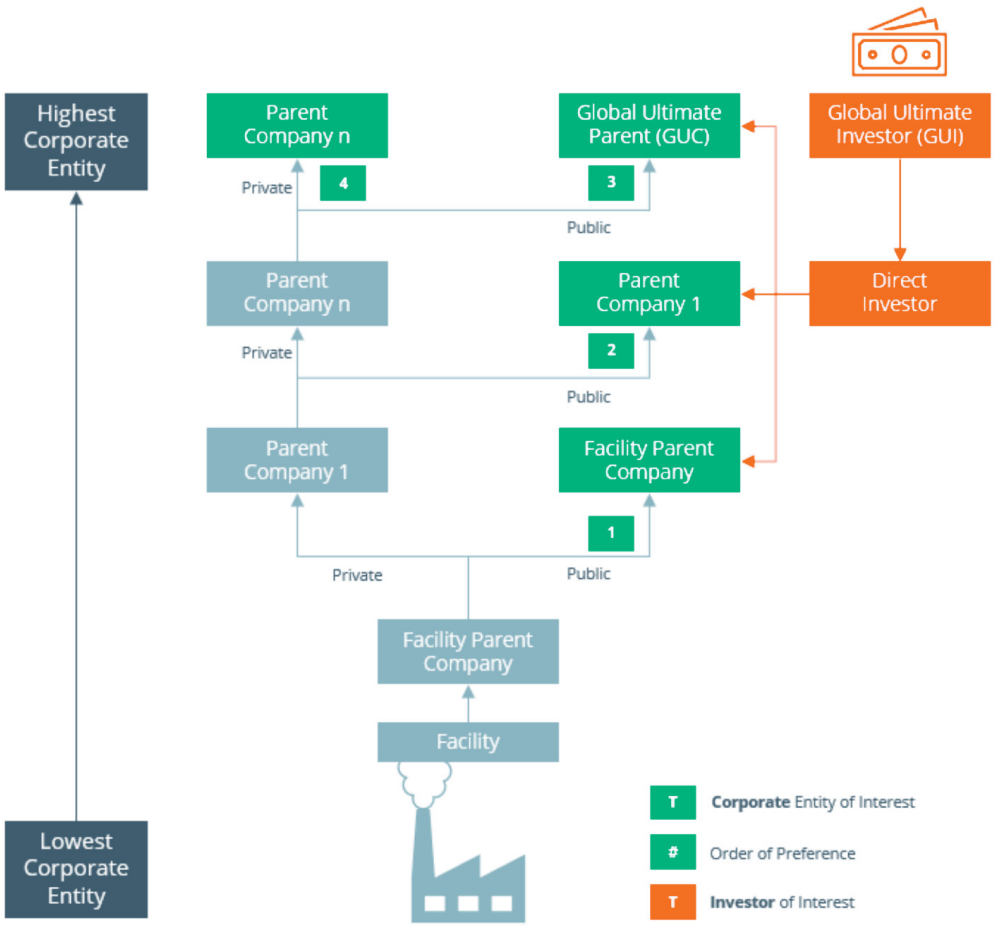

Figure 5: Identifying Parent Companies and Investors in Petrochemical Companies in Louisiana and Texas. Source: Planet Tracker.

Refinitiv was used to obtain data for publicly owned entities and Orbis for owners of private equity. Financing and underwriting data, referred to as financing in the report, starts from 1 January 2016 and runs until 18 November 2021, unless stated otherwise.

Not all facilities nor all facility parent companies could be identified in either of these databases. As a result, the final list of corporate entities analysed fell from 149 to 133, of which 76 are publicly listed.

Joint Venture Ownership

A holding adjustment factor was used to be able to account for joint ventures, such as the one between Chevron Corp and Phillips 66 Co. In such cases, total holding values were apportioned to each of the parties involved in the joint venture.

