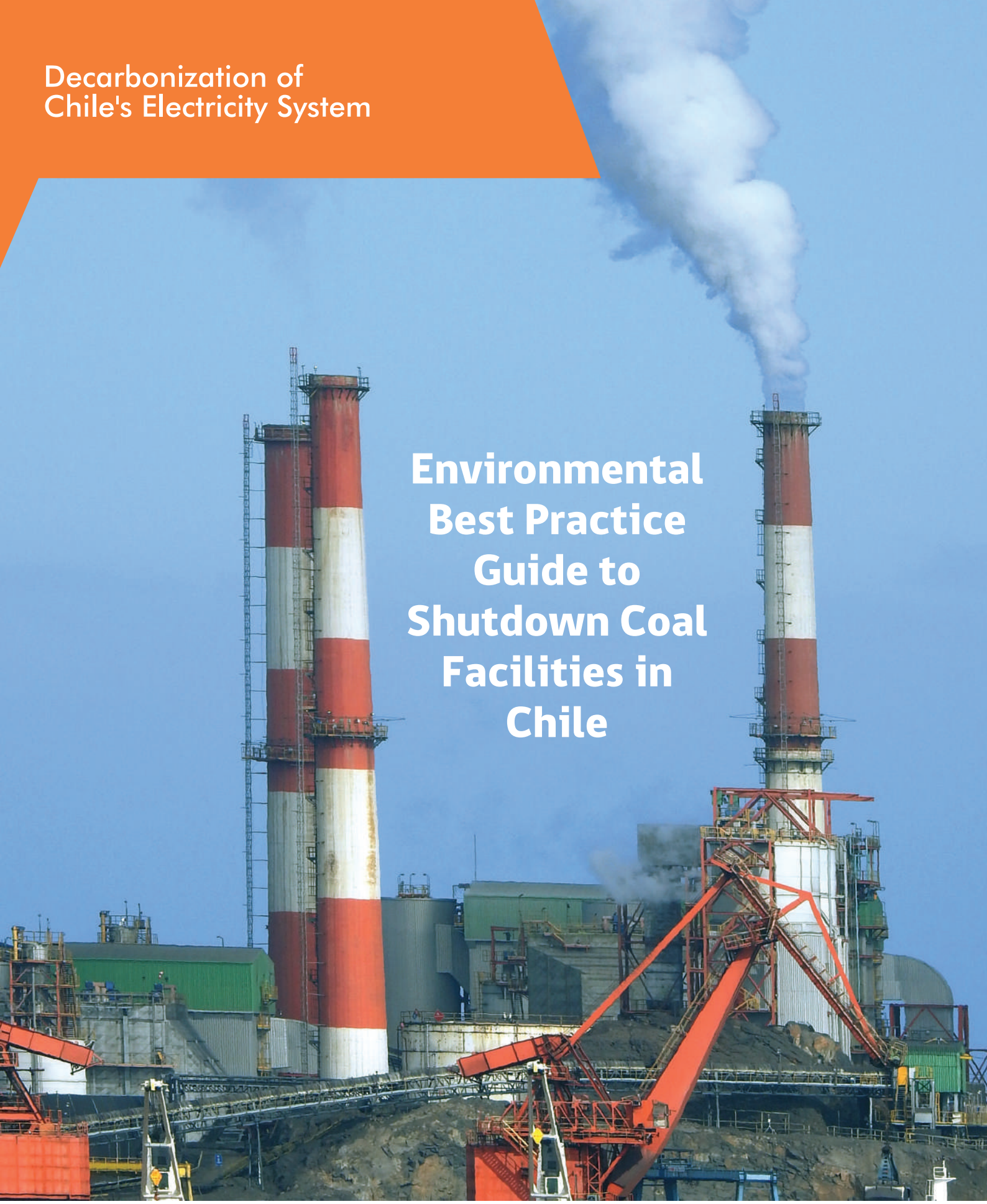
Decarbonization of
Chile's Electricity System

Environmental Best Practice Guide to Shutdown Coal Facilities in Chile



Programa de Energías Renovables y Eficiencia Energética en Chile

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

Document prepared on behalf of the Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) GmbH, in the framework of the project "Decarbonization of the energy sector in Chile" of the Renewable Energy and Energy Efficiency Program, in collaboration with the Ministry of Energy of Chile.
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ENVIRONMENTAL BEST PRACTICE GUIDE TO SHUTDOWN COAL FACILITIES IN CHILE

Decarbonization
of Chile's
Electricity System

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Introduction

The retirement of coal facilities is one of the main energy policy objectives within the Paris Agreement framework defined by the Conference of the Parties at United Nations.

The energy sector in Chile accounts for nearly 80% of greenhouse gas emissions in the country. Specifically, coal generation is one of the primary emission sources within the energy sector.

The primary goal of the Renewable Energy and Energy Efficiency Program (4E Program) led by the Deutsche Gesellschaft fur Internationale Suzammenarbeit (GIZ) GmbH, commissioned by the German Federal Ministry of Environment, Nature Conservation and Nuclear Security, is to promote the sustainability of the energy sector in Chile by working jointly with the Ministry of Energy of Chile in assessments and activities which will promote business development and finance.

One of the pillars in the 2050 Energy Policy of Chile is to make the energy sector and the environment compatible. Further, through this pillar support is committed to transition towards an energy generation mix and economy which generates significantly less carbon emissions by 2050.

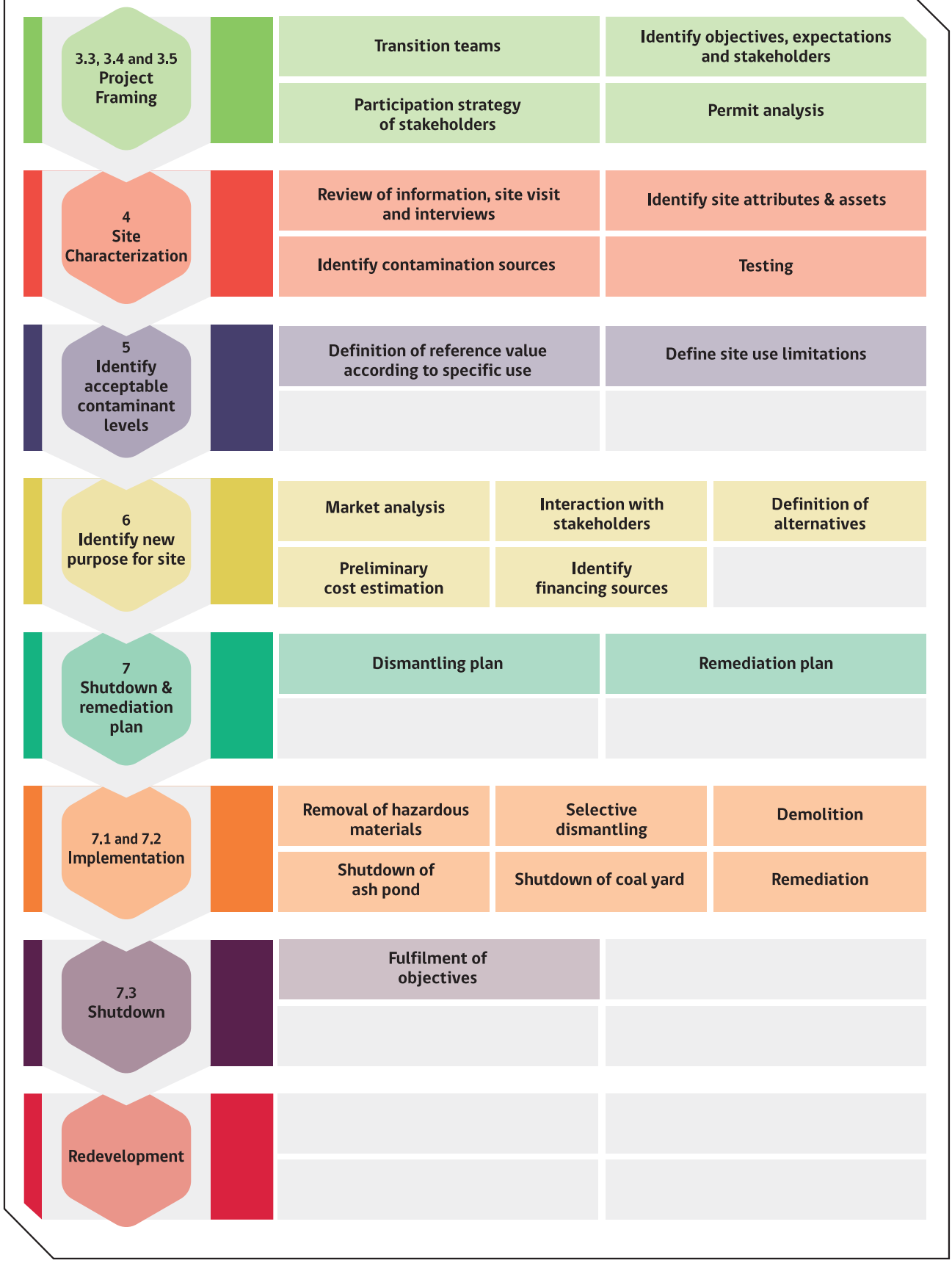
The retirement of coal units is expected to generate several environmental benefits such as: reduction of local and global emissions, decreased impact on marine habitats, reduction of risk of coal dumping, reduction of coal and ash emissions, recovery of space for other uses, decrease in noise, and others. However, achieving such environmental benefits could involve the following challenges: socio-environmental recovery of the affected areas, soil remediation based on international standards, recycling of steel and structures, and the application of environmental standards defined by the Chilean Environmental Assessment System (SEIA).

In the next several years an increased number of coal generation facilities are expected to start a process to close and shutdown operations. There are several options to approach the shutdown process. The coal facility could be converted to another type of generation unit, the space could be transformed for a different industrial activity, the facility could be dismantled or abandoned. Today, only a few thermoelectric facilities have a defined and approved shutdown plan which has been approved by the relevant authorities. The units which do not have an approved plan must define one and present it to the environmental authority.

The objective for this guide is to provide international best practices to face the environmental and social challenges generated when shutting down a thermoelectric facility. The shutdown process consists of seven stages which must be executed prior to developing a new project at the existing site. In the process, it's important to involve relevant stakeholders from the local community, the facility owners and relevant government institutions. Agreements can be used to reconcile the postures and interests of the affected stakeholders. Figure 1 shows the closure process, additionally the section in this report which further explains each phase of the process is referenced.

To execute the process multiple stakeholders of the public sector, private sector and civil society will have to be coordinated effectively. In the public sector, requirements from the Ministry of

Figure 1 / **Process to shutdown coal generation facility**



Source: Adapted from EPRI 2020

Energy, Ministry of Environment, Ministry of Health, Ministry of Urban Development and Housing, and local government will have to be considered and coordinated. Further, the companies which own the generation facilities will have to involve multidisciplinary teams within their organization. In each community relevant stakeholders, needs, social and environmental conditions inherited from industrial activities near the generation facilities expected to be shutdown will have to be considered.

The definition of a processs and work standards will be relevant in helping materialize a shutdown process in the most harmonious way possible. Focusing on the adequate structuring and execution of several processes will be important. Additionally, a mechanism should be established to share lessons learnt from the different shutdown processes which are materialized over time.

In the development of this project the inodú team was supported by the Electric Power Research Institute (EPRI, 2020). Additionally, there were several instances where stakeholders from the private and public sector provided feedback. This guide should be used jointly with the "Coal-fired power plant decommissioning: recommendations and best practices for stakeholder engagement", developed by Gestion Social and commissioned by the GIZ.

2

Objectives

The Environmental Best Practice Guide to Shutdown Coal Facilities in Chile was developed to provide guidance and best practices, which have been translated into minimum requirements to face the environmental and social challenges which are generated when shutting down a coal generation facility[1].

1 The community participation and social components are addressed in detail in "Guide for the participation process in energy projects: Shutdown of coal generation facilities", developed by Gestion Social.

3

Preliminary assessment

3.1 Contextualization of location and state of retirement of coal facilities in Chile

In Chile, there are currently 10 coal facility complexes distributed in 6 "comunas"[2] which contain 28 generation units. In 2019, the Ministry of Energy, signed an agreement which generation companies to shutdown all coal facilities by 2040. Additionally, the aspiration to reach carbon neutrality by year 2050 was presented. As part of the first stage of the agreement, generation companies committed to shutting down eight coal units which represent a total of 1047 MW. Later, as part of the COP 25 activities 334 additional MW of coal generation capacity were committed to be shutdown, this included units CTM1 and CTM2 – Mejillones. Finally, in May 2020 the previously committed shutdown of unit Bocamina I was advanced to the end of 2020 and the shutdown of Bocamina II was defined for year 2022. In total, 11 generation units, consisting of 1731 MW of capacity are expected to shutdown by 2024, representing 31% of the coal capacity currently operating in the country.

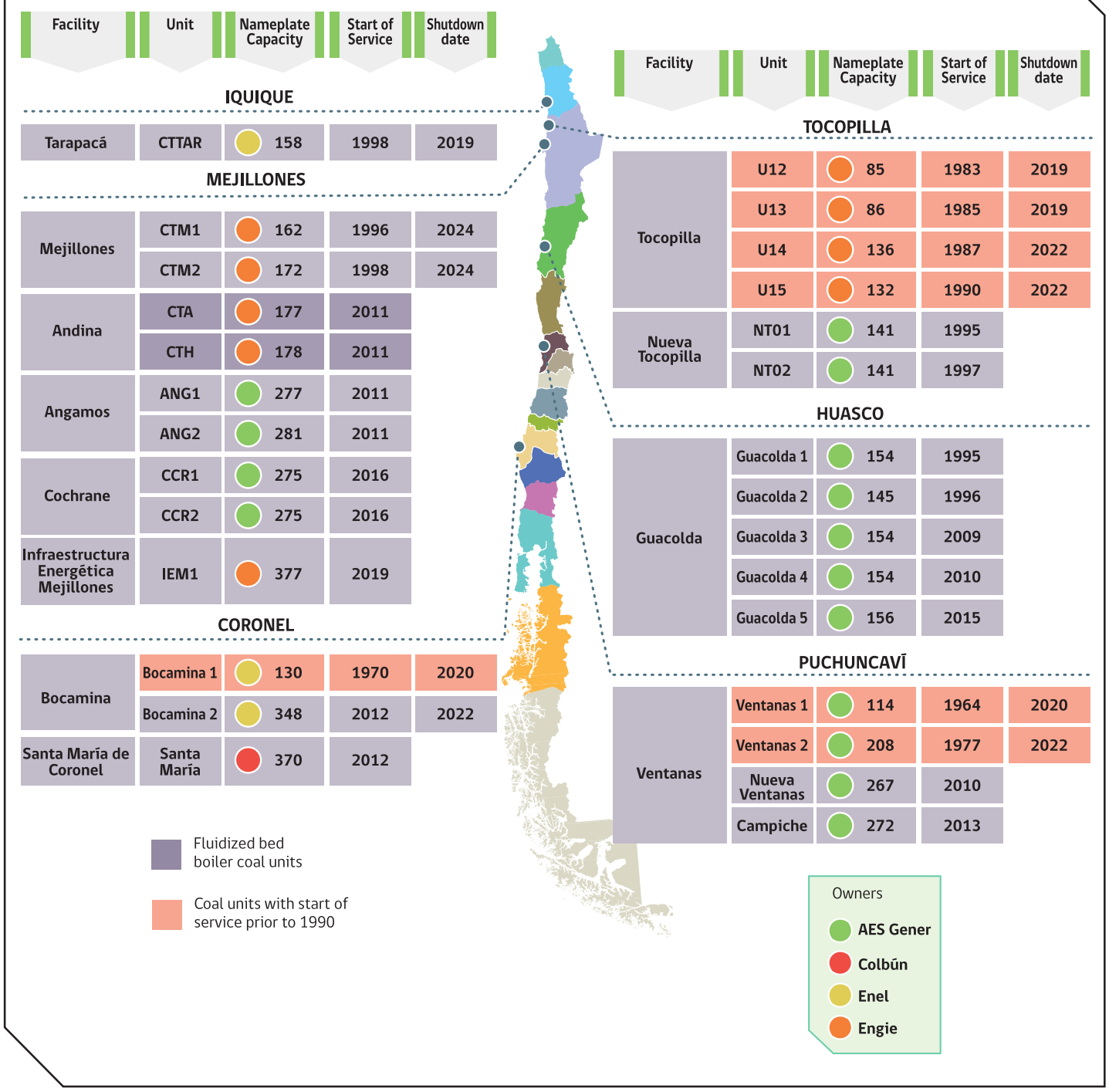
Figure 2 shows for each of the coal generation units in Chile: location, the installed capacity, the year of commissioning and the year committed for retirement. Coal generation facilities are located by the coast of the Pacific Ocean because of favorable economic and operational conditions the Chilean coastline provides to these units, some of the benefits are associated to cool water access and coal delivery.

Besides the Tarapaca and Santa Maria units, coal units are part of a complex of units which share infrastructure and services. The infrastructure units share within the complex includes: the port, the storage yard, the chimney, the water intake and discharge system, the water treatment facility, the ash ponds, and others. Therefore, the conversion or shutdown of some of the older units will have to be executed in a location where another newer unit might remain operational.

The use of the shared infrastructure and land between a retired unit and other units which continue to operate within a complex will affect the implementation of the shutdown or reconversion plan for the unit being retired. Therefore, the environmental and social challenges produced by a unit which belongs to a complex must be differentiated from those which are generated from the process to shutdown the complex itself or a unit within the complex.

2 The comunas are the smallest and basic administrative division in Chile. It corresponds to what in other countries is known as municipality. As of 1976 and because of the regionalization process, the communes came to replace the sub-delegations of the Government in their political-administrative functions and attributions, as a sub-national entity of local character. A group of communes make up a province.

Figure 2 / Map of coal generation facilities in Chile



Source: Own elaboration

3.2 Applicable national regulation

3.2.1 Coal facility shutdown

In some environmental permits, Resolution of Environmental Acceptance (REA), for existing coal generation facilities the shutdown phase was not defined. Hence, the option to replace existing equipment or develop new infrastructure in the project site was a possibility. Article 11 of the General Environmental Law (Law Nº 19.300) establishes that in case a project or activity within a REA is modified then the sum of the impacts caused by the modification and the existing project or activity must be considered in the permitting process.

If the objective is to shutdown the coal generation facility, it is important to establish if remediation will be necessary, in case remediation is necessary, the objectives for the remediation must be established. First it must be determined if there are contaminants present in the soil or groundwater at the coal generation facility site[3]. If contaminants are present, then an analysis must be conducted to determine if the contaminant concentrations are significant and pose a risk to the surrounding populations or the environment. The potential level of exposure people will have to contaminants must be considered and the contaminant concentrations detected must be compared with values in standards which determine acceptable concentrations. There are two types of reference concentration levels[4]:

- Those which are directed to determine if it is necessary to take a particular action at a site with contaminant presence.
- Those directed at determining the remediation objectives.

Currently in Chile, regulation which determines acceptable contaminant concentrations in soil is not available, therefore values are not defined in the regulation which could help establish remediation objectives. Only a reference guide which establishes a procedure to determine if a site poses unacceptable risk and requires action to be taken is available (Fundación Chile 2012). However, the guide does not specify acceptable contaminant concentration values which can be used in an environmental evaluation. Further, the Resolution Nº 406 of the Ministry of Environment which approves the Methodological Guide for Soil Management with Potential Contaminant Presence and Annexes does not define reference contaminant concentration levels.

In article 3, letter o) and number 11 of the Environmental Impact Assessment Rules (DS 40) reparation and recuperation of areas which are larger of equal to 10,000 m^2 and contain contami-

3 Found in various environmental permits analyzed of generation facilities, Annex (inodú, 2018).
4 "Although there are several possible situations, two main types of reference values can be distinguished: (i) those aimed at deciding whether to take any action on a particular SPPC or (ii) those aimed at determining remediation objectives" (Fundación Chile, 2012, page 69).

nants are defined as projects which can cause environmental impact. Depending on the circumstances, it is possible to justify that the shutdown plan for a coal generation facility does not present adverse elements or circumstances defined in Article 11 of law 19.300, therefore an Environmental Impact Assessment does not have to be conducted[5].

Article 8 of Law 19.300 establishes that the projects or activities defined in Article 10 can only be executed or modified prior to having their environmental impact evaluated[6]. Given the existing regulation and the environmental permits which were granted, it is not clear that an Environmental Impact Assessment must be conducted for a coal generation facility shutdown plan. In some cases, the shutdown plan is already defined and approved (Figure 3). For the generation facilities which have a REA without a shutdown plan, depending on the circumstances, will have to submit a shutdown plan through an Environmental Impact Statement (DIA). Additionally, those generation facilities which do not have a REA will have to present a shutdown plan through an Environmental Impact Declaration (DS 40, Article 2, letter g.2).

In the case an Environmental Impact Statement is presented in the shutdown process of a coal facility, this could include voluntary agreements not required by law, in which case the owner of the facility must abide by the agreements (Article 18, law 19.300).

After reviewing the environmental permits of the existing coal generation facilities and the ash ponds (inodú, 2018), the following was concluded:

- Seven units do not have an environmental permit associated to the original project.
- Six units were required to present a shutdown plan in their REA that should be started 6 months to a year before abandoning. Two units (Nueva Tocopilla) commited to develop before shutting down.
- The REAs of the remaining fifteen units state that the most probable outcome is that the units are reconditioned or reconverted with another generation technology. In the case that the site is abandoned, the following was committed: the disassembly and retirement of structures, superficial and marine equipment. However, the foundations are to be kept (they could be buried and covered with material from the surroundings to mitigate the visual impact). The details of the plans presented varied.
- There are five REAs for the ash ponds, which were presented separately from those of the generation facilities, because these facilities had to be expanded or modified after their

5 Article 18 of Law 19,300 indicates that project owners that must submit to the Environmental Impact Assessment System and do not require preparing an Environmental Impact Study, must submit an Environmental Impact Statement.
Article 4 of DS 40 establishes that a project owner that submits to the SEIA will do so by submitting a Environmental Impact Statement, unless said project generates or presents any of the effects, characteristics or circumstances indicated in Article 11 of Law 19,300, in whose case must present an Environmental Impact Study.

6 These projects are listed in detail in DS 40, Article 3.

initial construction. The facilites are Barriles, Central Térmica Mejillones (CTM), Puchuncavi, Bocamina and Santa Maria. The details covered in the shutdown plan are primarily associated to the covering of the ash pond.

In Figure 3 the details of the committed shutdown actions which were included in the REAs of the generation units and ash ponds are presented. Some of the points presented in the figure are worth noting for example: if a shutdown plan was committed or required[7], if there is an expectation recondition with another generation technology[8], the shutdown of the unit, measures committed to shutdown the ash pond, the disassembly of marine or coastal infrastructure, the demolition of infrastructure, the recycling and/or the disposal of the materials produced in the demolition process and if there are mitigation measures for visual and environmental impacts.