When assessing the ultimate investors in petrochemical companies for such joint ventures, the following actions were taken to identify the most accurate set of investors:

- **Chevron Phillips Chemical Co LLC** - Chevron Corp and Phillips 66 identified as 50/50 parents; hence both their investors were included in the analysis.
- **Deer Park Refining LP** - Pemex and Royal Dutch Shell were identified as 50/50 parents. Shell's investors were included in the analysis. Note that in January 2022 Shell sold its holding to Pemex.[iv]
- **Americas Styrenics LLC** - Chevron Phillips Chemical Co LLC and Trinseo AS were identified as 50/50 parents, hence investors in both companies were included in the analysis. Since Chevron Phillips Chemical Co LLC is a 50/50 joint venture between Chevron Corp & Phillips 66, the latter entities' investors were also included in the analysis.
- **American Acryl LLC** - Arkema and Nippon Shokubai Co Ltd were identified as 25/50 parents. Both companies' investors were included in the analysis.

Ownership Limitations

Below we identify some shortcomings with the ownership data to ensure the information is interpreted correctly.

- **Equity** ownership should not be confused with the valuation of the facilities, whether this be for accounting or market value purposes. Rather, it should be taken as an indication of the value of the holding of the corporate group controlling the facility.
- **Bond** ownership should not be confused with the amount of debt issued by the facilities. Rather, it should be taken as an indication of the total par issued by the corporate group controlling the facility.
- **Financing** amounts are not related to specific facilities but rather the overall amount underwritten to each corporate owner, hence the values should not be taken for direct financing arrangements for facilities, but simply as an indication of those financial institutions indirectly financing those facilities' operations.

A GUIDE TO USING EPA DATA

Data Access

TRI data can be accessed from three main sources, known as the Basic files, Basic Plus files, and through the Envirofacts API. TRI data are available for all states, for all years between 1987 and 2019 and from all three sources.

A complimentary dataset on the toxicity and human health impacts of the chemicals, called Risk Screening Environmental Indicators (RSEI), is available from the EasyRSEI dashboard. This enables users to directly compare the release of different chemicals based on their impact. This can produce completely different results when comparing chemicals based only on the physical quantity released. RSEI Hazard and RSEI Score are calculated once per year and released around December. This is two months after the latest year of data is released by the TRI. RSEI Hazard and RSEI Score values are broken down into two sub-categories - cancer and non-cancer impacts.

Chemical Releases - measured in grammes for dioxins or in pounds for all other chemicals. Releases are disclosed according to one of 48 categories which capture the waste management route (release, treatment, energy recovery, or recycling), the location of release (on-site or off-site), the media the chemical was released to (air, land, or water) and if the chemical was released as part of normal business operations or not (production or non-production related).

RSEI Hazard - calculated by multiplying the physical quantity of a chemical released by its toxicity factor, this measure communicates the magnitude of the potential impact of a toxic release on human populations. This is calculated for around two-thirds of the TRI chemicals.

RSEI Score - estimates the amount of a toxic release that reaches human populations and quantifies its impact by modelling how the chemical travels through the environment.

Toxic Release Inventory (TRI)

Reporting Criteria

Facilities only report to the TRI if they meet certain criteria. These include if the NAICS code is covered by the TRI, if the facility employs more than 10 FTE and if the facility manufactures, imports or processes any EPCRA Section 313 chemical above stated thresholds.

Facilities that report to the TRI are classified according to the North American Industry Classification System (NAICS). One facility can report up to six NAICS codes. These are self-assigned based on the volume or value of goods produced at the sight.

The NAICS classification undergoes a revision approximately every five years, the latest being in 2017. The TRI officially adopted the NAICS classification in 2007, so you may see a change in how facilities report their activities around this time.

Facilities reporting to the TRI can be made up of many establishments that are classified under many different NAICS codes. Facilities with multiple establishments may report separate and unique TRI reporting forms under the same TRI facility ID. This can make it seem as though there are duplicate entries in the Basic data files where, in fact, the entries need to be aggregated in order to attain an accurate value for its releases.

If the entire facility meets a TRI chemical reporting threshold, disclosures to the TRI must include all chemical releases from each establishment, even from those establishments with NAICS codes not covered by the TRI.

Facilities disclose their releases to the EPA using its Form R report. The forms submitted by individual facilities can be found here.

Chemical releases in the TRI for the most recent year are likely to increase in the subsequent year due to resubmissions and late filings made by facilities. The TRI release data are at least 10 months behind calendar dates, as data is released in October for the previous calendar year.

GuideME provides useful and more detailed information on reporting requirements for facilities.

Data Qualities

The following section is useful for interpreting the downloaded TRI data.