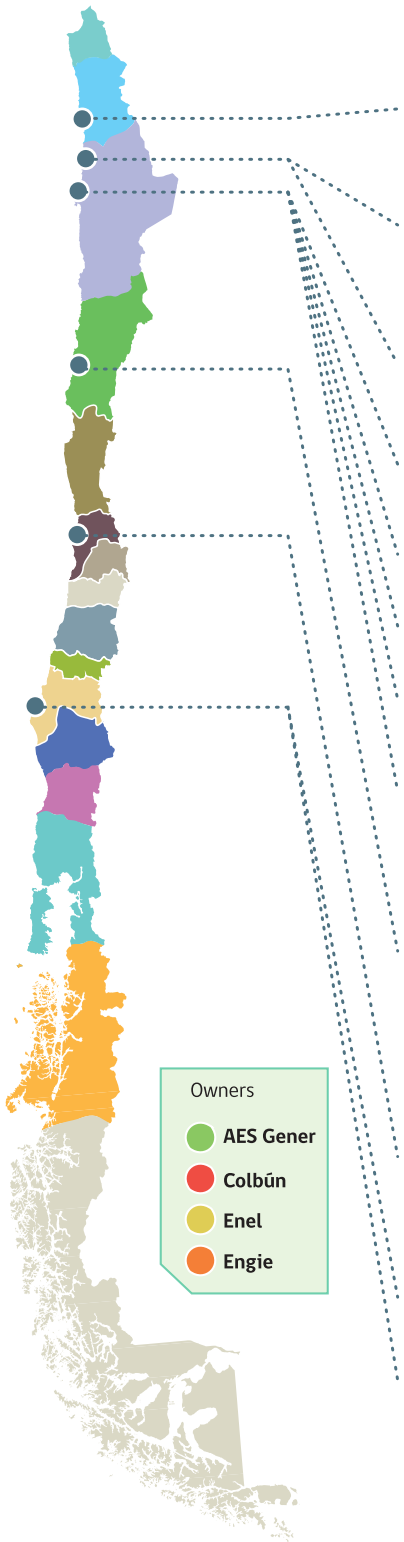
There are generation complexes where generation units with a defined and undefined shutdown plan co-exist, hence it must be decided what will be applied when defining a shutdown plan for the complex. A decision must be made because the scope of an REA is limited to the project it was associated to. However, such problem does not apply to a generation unit that does not have an REA because of its age.

The definition of the remediation objectives which are more ambitious than those defined in the REAs for each unit, would have to be generated through a voluntary agreement between the state and the owner of the facility. Such definition would also apply to units which do not have a REA to operate. The commitments made in these voluntary agreements would be within the scope of what is defined in Article 18 of the 19.300 law.

7 For example, units NTO1 and NTO2 have a shutdown plan defined, however these plans do not consider the shutdown of the facility. Specifically, in both Environmental Impact Assessments in the abandonment plan (Section 2.6) the following is included: "To date, the abandonment of the installations is not considered for the Nueva Tocopilla Facility. At some point, Norgener S.A. will develop an abandonment plan for the facility."

8 For example, in the case of the IEM facility, Figure 3 shows that a reconditioning plan is included in the Environmental Impact Declaration of the facility. Specifically in Section 1.9 (Abandonment Stage) the following is included: "The abandonment stage of a facility is not defined in time, because it is always possible to replace the equipment which has reached useful life, if needed, install a new infrastructure in the existing site."

Figure 3 / Commitments in shutdown plan defined in environmental permit



Facility	Unit	Year		REA*	Shutdown plan	Recondi-tioning	Shutdown of unit
Tarapacá	CTTAR	1998		✔		✔	
Tocopilla	U12	1983		X			
	U13	1985		X			
	U14	1987		X			
	U15	1990		X			
Nueva Tocopilla	NT01	1995		✔	✔		
	NT02	1997		✔	✔		
Cochrane	CCR1	2016		✔		✔	required
	CCR2	2016		✔		✔	required
Angamos	ANG1	2011		✔		✔	required
	ANG2	2011		✔		✔	required
IEM	IEM1	2019		✔	✔		If not reconditioned
Andina	CTA	2011		✔	✔		If owner decides
	CTH	2011		✔	✔		If owner decides
Mejillones	CTM1	1996		✔			
	CTM2	1998		✔			End of activities & removal of structures
Guacolda	U1	1995		✔			
	U2	1996		✔			
	U3	2009		✔	✔	✔	If needed
	U4	2010		✔		✔	If needed
	U5	2015		✔			If needed
Ventanas	U1	1964		X			
	U2	1977		X			
	Nueva Ventanas	2010		✔	✔	✔	If not reconditioned
	Campiche	2013		✔	✔	✔	If not reconditioned
Bocamina	U1	1970		X			
	U2	2012		✔		✔	Shutdown and abandonment if not reconditioned
Santa María	U1	2012		✔	✔	✔	Shutdown and abandonment if not reconditioned

* Resolution of Environmental Acceptance

[1] If the cost to maintain or refurbish the facility is excessive, then the facility will be abandoned or dismantled. Access to all buildings is shutdown and fences are built around the site to prevent access until a new use is defined.

	Shutdown of ash pond	Dismantling marine infrastructure	Demolition	Recycling	Disposal	Mitigation of impact
▲	Area with Urban potential					
▲	Perimeter barriers, handling of rainwater, covering					
▲	Perimeter barriers, handling of rainwater, covering					
▲	Perimeter barriers, handling of rainwater, covering					
▲	Perimeter barriers, handling of rainwater, covering					
▲	Perimeter barriers, handling of rainwater, covering					
▲	Perimeter barriers, handling of rainwater, covering					
▲		Partial	Yes except foundations			Covering of foundations to mitigate visual impact
▲		Partial	Yes except foundations			Covering of foundations to mitigate visual impact
▲	Covering	Total	Partial or total	Steel, materials, equipment and machinery	Materials, equipment and machinery	Soil layer
▲	Covering	Total	Partial or total	Steel, materials, equipment and machinery	Materials, equipment and machinery	Soil layer
▲	Level ground	Dock, including columns	Above ground level	Steel, oil, lubricants, copper & aluminum cables, glass, ponds, piping	Plastics, waste, minerals for insolation, other	General cleaning
▲	Level ground	Removal		Steel, oil, lubricants, copper & aluminum cables, glass, ponds, piping	Plastics, waste, minerals for insolation, other	
▲	Level ground	Removal		Steel, oil, lubricants, copper & aluminum cables, glass, ponds, piping	Plastics, waste, minerals for insolation, other	
▲						
▲	Shutdown					
▲	Leveling, covering with low permeability, resistant to erosion, without need for maintenance					
▲	Leveling, covering with low permeability, resistant to erosion, without need for maintenance					
▲	Leveling, covering with low permeability, resistant to erosion, without need for maintenance		Partial or total	Steel, oil, lubricants, copper & aluminum cables, glass, ponds, piping	Plastics, minerals for insolation	Soil layer and vegetation cover
▲	Leveling, covering with low permeability, resistant to erosion, without need for maintenance		Partial or total	Steel, oil, lubricants, copper & aluminum cables, glass, ponds, piping	Plastics, minerals for insolation	Cleaning where necessary, soil layer, vegetation cover
▲	Leveling, covering with low permeability, resistant to erosion, without need for maintenance		Partial or total	Equipment and structures		Soil layer and vegetation cover
▲	Incorporation of plan to SEIA. cleaning and restoration of surroundings, care of vegetation					
▲	Incorporation of plan to SEIA. cleaning and restoration of surroundings, care of vegetation					
▲	Incorporation of plan to SEIA. cleaning and restoration of surroundings, care of vegetation	Restoration of coastline	Partial or total	Equipment and structures	Residues	Soil layer and vegetation cover
▲	Incorporation of plan to SEIA. cleaning and restoration of surroundings, care of vegetation					
▲	Cover and vegetation cover					
▲	Cover and vegetation cover		Partial or total	Furniture, equipment, structures and ponds	Equipment, structures and ponds	Soil layer and vegetation cover
▲	Covering with soil , resistant to erosion and without need for maintenance			Wood, boxes, piping, paint, insulation, beams, iron, other	Piping, wood, cardboard, boxes, steel, sheets, etc.	

Ash pond ▲ Barriles ▲ Cerro Gris ▲ Guacolda ▲ Santa María ▲ Bocamina ▲ CTM ▲ Puchuncavi ▲ Tarapacá

Source: Own elaboration

3.2.2 Other regulatory consideration

The following are regulatory requirements which could be of interest:

- Standards for the handling and disposal of waste defined in Articles 78-82 and 84 of DFL 725 of the Ministry of Public Health, Health Code.

- Article 67 of DFL 725 of the Ministry of Public Health, Health Code: Assigns the responsibility to the National Health Service to eliminate or control all the factors, elements, and agents in the environment. Specifically, those which affect the health, security, and wellbeing of the population by abiding to the stipulations defined in the Health Code and associated rules.

- Decree 594 of the Ministry of Health, which approves the rules associated to the basic sanitary and environmental conditions in the workplace:

    - Article 17: It is prohibited to release mining or industrial discharge or contaminated water with toxic substances of any nature, without previously being treated with the prescribed treatment by the sanitary authority to groundwater, irrigation channels, aqueducts, rivers, estuaries, streams, lakes, lagunes, dams or any other waterbody or waterway.

    - Article 18: The accumulation, treatment, and end disposal of industrial waste within the industrial site or worksite must be authorized by the sanitary authority.

    - Article 19: The companies which treat or dispose of industrial waste outside the site, either directly or through third parties, must be authorized by the sanitary authority prior to the start of activities. To obtain a permit, the company which produces the industrial waste must show that the transportation, treatment, and final disposal is being conducted by professionals or companies which have been authorized by the Health Service.

    - Article 20: In all cases where industrial waste has to be treated or disposed of outside or within the industrial site, the company, prior to start of activities, must present to the sanitary authority a declaration which contains the quantity and quality of the industrial waste generated, clearly differentiating hazardous industrial waste.

- Decree 144 of the Ministry of Health establishes the standards to avoid producing atmospheric vapors or contaminants of any nature. Article 1: The gases, vapors, smoke, dust, or contaminant of any nature and produced in any production or work establishment must be captured or eliminated in a way which does not create danger, harm, or discomfort to the adjacent population.

- Decree 148 of the Ministry of Health approves the sanitary rules associated to the handling of dangerous waste. These rules establish the minimal sanitary and safety conditions which must be met when generating, possessing, storing, transporting, treating, reusing, recycling, disposing, or eliminating dangerous substances.

- Law 458 of the Ministry of Housing and Urban Development, which approves the General Law of Urban Development and Construction. Article 116: The construction, reconstruction, alteration, expansion, and demolition of buildings require a permit from the corresponding Municipal Works Agency. All works must meet technical standards, the general ordinances, and the regulating plan for the corresponding municipality.

- Conditions for vehicles which transport waste, sand, gravel, or other materials: Article 2 of Decree 75 from 1985 of the Ministry of Transportation and Telecommunications, establishes the conditions to transport loads. To transport hazardous substances through roads and streets the Decree 298 of 1995 from the Ministry of Transportation and Telecommunications must be considered.

3.3 Early-stage definitions which affect the process

3.3.1 Coal generation facility operator

The owner of the generation unit which is set to retire has several options of what to do with the existing generation infrastructure and site, the options are summarized in Figure 4.

Figure 4 / **Options of the owner of a generation facility that will be retired**

Note: Adapted from Raimi, 2017

The option to maintain the units which have not been retired from the system as a strategic reserve for five years exists in Chile. In this case, the unit will not operate unless it is called upon to operate by the Chilean National Electricity Coordinator (equivalent of Chile's independent system operator). The recommendations presented in this guide apply once a unit finalizes its operations or when the strategic reserve period comes to an end.

The recommendations presented in this guide apply in the case where the owner decides to sell the asset and all the associated environmental liabilities.

The cold and dark state is a transitory solution which involves closing the facility, demolishing some of the infrastructure, remediating the site partially closing the site and restricting access

to people. Usually, the site is guarded with physical barriers and security, the operations are abandoned. Such is a temporary solution for sites which don't have significant value or when they can't obtain interest or financing to start the redevelopment of the site. This option can also be used for units which are shutdown but share a site or infrastructure with other units which are still operating. For such option, the retired unit can be left in standby and voluntary environmental commitments or agreements for the handling and decommissioning can be defined[9]. These environmental commitments or agreements are executed primarily when all the units in the generation complex are retired or when it is economically feasible to redevelop the site partially or fully. It is important to consider that in general a redevelopment can be executed when it is economically feasible.

A voluntary agreement is a viable option when the risk towards the population and the environment is low[10], even when additional cleaning at the site is desired. The additional cleaning at the site could be conducted if a redevelopment is executed, such stipulations could be included in the official documentation associated to the site. Additionally, there are contaminant levels that are acceptable and do not pose a risk for health and the environment, therefore remediation actions are not necessary, such is known as minimis condition[11].

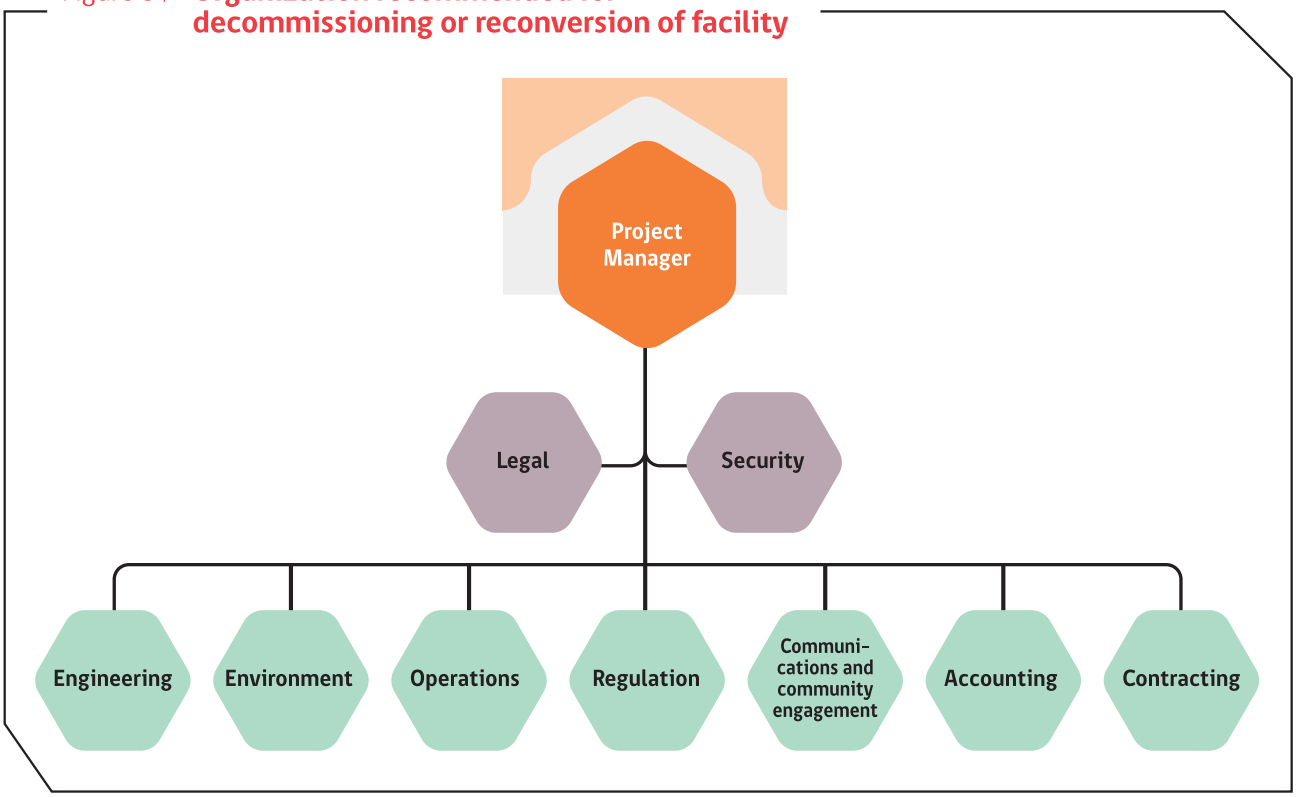
3.3.1.1 Need to create a transition team

The entity responsible of a coal generation unit set to retire must create a transition team which should have the authority to execute the decommissioning process. The team will be assigned the following functions: project management, operations and technical components of the redevelopment and communications. The transition team should have the support of the company's upper management, have qualified professionals, should have the support of the rest of the organization and have access to the facility's records and information.

The functions of the transition team will evolve over time depending on the stage and the approach taken to shut down the unit. For example, units which opt to become a strategic reserve for 5 years will have different management needs than those which decide to fully cease operations. The transition team should not only interact with different areas within the company, but also with local organizations, regional organizations, and different government agencies.

9 More details about the environmental commitments are presented in Section 6.2.
10 More details in the risk analysis section, Section 6.1.
11 The definition of minimis condition is defined in standard ASTM 1527 -13, Section 2.2.22 and ASTM E1903-11, Section 3.1.15.

Figure **5** / **Organization recommended for decommissioning or reconversion of facility**



Source: EPRI 2020

3.3.2 The regulator

The shutdown of a coal unit involves a transition process that not only affect the owners of the facilities and the locations where the facilities are located but also the whole country. The development of this transition process involves a coordinated interaction between multiple government agencies. To encourage coordination and agility within the government, it is important that the state establishes a transition team which can facilitate the coordination which must be materialized between the entities involved.

Reconverting a site for new uses is in part conditioned by the strategic needs which could be tackled at the different sites and the associated public policy. For example, the supply of potable or industrial water, the production of hydrogen, firm generation capacity with low emissions, development of distribution centers or other options. The development of such projects could also be conditioned by the contaminant levels present at the site which is to be reconverted and the corrective actions which are defined as a function of a risk analysis assessment.

The structuring and application of corrective actions based on a risk analysis are also conditioned by public policy which is critical to the risk management process. Amongst the regulatory definitions which have to be established to conduct a risk analysis are the definition of objectives for quality of information, the definition of target risk levels, adequate data and statistics required to adequately determine contaminant levels, the selection of exposure assumptions, the process to establish consensus and to accept decisions, limitations of land use[12], the effectivity of remediation measures, the cost of the measures, amongst others.

The definitions described in this section must be executed prior to the start of a risk analysis-based remediation program. According to recommendations defined in the international standard ASTM 2081 – 00 (Risk-Based Corrective Action), the company which is starting a shutdown process and defining the remediation for a site must inquire the relevant authority for the definitions described in this section prior to implementing risk based corrective actions.

Section 4.4 of the ASTM 2081 – 00 standard recommends that the user avoids prescribing reference values or risk levels associated to the concentration of contaminants.

3.4 Permit analysis for generation facility

The operator of the generator facility must conduct a permit analysis for the generation unit and related modifications. The permits which are related to the complex or subcomponents of the complex such as the water withdrawal system should be identified.

It is desirable to identify if some subsystems are permitted to operate independently of the generation facility to identify specific installations that could be used for different purposes once the generation facility is retired.

12 From a public policy perspective there is not a preference to determine remediation actions or control measures based on establishing limitations for land use. Limiting the land use requirements in a property can affect the cost efficiency and agility to implement the project. The definition of remediation activities when a remediation standard has been defined based on land use can in some cases increase the value of land, reduce the monitoring cost in the long term, and increase the effectivity in protect the health of people. Performing a cost benefit evaluation of the options to meet the objectives of health and environmental protection is recommended.

3.5 Plan the participation strategy of stakeholders

The participation activities of the stakeholders should have the objective of ensuring that the stakeholders are involved and if interested get involved in the planification of remediation and reuse of the site. It is important to inform early the risks associated to the facility shutdown and what are the alternatives to control and mitigate the associated impact. Stakeholders from the private and public sector should develop the participation activities.

In the initial stage, the participation activities should have the following purpose:

- Communicate the plans to shutdown and cease operations of the generation facility, particularly the plans considered a temporary partial shutdown (there could be a unit that still operates in the complex), a definitive shutdown and an eventual remediation or reconversion of the site.

- Communicate potential risks to the environment and people generated by the shutdown of the facility and the public policy which is critical to the risk management process.

The scope of the participation activities and the involvement of the stakeholders should be diverse. There will be activities focused on defining the potential redevelopment or to clean up the site, these activities are conditioned by:

- The associated public policy definitions,

- The type of reuse alternatives which will be evaluated,

- The contamination levels generated by anthropic diffuse sources present at the site, and

- The reference target contaminant concentration value which should be achieved for soil or water.

For example, if the contaminant concentration values which are to be used to evaluate the risk level of a particular site are established by standard values defined by the regulator at the local or national level[13], then the level of involvement of the stakeholders can be less significant than if the contaminant concentration values have to be determined for each specific site[14].

[13] In case these values are defined at a national level or a reference for them.
[14] If reference levels are established for a specific site then the exposure parameters must be defined jointly with the stakeholders, which is different than the approach of using standard conservative values.

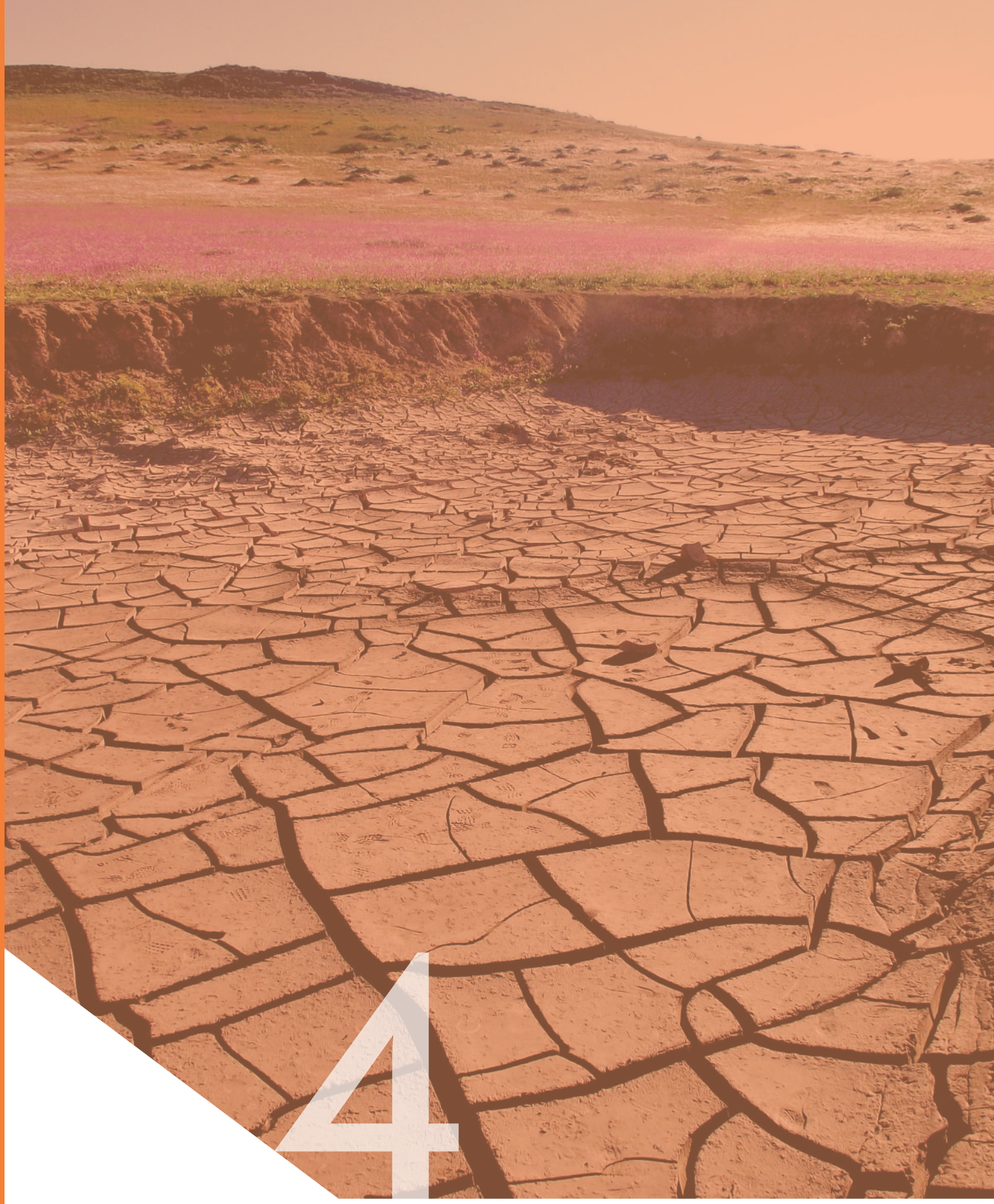
At sites where the stakeholders have shown a high level of interest to remain involved it is important to develop a participation plan which considers gathering information about:

- General context of site,
- History of participation activities which stakeholders have been involved in,
- Already established control measures,
- Participation opportunities to define reuse of site[15],
- Participation opportunities for remediation measures,
- Activities which will be developed to evaluate and incorporate remediation concerns,
- General description of risks in the process to define reuse and/or remediation of site and the instances where stakeholders will be able to be involved to define and communicate the risk reduction measures which are to be implemented.