Section 8 - Totals for the releases of chemicals can be found in Section 8 of the dataset. This section contains the total on-site and off-site chemical releases, and chemicals sent for disposal, treatment, energy recovery, and recycling. Releases are categorised as production- and non-production-related. Non-production-related releases are chemical releases that do not occur as part of the usual operation of the facility. This can include releases caused by damage done to the plant during a hurricane, or through negligence which causes a chemical release.

The rest of the dataset contains a mixture of sub-totals and individual measurements of chemical releases. For instance, releases sent to publicly owned treatment works (POTWs) and direct releases to surface water bodies. Releases to POTWs are complicated as these releases are further broken into subcategories which are not available in the Basic files.

Six quantities in the dataset are only provided up until 1995 or 2002 as they are subsequently replaced by newer categories.

Media - It is not known in all cases which media (air, land, or water) chemicals are released to. This is the case for five categories that classify off-site releases. Example categories include "Other Off-Site Management" and releases sent to waste brokers.

Trade Secrets - companies can conceal their toxic releases by classifying the chemicals as "trade secrets". These chemicals do not have toxicity factors so their impact on human health remains unknown.

Parent Companies - The EPA has attempted to standardise parent company names to account for errors or quirks in spelling names between different facilities owned by the same company.

Risk Screening Environmental Indicators (RSEI)

RSEI Metrics

The RSEI dataset provides two main metrics to communicate the hazard and risk of chemical releases to human health – RSEI Hazard and RSEI Score. The EPA has toxicity information for over 400 of the roughly 600 chemicals and chemical categories on the 2019 TRI Chemical List in order to calculate RSEI Hazard values. RSEI Score values require further complex modelling to estimate the intake of chemicals and their impact on chronic human health conditions. Both metrics can be viewed in terms of their hazard and risk to cancer and non-cancer effect on chronic human health conditions.

Chronic human toxicity includes developmental toxicity, reproductive toxicity, and neurotoxicity which is associated with long-term chemical exposure and does not address concerns for either acute human toxicity or environmental toxicity.

The RSEI dataset assigns one set of NAICS codes for each TRI facility. For multi-establishment facilities, as explained earlier, the EPA uses the Form R reported NAICS code provided by each establishment, which means that different releases for the same TRI facility can appear under different NAICS codes. To analyse the RSEI data using the same NAICS codes as reported for facilities in the TRI, the user will need to merge to the TRI and RSEI datasets together.

Data Qualities

The RSEI Hazard and RSEI Score metrics are useful risk indicators and can be used to compare facilities and companies within the dataset. They should not be used outside of this dataset and compared with other toxicity or impact analysis.

The RSEI Hazard value is calculated by multiplying the physical quantity of the chemical release by its toxicity weight. RSEI Score is calculated by multiplying the estimated dose, population receiving the dose, and toxicity weight of the chemical.

It is important to note that when chemicals are removed from the TRI chemical list, RSEI's chemical database is modified to remove all results for these chemicals from previous years. RSEI results are then recalculated for all years so that changes in RSEI Hazard and Score values can be compared using a consistent set of chemicals.

Combining the Datasets

Merge Datasets with Caution

In order to combine the TRI and the RSEI datasets, be aware that:

1. The same facility can report a chemical release under different NAICS codes for the same year.
2. A facility can report the same chemical being emitted to the same media in the same year. This can be caused by multiple Form R reports being submitted by the facility for the same year.
3. Not all chemical names match between the TRI and RSEI datasets, and chemical identification numbers are not available in RSEI datasets.
4. There are some entries in the TRI that do not exist in RSEI. This is because RSEI Hazard or Score metrics are not calculated for that release, or because the RSEI dataset has not been updated. The TRI dataset is updated multiple times throughout the year, whereas the RSEI datasets are updated once per year.

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REFERENCES

i US EPA (2021) **Toxics Release Inventory**. United States Environmental Protection Agency. See here for Programme homepage

ii US EPA (2021) **Risk-Screening Environmental Indicators**. United States Environmental Protection Agency. See here for EasyRSEI Data Dashboard

iii US EPA (2021) **Enforcement and Compliance History Online**. United States Environmental Protection Agency. See here for Facility Search page

iv Shell announcement of sale of interest in Deer Park Refining