There will probably be differences in opinion amongst the stakeholders, specifically associated to the public policy and regulation which conditions the remediation and the improvement program based on a risk assessment. The limitations imposed on the use of the site, the remediation requirements and the contamination concentration reference levels are elements that will also generate tension amongst the stakeholders. In general, the goal of the process is to commit the stakeholders to the participation process and reach as broad of a consensus as possible amongst the different points of view on the issues discussed.

For more details of the definition of the participation process we recommend reviewing the Guide "Coal-fired power plant decommissioning: recommendations and best practices for stakeholder engagement".

15 More details about participation process to define new use alternatives for site is covered in Section 6.2.



4

Identification of environmental challenges at site

The activities defined in this section were defined to obtain a detailed description of the characteristics of the generation facility site in order to take informed decisions of the potential redevelopment of the site. The description of the site should consider the following: topographic, geological, hydrological, land use and disposal of waste within the site.

Additionally, it is important to identify that substances which generate a health risk or a risk for the ecosystems are present within the site, such condition is called a "Recognized Environmental Condition"[16]. Such condition could have been caused by the possibility that there has been a discharge, clues of possible discharge, or the conditions exist which threaten a possible future discharge of substances which generate a health risk or risk for the ecosystem at the site[17].

On the other hand, the presence of a "Controlled Recognized Environmental Condition"[18] must be identified. The "Controlled Recognized Environmental Condition" is a recognized environmental condition which is derived from the release of hazardous substances or petroleum derivatives in the past at the site, but which release was conducted considering the recommendations of the relevant authority. In such case, hazardous substances or petroleum derivatives could remain at the site if the necessary controls are implemented. At this stage of the process, the identification of a "Controlled Recognized Environmental Condition" does not imply that the professional which oversees the characterization of the location should evaluate or determine if the control method used was adequately selected and continues to be effective. For example, if a spill of a substance was cleaned according to a non-residential standard, but does not meet a residential standard, then the control measure belongs to and will remain classified as industrial use, hence not permitting its residential use.

A minimis condition is not considered under a "Recognized Environmental Condition" or "Controlled Recognized Environmental Condition".

It is important to adequately characterize the site because it helps prevent the emergence of unexpected environmental challenges which can involve additional costs.

4.1 Preliminary activities

The objective of this section is to describe the process which must be executed in order to gather the necessary information to characterize the site. The site characterization includes the following three preliminary activities: records review, site reconnaissance, and interviews. These activities can be executed in any order desired, in sequence or in parallel. These activities help identify

16 Recognized Environmental Condition according to Section 1.1.1 of standard ASTM 1527 (2013) and Section 3.1.43 of standard E1902-11.
17 More details about contaminants which are located in sites of coal thermoelectric facilities in Section 5.3
18 Controlled Recognized Environmental condition according to standard ASTM 1527-13, Section 3.2.18.

the attributes of a particular site, the available assets (described in Section 4.2), the potential sources of contaminants and/or the contaminated sectors (described in Section 4.3). During the initial phase it is not necessary to take any samples and conduct chemical analysis of materials, water, soil, construction materials, etc. The goal of this phase is to identify in a simple and economical fashion if there will be a need to conduct testing (standard ASTM E1527, section 7 to 11 and Re MMA No 406 from 2013).

4.1.1 Records review

The objective behind reviewing historical records for the site is to determine the potential contamination sources that exist or existed at the site. Therefore, information must be gathered about the site uses, groundwater sources and chemical analysis of the soil. The gathered information helps identify the presence and movements of the contaminants at the site (ASTM E1527, 2013).

The ASTM 1527 standard recommends that records are gathered starting from whatever date occurs later: the date of the first use of site or 1940. The use of the site should then be determined for the site starting with the evaluation date and continuing every five years until the present[19]. To conduct the analysis, government reports and documents which contain the necessary sector or environmental scope such as resolutions and ordinances[20], administrative acts, sector centered listings and registries, environmental databases, technical studies, complaints and sanctions, information about environmental incidents, and others should be considered. Equivalent sources of information could be requested from the Municipalities (Re MMA No 406 from 2013, Phase I, letter a). For example, the Certificate of Prior Information can be solicited from the Directorate for Municipal Works, which contains the applicable conditions for the site which were derived from the urban standards in the Territorial Planification Document of the commune. Additionally, information can be gathered from the property title, aerial imaging, maps, local newspapers, amongst other sources. If after reviewing an information source, there is evidence which points towards possible sources of contamination in the properties surrounding the site, these must also be considered in the site characterization exercise (ASTM E1527, 2013).

In the final report all the sources which were used in the analysis should be sited. It is possible that not all necessary information is gathered, given the lack or limited amount of information available about the site or the surrounding sites. The inadequate availability of information about the site is known as data failure according to standard ASTM 1527. If not enough information is gathered, because of the lack of information or lack precision and reliability of the information, about the historic uses of the site during the prescribed time interval of analysis, then the final report should present a data failure.

19 If information is available for one use for a long period of time, it is not necessary to find additional information which corroborate the site use during the extended period of time.

20 For example, the master plan for the coastal border.

It's important to identify if spills or leaks of hazardous substances or petroleum derived products occurred in the past. Additionally, it is important to identify if an area of the site was used to store chemicals or hydrocarbons, because these could be a source of contamination. Since the coal generation facilities are located by the coast, in coastal areas where there are other industrial activities, it is important to research how the other activities could have affected the site. It is possible that the contamination at the site could have arrived through the air, ocean water, or through diffusion in soil or groundwater.

4.1.2 Site reconnaissance

The site reconnaissance has two objectives. First, identify all the structures, machinery and other assets which are present at the site and their respective state. Secondly, identify the possible sources of contamination and the environmental liabilities at the site (ASTM E1527, 2013).

During the site visit, the area of the site, the site topography and subdivisions by use should be identified. For example, coal storage, main buildings, generation units, ash ponds, water intake system, substation should be identified. It is important to identify and describe all the buildings and their existing state, size, number of floors and age (ASTM E1527, 2013). Other structures such as warehouses, roads and parking areas should be documented and described. Special attention should be placed if there is a risk that there is a presence of asbestos, PCBs or lead (usually present in paint), especially if the buildings are old. The current use of all the permanent structures should be identified in the most detailed manner possible. Special attention should be placed to areas which stored or disposed of dangerous substances or petroleum derived products (ASTM E1527, 2013). It must be determined if there is drinking water or wastewater system available, specifically noting age, function, and state.

In the zones outside the buildings the presence of the following should be evaluated: liquid accumulation, containers with or without leaks, corrosion signs, spots on the ground or pavement, solid or liquid waste, septic tanks, smells or any other element which might hint contamination is present at the site (ASTM E1527, 2013).

The site visit should also include an inspection outside the site and of the perimeter. The uses of neighboring properties should be documented if possible, especially if the uses can be associated to a "Recognized Environmental Condition" in the neighboring properties or in the main site. In some cases, the identification of historical uses in the neighboring properties can be identified through the site visit or through interviews. The neighboring properties and main properties should, if possible, be associated to a "Recognized Environmental Condition" and then documented.

As a result of the inspection activities, the inspection form included in Annex Nº 2 of Re MMA Nº 406 of 2013, Phase I, letter d should be completed.

4.1.3 Interviews

The primary objective of interviews is to gather information about the possible presence of contaminants at the site.

People related to the site either in the present or past should be interviewed. Some examples of the people which should be interviewed are the owners, operators, and workers. As a starting point, it might be useful to ask the interviewed, especially the owners, for documents associated to the property, which should be reviewed considering the activities defined in Section 4.1.1. (ASTM E1527, 2013).

The questions can be focused on understanding the various uses the property has experienced over time and if certain locations of the site have been exposed to contaminant release or leaks. Questions should be asked about the previous uses for the site, the current or past presence of chemicals or hazardous substances in the property, any accidents which occurred, accidental spills or release of hazardous substances at the site or adjacent properties (ASTM E1527, 2013). It is also important to ask about any temporary structures used for maintenance which were operated at the site in the past, especially when conducting the interviews at the older generation facilities, because these structures could point to a potential risk for soil contamination.

Finally, questions should be asked about the existence of procedures, audits, inspections, complaints, or accusations about the environmental violations related to the property, or if an environmental remediation has been conducted for the site (ASTM E1527, 2013).

The purpose of the interviews does not have the objective to assign responsibility or sanction the people responsible for identified challenges, which must be informed at the moment when the interviews are conducted.

4.2 Identify the site attributes and assets

The objective of this section is to characterize the site and location. Once all the activities defined in Section 4.1 have been executed, a description of the region where the generation facility is located must be generated, specifically describing the surroundings and if the region is industrial or urban. It is important to describe the site, specifying the use of the site and the

structures present in each part of the site, its location and area (Kevin Gallagher Consulting, 2019). Maps for the site should be used as supporting material.

To identify the attributes and assets within the site, all the parts of the site should be characterized. Specifically, the assets present at the property should be described in detail in terms of quantity, state, size, functionality, age of the construction and equipment, and the permits which are available at the property or generation facility (Kevin Gallagher Consulting, 2019).

The assets which are part of a coal generation facility usually include: water intake systems, port or access to a port, substation, electrical wiring, buildings and structures, internal and access roads, connections to public transport, parking areas, a waste collection system, drinking and wastewater services and others.

4.3 Identify contamination sources and contaminated areas

With the information collected in Section 4.1 all the uses which the property has experienced should be available and if any of these uses possibly generates a "Recognized Environmental Condition". The site characterization should be used to identify the presence of contaminants or hazardous substances[21] from a probable or known release in the soil and possibly groundwater[22]. To conduct a more detailed characterization the ASTM 1903 -11 (Standard Practice for Environmental Site Assessment: Phase II Environmental Site Assessment Process) should be used.

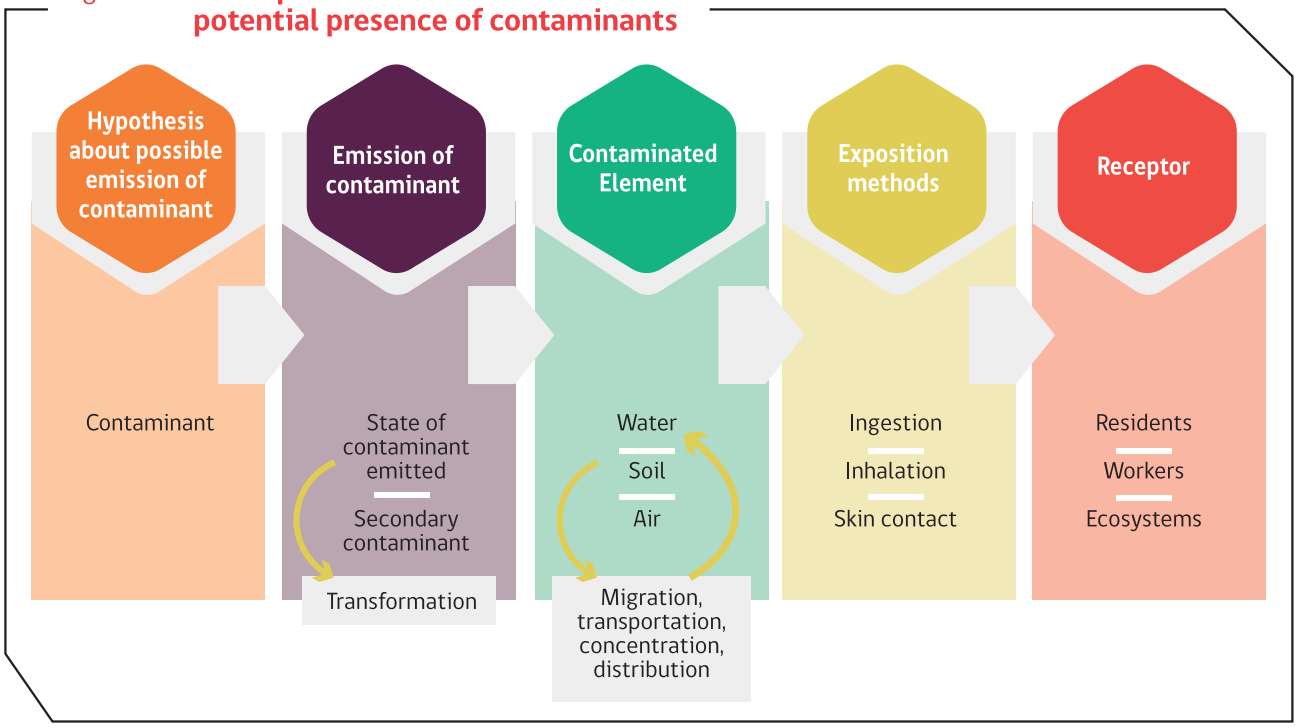
A conceptual model should be prepared for each area of the site (Re MMA No 406 of 2013, Phase II, letter a.5). Considering the different uses of the site, the following should be identified: possible contamination sources, the contaminants which are present because of a known or probable release of hazardous substances and contaminants, and the zones where contaminants and hazardous substances may be present in higher concentration. The model should generate a hypothesis about the presence of contaminants and should also present the behavior, fate and transport distribution, and concentration of the contaminants. Additionally, the presence of potential receptors, exposure points, and mechanisms of exposure of the contaminant should be included[23] (ASTM E1903, 2011). The conceptual model of the site must include an understanding of the current state and possible use conditions which might emerge in the future for the site (ASTM 2081 - 00, section 3.2.52 and section 6.3). Figure 6 shows a schematic for the conceptual model which must be developed for each contaminant of interest.

21 Article 2 letter d of the 19.300 law defines a contaminant like an element, substance, chemical or biological substance, energy, radiation, vibration, noise, or a combination of them as a possible risk to the quality of life of people, the health of the population, the preservation of nature, and the conservation of environmental heritage. The presence of these elements in the environment can occur at certain levels, concentrations, and periods of time.

22 The ASTM 1903 Standard -11 defines the scope of a release of a dangerous substance or contaminants which are defined as a release (section 3.1.44). The standard also defines the likely release area in section 3.1.28. The definition of the conceptual model is presented in Section 3.1.11, 6.4.3 and 7.4.

23 Normally ingested in contaminated water, through skin contact and/or inhalation of suspended particles.

Figure 6 / **Conceptual model of a site with potential presence of contaminants**



Source: Own elaboration

Historically, the contaminants that are present at the coal and ash storage areas include: arsenic, cadmium, chromium, iron, lead, mercury, nickel, selenium, manganese, zinc. The coal generation facility sites could contain contaminants accumulated from the storage of fuel sources and the functioning of equipment: PCB, polycyclic aromatic hydrocarbons, BTEX (benzene, toluene, ethyl benzene, xylenes) and other petroleum derived products (EPRI, 2006)[24].

If the information gathered through the conceptual model for the site is enough to show that there are no possible and complete exposure paths, no new actions are required (ASTM 2081 – 00, Section 1.8.1). The exception is to ensure that in the site use limitations, if they have been defined, have been adequately identified (ASTM 2081 – 00, Section 6.16).

4.4 Validating the conceptual model: testing through chemical analysis

If after finishing activity 4.3 it is determined that a "Recognized Environmental Condition" could exist, then the recommended step is to sample soil and/or groundwater to confirm the presence of contaminants at the site. Moreover, sampling might be required if in the previous steps a data

[24] In the case of Chile, Vanadium could be present. This contaminant is not listed in the cited reference.

failure[25] was generated, because not all the historical uses for the site were identified (ASTM E1903, 2011).

In order to conduct the sampling process and chemical analysis the recommendations presented in the "Methodological Guide for Soil Management with Contaminant Presence Potential"[26] should be used. Specifically, the guidance provided in section 5.2.2.2 called sampling plan, execution and analysis and the recommendations presented in the Re MMA No 406 of 2013, Phase II, letter b should be used.

Chemical analysis must be conducted to determine the presence of specific pollutants in areas which have been identified as potentially contaminated according to the conceptual model. It's important to use the conceptual model presented previously in Section 4.3 as a sampling guide. The conceptual model must be refined and improved with the most recent information available throughout the testing process. Specifically, the upcoming sampling locations and the chemicals to be addressed can be determined considering the information obtained from prior sampling (ASTM E1903, 2011).

Once the results of the chemical analysis of soil and/or water have been obtained, the conceptual model could be validated to confirm contaminants at the site and their respective concentrations. If necessary, the conceptual model developed in section 4.3 can be modified or adjusted to effectively represent the existing contaminants which are present on the site, the exposure paths and the receptors which can exist (ASTM E1903, 2011). If the results obtained are not sufficient from the sampling to validate the conceptual model, an evaluation must be conducted to determine if the process needs to be redone. Any iteration must take into consideration the costs and possible of effectiveness of repeating the process. The evaluation should determine the steps that need to be taken to define the conceptual model and conduct a chemical analysis (ASTM E1903, 2011).

In case contaminants are found at the site, it is important to interpret the obtained results to determine, if the presence of the contaminants can be attributed to the coal generation facility which is up for retirement. If this is not the case, the source of the contaminants could have been: other emissions in the region; diffuse anthropic sources, which are activities which cannot be assigned to specific release point or site (ASTM E1903, 2011)[27], or simply the elements and substances are naturally present in the region. In such cases, environmental agreements with relevant stakeholders about the obligations and responsibilities of each of the stakeholders involved and the remediation objectives for the zone become more relevant.

25 Data failure according to Standard ASTM 1527 - 13, Section 3.2.20.
26 Fundacion Chile. Available in: https://fch.cl/publicacion/guia-metodologica-para-la-gestion-de-suelos-con-potencial-presencia-de-contaminantes/
27 The ASTM 1903 - 11 standard defines background concentration in Section 3.1.2, for diffuse anthropogenic contamination in Section 3.1.16 and establishes a guide to interpret the evaluation results in Section 8.

The contaminant concentration levels identified through the analysis should be compared with reference values. As shown in Section 3.2, in Chile soil quality standards do not exist, therefore there are not any reference values to establish the remediation objectives. In Section 5 of this guide the values used in the United States are presented. However, as shown in Section 3.3, before starting the corrective analysis based on a risk assessment the reference values which affect the remediation process must be defined early in the process between the relevant government entity jointly with the stakeholders.

5

Identify acceptable contaminant levels in water and soil

5.1 Definition of reference value according to specific use

The possible land uses for the generation facility are defined by the municipalities in their master plan. The master plans can be modified to adapt the land use to new development objectives or take into consideration the acceptable risk levels for the presence of contaminants in soil and water. Therefore, the need to remediate will depend on the concentration of contaminants present at the site and the permitted use for the site.

If applicable, the site remediation must consider the soil and the groundwater. The remediation objectives must be defined specifically considering the future use of the site, especially considering whether the use will be residential or non-residential. This guide focuses on defining the recovery of a site for future non-residential use given the location of the generation facilities.

The definition of target reference values is an early-stage decision that must be made by the regulator and condition the redevelopment and remediation process for an industrial site. In general, international best practices recommend that the company which must remediate the site does not prescribe target reference values. The objective of this section is to present criteria which can be used to define target reference values for the remediation of a site which is to be used for industrial (not residential) activity. The recommendations in this section were derived considering the procedures defined by the Environmental Protection Agency of the United States (US EPA) and the Environmental Protection Division of the State of Georgia (Geogia State EPD). The regulator must define the target reference values for remediation to consider in the process through the public policy mechanism it deems appropriate.

The site cleanup standard should be calculated considering the excess lifetime cancer risk of 10^{-5} and a hazard quotient of 1.0 for non-carcinogenic substances[28]. The site cleanup standard should be calculated for any regulated substance which presents a risk for the population. For a substance which generates a risk for cancer or any other health risk other than cancer, the standard should be derived considering the most sensitive effect[29] [30] [31] (Georgia's State EPD Rule 391-3-19-.07, (2)). For this guide, the requirement is defined as Health Based Derived Criteria (HBDC).

28 Other criteria should be reviewed in Section 6.2.1.4 of the Methdological Guide for the Management of Soil with Possible Presence of Contaminants (Fundacion Chile 2012).

29 The standard for groundwater could be determined considering equation 1 (carcinogenic effects) or equation 2 (non-carcinogenic effects) of RAGS part B for consumption (US EPA, 1991), RAGS, Part E for skin contact (US EPA, 2004) and RAGS, Part F for inhalation (US EPA, 2009).

30 The standard for soil could be determined considering equation 6 (carcinogenic effects) or equation 7 (non-carcinogenic effects) of RAGS part B for consumption (US EPA, 1991), RAGS, Part E for skin contact (US EPA, 2004) and RAGS, Part F for inhalation (US EPA, 2009).

31 For mutagenic carcinogens, the standard can be derived utilizing the adjustment factors depending on the age defined in appendix III, Table 3 Subject 391-3-19 Hazardous site response, of the Environmental Protection Division of the State of Georgia in the US. The values shown in a table have been determined having as a reference various resolutions from the EPA.

The remediation objectives can be defined generically or for a specific site. The later can be more permissive than the first, because specific parameters for the site are used. Conversely, the generically defined remediation objectives could rely on more conservative values.

In the following tables the objectives are defined for different situations, differentiating between general criteria and site-specific criteria, for both soil and groundwater.

Table 1: Soil remediation objectives for a general or site-specific strategy

		Objective
1	**General criteria**	▶ Remediation of regulated substance concentrations that pose no significant risk on the basis of standardized exposure assumptions and defined risk levels for the non-residential use scenario.
2	**Site-specific criteria**	▶ Remediation for regulated substance concentrations that pose no significant risk on the basis of a site-specific risk assessment for non-residential land use. This option is applicable where the responsible party documents that the activities being conducted on the property satisfy the definition for non-residential property and documents that a monitoring program or an environmental covenant executed as defined in Section 6.2. For those substances for which neither calculation can be made, the standard shall be the higher of concentrations in Table 1 or 2 of Appendix III of EDP Rule 391-3-19, background concentrations, or detection limit concentrations[32].

32 Table 2 for soil and Table 1 for groundwater as defined in Geogia's State EPD Rule 391-3-19, Appendix III.

Table 2: General remediation objectives for soil	
	General criteria
1 **For the whole ground column**	▶ Concentrations at any point above the uppermost groundwater zone in soil that has been affected by a release shall not exceed the concentrations indicated in Table 2 of Appendix III of EPD Rule 391-3-19 of the state of Georgia in the US. For the substances which are not included as part of the table the highest value between the following should not be exceeded: ● Concentration levels for soils presented in Appendix I of EPD Rule 391-3-19 of the state of Georgia in the US, excluding the values inside the brackets[33]. ● Concentration values calculated using the equation and the standard parameters defined in Table 4 of Appendix III of EPD Rule 391-3-19. Specifically using the Type 3 groundwater RSS. A dilution factor of 20 should be assumed. Unless the relevant authority can justify another value is more adequate in protecting the health of the population and the environment. For lead the standard is 400 mg/kg.
2 **For the ground surface (30 cm from the surface)**	▶ The substance concentration at the surface should meet the requirements defined for the whole ground column. Additionally, the minimum of the values calculated according to the HBDC using the non-residential exposition standard presented in Table 3 of Appendix III of EPD Rule 391-3-19 of the state of Georgia in the US. If such calculations cannot be performed, then the criteria used for the surfaces should be equivalent to that of the whole ground column.
3 **Below the ground surface (more than 30 cm from the surface)**	▶ The criteria for the ground surface cannot be met by applying 30 cm of clean soil to the original surface. The concentration of substances below the surface must meet the criteria defined for the whole ground column. Additionally, should not exceed the lower of the values calculated for the HBDC using standard excavation worker exposure assumptions accepted by the authority. If the calculations cannot be performed, then the criteria used should be equivalent to the criteria defined for the whole ground column.

33 The values presented in the table synthesize controlled substances from the following references:
- List of Hazardous Substances and Reportable Quantities, 40 CFR Part 302, Table 302.4;
- List of Extremely Hazardous Substances and Their Threshold Planning Quantities, 40 CFR Part 355; and
- Hazardous Constituents, 40 CFR Part 261, Appendix VIII.

Table 3: Site-specific remediation objectives for soil	
	Site specific criteria
1 **For the whole ground column**	▶ The concentration of substances at any point on the ground above the highest region of the groundwater which has been affected by contaminants should not lead to contamination of the groundwater at levels which exceed the maximum values defined in Table 4 and Table 5 (presented following this table). The exposure point could be defined for example as a function of the water withdrawal location of any well which can be installed on site. The soil concentration levels can be estimated by using laboratory testing and/or a transport model which has been accepted by the relevant authority[34]. Other site-specific information, such as the age of the contaminant discharge or concentration in groundwater could be used by the relevant authority to show that the concentration levels in the soil are adequate for the groundwater. The relevant authority can define more stringent requirements if the authority concludes that its necessary to protect the health of the population or the environment.
2 **For the ground surface**	▶ The substance concentration at surface must meet the criteria defined for the ground column. Additionally, the substance concentration should not exceed the lowest value calculated according to the HBDC using the exposure assumptions for the specific site for a non-residential use. The depth of the ground which can be considered part of the surface could be defined based on specific site exposure criteria approved by the relevant authority. However, 30 centimeters from the surface can be assumed as the default value. The criteria for the ground surface cannot be met by applying clean soil or barrier to the original surface. The lead concentration at the site surface cannot exceed the concentrations defined in the procedures specified in Appendix IV of EPD Rule 391-3-19 of the state of Georgia in the US. In case children frequent the site, the concentration levels can be more stringent if the relevant authority concludes that it is necessary to protect the health of the population.

34 More information at https://epd.georgia.gov/fate-and-transport-model-reporting-requirements

3	**Below the ground surface**	The concentration of substances below the surface must meet the criteria defined for the ground column. Additionally, should not exceed the lower of the values calculated for the HBDC using the site-specific excavation worker exposure assumptions accepted by the authority. If the calculations cannot be performed, then the criteria used should be equivalent to the criteria defined for the whole ground column. The lead concentration below the surface at the site cannot exceed the concentrations defined in the procedures specified in Appendix IV of EPD Rule 391-3-19 of the state of Georgia in the US. using the site-specific excavation worker exposure assumptions accepted by the authority.

Table 4: General remediation objectives for groundwater

1	**General criteria**	At any point of the body of groundwater which has been affected by the discharge of contaminants, the substance concentration should not exceed the Maximum Contaminant Levels (MCL) defined in the Safe Drinking Water Act (40 CFR Part 142, Subpart G) or an equivalent standard in Chile, for example NCh 401 or the Decree 735 of the Ministry of Health which defines the rules for water services for human consumption[35]. For those substances which have not been defined, the lowest concentration value should be calculated with the HBDC using the standard assumptions for non-residential exposition specified in Table 3 of EPD Rule 391-3-19 of the state of Georgia in the US. If an MCL is not available and the calculations cannot be performed, then the standard adopted for groundwater should be between the values specified in Table 1 of EPD Rule 391-3-19 of the state of Georgia in the US. The background concentration or detection limit concentration should be considered. If the background concentration of the substance in the groundwater table is greater that the MCL defined in the regulation or it's a substance that doesn't have an MCL defined, then the concentration limit should be equal to the background concentration.

35 Keeping in consideration that in this case the primary objective is to reduce the exposure risk to protect the health of the population. As highlighted in Section 4.3.2 the definition of target remediation values by the regulator is an early-stage definition made by the regulator.

Table 5: Specific remediation objectives for groundwater	
1 General criteria	▶ For regulated substances in groundwater the lowest concentration value should not exceed the values defined in the HBDC considering the exposure factors for a specific site of non-residential use. Such requirement should be met at any point unless there is a special requirement defined for the use of groundwater for the site. The restrictions could be associated definitions which limit use at the site and environmental agreements (Section 6.2). For those substances, whose groundwater standard values cannot be established, then the standard adopted should be the maximum of the concentrations defined in Table 1 of EPD Rule 391-3-19 of the state of Georgia in the US. The background concentration or detection limit concentration should be considered. If groundwater use restrictions are utilized, groundwater contaminated with regulated substances in excess of appropriate standards must not migrate beyond the control limits defined. The responsible party shall demonstrate that such migration will not occur or implement groundwater monitoring to ensure that migration is not occurring, unless the relevant authority determines that monitoring is not needed.

Considering that in Chile certain generation facilities already have a shutdown plan defined and approved by an environmental permit and others facilities must possibly define their plan through a Enviromental Impact Declaration, the definition of remediation objectives could be defined through a voluntary environmental agreement, as stipulated in Article 18 of Law 19.300.

5.2 Definition of site use limitations and land use agreements

The construction, reconstruction, alteration, expansion or demolition of a building in Chile requires a permit from the Directorate for Municipal Works (Law 458 of the Ministry of Housing and Urban Planning, which was approved by the General Law of Urban Planning and Construction, Article 116º). All the works must comply with the technical standards defined in the General Ordinance and Master Plan for the corresponding Municipality.

The General Ordinance of the General Law of Urban Planning and Construction (DS 47), particularly in article 2.1.17, shows that the master plans could define restricted areas for urban develop-

ment, which constitute a potential danger to the population. In the same article, the definition of "Risk Area" is limited to security concerns associated to natural disasters or similar natural events. Additionally, these areas might require the development of works which can withstand natural disasters or similar natural events. The classification as a "Risk Area" does not include a site with presence of contaminants generated by human activity or intervention according to such document[36].

According to the DS 47, Article 4.14.2, the industrial establishments, or warehouses must be classified on a case-by-case basis by the Regional Ministerial Secretariat of Health. The classifications should consider the risks that the operations can generate for workers, neighbors, and the community. The classification categories are inoffensive, bothersome, unhealthy or contaminating, and dangerous. The industrial establishments or warehouses must meet all the requirements defined in the DS 47. The industrial establishments or warehouses are only allowed in the sites deemed permissible in the corresponding territorial planning instrument[37].

The Ordinary Pamphlet No 935 of December 2009 (DDU 227), developed by the Division Chief of Urban Development of the Ministry of Housing and Urban Development defines how to formulate and scope of action of the Commune Specific Master Plans. According to this document, the master plan, not only should it consider the existing use of land, but it urban needs of the community. Additionally, the master plan should be based on the existing conditions and project the existing conditions into the future. Furthermore, the feasibility of investment in infrastructure and public spaces must be considered to support the urban development which the standard promotes. The projected public and private investment and the capacity for future investment should be analyzed, which considers the new equipment and infrastructure requirements defined in the plan. The law enables master plans to establish standards of land use, amongst other things.

It is the responsibility of the Municipalities to establish a project to define the Communal Master Plan and modifications. The Master Plan should provide various instances for stakeholders to participate and must be approved according to Municipal Council. To elaborate the plan, diverse technical documents must be considered, these are further detailed in Section 3.2 of the DDU 227. Additionally, the environmental restrictions of the territory must be considered and studied. In the same section, the requirement to consider a Risk Study is defined. However, the Risk Areas are defined by Article 2.1.17 of the DS 27[38].

In the future, defining "Risk Areas" to include areas which generate a risk because of exposure to contaminants should be evaluated.

36 It is recommended that this requirement be re-evaluated in the future.
37 When not available, in the locations identified by the municipality prior to a favorable assessment from the Ministry of Housing and Urban Planning and Regional Ministerial Secretariat of Health.
38 A "Risk Area" must consider the zones or areas with risks generated by activity or human intervention, such risks are related to security concerns against natural disasters or other events.

Under current regulation, the territorial planning instruments must define the land use for each region, the following are the definition alternatives: Residential, Equipment, Productive Areas, Infrastructure, Public Space and Green Area (DS 47, Article 2.1.24)[39].

Since today a standard reference level for concentration of contaminants in the soil and groundwater is non-existent, it might be desirable to define commitments or agreements which limit land use[40]. These types of agreements are a valid option when the risk towards people and the environment are low, even when additional cleaning of the site is desirable. Additional cleaning can be required prior to realizing a redevelopment, which could be inscribed into the legal documents for the site.

A land use limit agreement should:

- Limit the development of activities in the property which can interfere in a substantial way with a remediation action. Measures could be adopted such as operation and maintenance; long term monitoring, or other necessary measures which contribute to ensuring that the integrity of the remediation action is met.

- Limiting the development of activities which might result in the exposure of people to contaminant levels higher of those defined in international standards in scenarios for residential or non-residential use.

- Describe the limitations of property use.

- Allow the authority to ensure the agreement is met considering relevant legal action.

Finally, if the cause for an increased concentration of a substance can be attributed to diffuse anthropic sources, then various emission sources within the region could be responsible. Therefore, the relevant government agency and the affected should define a participation process to establish the remediation objective, particularly to set boundaries for the responsibility of the industrial installation which is set to shutdown.

39 The type of residential use id defined in Article 2.1.25, the type of Equipment use is defined in Article 2.1.27, the type of use for Productive Activities is defined in Article 2.1.28, the type for infrastructure use is defined in Article 2.1.29, the type for Public Space is defined in Article 2.1.30 and the type for Green Areas is defined in Article 2.1.31.

40 In the United States, in some states "Environmental Covenants" are defined (Georgia's EPD 2008) (Pennsylvania's DEP).

6

Identify new purpose for site

The purpose of this section is to generate and describe viable options for the future development of the site. The options should align with the interest of the possible beneficiaries of the future developments and the community. It is important to take into consideration the surroundings of the site, the facts and the perceptions which worry the stakeholders for a new development being considered for the site. Additionally, the competitive advantage of other options should be considered, both technological and site driven, which compete against the alternatives being evaluated to redevelop the site where the coal generation facility which is set to shutdown currently exists.

6.1 Analysis considering market and territory

One of the objectives in redeveloping the site being occupied by a coal generation facility is to understand the needs and the advantages of the site up for redevelopment. Any project which is developed to replace the coal generation facility must be aligned with needs at different levels (systemic, regional and/or local). The development must also have the capacity to create a positive value exchange with the local stakeholders that is sustainable over time.

Considering that historically the sites have been used for electricity generation, it is advisable to analyze the option to install another type of electricity generation technology at the same site. The retirement of coal generation facilities should create an opening for other generation or energy storage facilities which can provide low-emissions firm energy to the system and contribute with ancillary services to the system. There is an opportunity to replace the coal unit with other generation and energy storage technologies, therefore it is important to analyze the energy situation in the region and identify the competitive advantages that the site offers compared to other sites.

Research should be conducted about the other industries or sectors that the local or federal government is looking to promote in the region, this could serve as an input to define the site redevelopment. Perhaps aligning with the government's development goals could lead to receive some support and interest from the state. State support will probably be more relevant at a site where the competitive advantage is not significant to those observed in other locations in the country.

To conduct an analysis of a market of interest for the site different factors should be evaluated such as: gaining a deeper understanding of the targeted market, the capacity of the local workforce to work in the targeted industry and the possibilities that location has in attracting the workforce with the skillset required in the targeted industry from other areas in the country.

To understand the location, it is important to gather a detailed understanding of the region, the commune, and the area where the site is located. Some of the trends that should be analyzed for the location are: land use, neighboring communities or cities, number inhabitants in different age groups, population growth amongst age groups in the region, employment and unemployment levels, average income (by age/education level/sex), education level. Gathering this information will help create understanding of the workforce and the needs of the region. The infrastructure available such as schools, hospitals and entertainment should be explored to assess the ability to attract workers to the region to develop the project (Kevin Gallagher Consulting, 2019). The demographics, the industries present, and other productive sectors should be analyzed[41].

6.2 Interact with the local community and other stakeholders which relate to the project to explore development options and the definition of a new purpose

The primary purpose of interacting with the stakeholders is to define development alternatives for the the site and generate consensus amongst stakeholders, to reduce the possibility and scale of future conflicts.

The evaluation of alternatives yields better results when stakeholders are involved from early stages, so that all the involved work together defining objectives for the site. The group of stakeholders involved must be diverse politically, economically, and demographically (ASTM E1984, 2003). Ideas, opinions, and perspectives of the stakeholders must be incorporated from the earlier stages during the brainstorming and design stage (Kevin Gallagher Consulting, 2019).

There are three levels of stakeholders which must be engaged while the process to shutdown the coal generation facility is being executed: company level, people, and government institutions. At the company's level, it's important to establish conversations with different companies which belong to the relevant industries in the region, these companies should be identified in the market analysis defined in Section 6.1. Engaging companies can help develop allies for the site development. The companies engaged could have needs or ideas which transform in development opportunities for the site. Additionally, national, and international companies whose capabilities align with the development objectives for the site should be identified.

At the people's level, interactions with stakeholders such as local organizations involved in the community should be relevant to understand the local preferences and ideas for the site redevel-

41 If the predominant activities in the region are not clear or difficult to identify, then the location quotient (LQ) can be used to simplify the analysis. The LQ is a tool which can be used to measure the local economy and the industries that the region specializes, in comparison with a reference economy (national economy for example). The LQ helps determine how concentrated is an industry in the region or commune compared to the national average. An LQ higher that 1 shows that the region might have a competitive advantage in that industry compare to the rest of the country (Kevin Gallagher Consulting, 2019).

opment. Engaging these stakeholders would help gain an understanding if there is a preference for the economic activity for the site, for example remaining an electricity generation facility, becoming an industrial or manufacturing entity or if the site should adopt a commercial or institutional focus[42]. Engaging the community will help gain understanding of which criteria are important for the development for example the number of jobs created (Kevin Gallagher Consulting, 2019) or the need to gain access to reduced electricity prices within the context of the Law of Tariff Equity (Law 20.928 of the Ministry of Energy).

Before starting the interaction with the community to define redevelopment strategies, it is important to educate the involved about the state of the site. A presentation should be organized to inform the community about the risks that exits at the site (if applicable) and compare those risks to other risks that exist in the community. Also, technical assistance should be provided to the stakeholders which require it, so they can properly analyze the state of development for the site and increase their knowledge of the situation as required (ASTM E1984, 2003).

Additionally, the position of the local and national government in the face of development should be identified. It is important to understand the plans for local development and the specific objectives that the local and national government have for the region. This way the developer will know if the possibility to renew the existing permits is a possibility such as those needed for the water intake system or for electricity generation or even obtain new ones. Further, the possibility of upgrading local public infrastructure is an option to ensure the proper functioning of the redevelopment and if the possibility exists to re-evaluate the permitted uses in the commune master plan (Kevin Gallagher Consulting, 2019).

6.3 Define the development alternatives

The decommissioning of the coal generation facility involves the preparation of the site for its new purpose, which could involve the demolition of some or all the structures or environmental remediation actions to reduce the risks for contamination that might exist in the property. There are at least three clear options for redevelopment, these are: reuse the site for electricity generation with another technology, reconvert the site for industrial use, or reconvert the site for commercial or institutional use (Figure 4). Each of these options will require different maximum levels of contamination that are tolerated at the site.

To define the decommissioning and redevelopment alternatives, the current conditions for the site should be kept in consideration to come up with a cost-effective strategy for redevelopment

42 Because the generation facilities are located in industrial or productive zones and in some instances the master plan of the region defines the zones where the facilities are located as such, which ultimately prohibits residential use, therefore a residential development is less likely.

(ASTM E1984, 2003). The contamination levels could condition the possible options for redevelopment or remediation required for the selected redevelopment. If a residential use is selected, the acceptable levels of contaminants are more stringent, therefore the remediation will have to be more thorough and hence more costly than for an industrial site. These preconditions must be considered when defining alternatives for the redevelopment, in order not to propose of analyzing infeasible options because of their high remediation costs.

Based on the interactions with the stakeholders, the analysis of the market where the site is located, the structures which can be reused and the environmental state of the site, segments of the industry in which the redevelopment of the site would be feasible should be analyzed. Example of these segments include energy generation, manufacturing, industry with intensive use of energy, amongst others (Kevin Gallagher Consulting, 2019). Selecting a segment should be properly justified as an adequate option for the development of the site.

Within each identified segment, different concrete alternatives for the development of the site should be evaluated. When identifying different alternatives, the following should be considered: actual use, environmental conditions of the site (identified in Section 4), location and markets for site (Section 6.1), needs of the community and stakeholders (Section 6.2), impact that the project will have in the region and its surroundings, possible mechanisms to finance the project and associated costs, and inherent value of property. If the site is in a good location, has good connectivity and contains valuable natural resources, the interest to redevelop will be higher. It is important to keep in mind these factors in order to define realistic alternatives for the reutilization of the site (EPRI, 2006).

The identified alternatives can utilize the property completely or only certain portions of it. More than one redevelopment option for the site could be materialized to best take advantage of the zones, structures and uses that the site has. For example, part of the site could be used to install a generation facility with a different technology and on another location of the property an industrial activity which is energy intensive could be developed, hence the new industrial activity could be supplied by the generation facility (Kevin Gallagher Consulting, 2019).

To conduct a low-cost preliminary analysis for each of the proposed alternatives the following is recommended (Kevin Gallagher Consulting, 2019):

1 **General description of alternative**
A description of the proposed alternative should be presented which describes its functionality and characteristics. The description should be accompanied by a referential diagram or image which describes the redevelopment.

2 **Description of the location of the site sector and the infrastructure which will be reused**
The location of the site which will be used for each alternative should be presented in a detail. Further, the structures which will be reused and demolished should be presented in detail as well. A map should be included in which the redevelopment site is clearly marked.

3 **Examples of similar developments or experiences**
Similar developments or experiences executed by the company in Chile, or any other location should be described. Also, similar developments or experiences executed by other entities should be presented.

4 **Advantages**
The benefits which the alternative will bring at the location should be described. For example, if the development aligns with the vision of the community for the sector; with the development objectives of the local or national government; if existing infrastructure is reused therefore reducing the costs of a similar greenfield project; if employment is created; if a similar development experience is available; etc.

5 **Disadvantages**
The disadvantages for the alternative should be described. For example, if the alternative generates a low employment number, will increase traffic in the region, etc.

6 **Necessary actions**
The actions that will have to be executed to confirm the feasibility of the alternative should be described. For example: evaluate the possibility of improving public infrastructure needed for the redevelopment evaluate the possibility of renewing or transferring existing permits; conduct an analysis of structural and geotechnical conditions; develop a PPA for energy sale; attract a company which is interested at locating at the site; etc.

It is important to be creative and not disregard ideas before conducting the recommended analysis. Some examples for the possible alternatives for site reutilization for electricity generation are gas generation unit, wind generation, energy storage, etc. (inodú, 2018). The investment in transmission infrastructure has already been paid for then, the development of projects which take advantage of this infrastructure would create some savings, also part of the existing build-

ings could be leveraged. Examples of alternatives for industrial use are desalination of water, distribution centers, data centers, hydroponic agriculture, use of the port, etc. In the case of mixed use, the site can be reconverted to house a site which provides public access to the coast (in case of generation facilities within the urban radius), together with other types of installations (Kevin Gallagher Consulting, 2019).

6.4 Conduct a preliminary cost estimation of the alternatives

The main objective behind conducting a preliminary cost estimation for the different alternatives proposed in phase 6.3, is to compare amongst them in economic terms. At this stage of the process, conducting a lower accuracy cost estimation for the alternative requires relatively low amount of time and effort invested, but can provide an approximate value for the costs involved and remove some of the biases of the costs involved in the alternative[43]. Commonly when this level of cost estimation is conducted, not much is known about the project except its type, capacity, and location (AACE, 2019).

At this stage, a conceptual cost estimation of the alternative is desired, which implies knowing about 2% of the design of the project. The goal of the assessment is to have an estimation which allows to evaluate the initial viability of the alternative and the resources required to move forward with the alternative.

To develop a preliminary estimation, the only information that is required about the project is its description and scope, installed capacity or production capacity and location. Also, a diagram which describes the concept of the alternative once completed is required.

Within the costs to consider for the new development two levels exist: remediation and restoration of the site. Remediation is preparing the site for the new project and restoration is the development of the project itself. The cost assessment should assign costs to the remediation and restoration categories which could be similar to different alternatives, therefore the costs are presented in a clearer fashion amongst alternatives.

For the remediation and restoration of the site 4 stages should be evaluated, once the site has been characterized and the remediation objectives have been identified (Sections 4 to 5 of the ASTM E2150, 2017).

43 Class 5 estimate according to the Guide "Cost Estimate Classification System - As applied in Engineering, Procurement and Construction for the Process Industries" AACE.

1. **Design**
The costs associated to the defining the site remediation and restoration plan should be included. The remediation and restoration could be in situ or ex situ, through biological treatment, chemical treatment, physical treatment, thermal treatment, stabilization, encapsulation or fixation. An analysis of the structures which will be demolished and the methods to dispose of and transport the waste and demolished construction material should be included.

2. **Construction**
The following costs should be included: to implement the selected remediation technologies in the design phase; demolition costs; transport and disposal of waste; compacting and soil movement; removal of structures and machinery; to contain dust emissions; disposal of dangerous materials.

3. **Operations and maintenance**
The costs associated to the inspection of the site after it has been dismantled or remediated should be included.

4. **Long term monitoring and surveillance**
Considers the costs associated to the monitoring and surveillance activities after the remediation. The primary goal is to maintain a low risk level for human health and the environment.

For the level of development of the new project, five stages should be considered (ASTM E2150, 2017)

1. **Evaluation**
The costs associated to the creation of a work plan and information or document collection prior to the design phase.

2. **Design**
The costs for engineering design of the alternative which will be evaluated.

3. **Construction**
Evaluate the construction costs to implement the alternative. Within this category the following are included, for example: materials necessary for the construction of infrastructure, cost of labor, costs to obtain the permits for construction, etc.

4. **Operations and maintenance**
All the costs associated to the alternative are considered once operations start. Within this category the following are included: costs of materials necessary for operations, repair of parts and components, preventive, and corrective maintenance, etc.

5. **Shutdown**
The costs associated to the shutdown phase of the new project.

6.5 Identify financing sources and development instruments

The transition team, in the involved companies and the state, must identify how the funding available at the national and international level can be articulated in order to facilitate the environmental remediation challenges according to the remediation objectives which have been defined.

In the national regulatory context, Article 66 of Law 19.300 states that the Ministry of the Environment should oversee administering an Environmental Protection fund, whose objective is to finance fully or partially projects and activities which protect or can repair the environment, sustainable development, the preservation of nature, or the conservation of environmental heritage.

Additionally, internationally there are diverse funds which are geared towards developing a just transition.

7

Definition and implementation of a remediation strategy

The implementation of a standard for risk reduction should provide sufficient protection for the health of the population and the environment. A corrective action will be completed once it can be demonstrated that the site complies with one or more risk reduction standards. Currently in Chile, regulation which defines remediation goals is non-existent, however through a voluntary environmental commitment which meets the following requirements, when applicable, should be considered:

- The soil should not contain dangerous waste as defined in Title II of the DS 148 of the Ministry of Health.

- In each stage of the handling of hazardous substances, mixing dangerous waste with other types of waste, materials or substances is strictly prohibited. Especially when mixing substances has the objective of diluting or reducing the concentration (DS 148, Article 7)[44].

- The corrective action must protect the bodies of water. The discharge could have a negative impact and lead to exceeding the criteria in the applicable water quality standards. If the concentration levels are not defined in the standards, then the concentration level of contaminant in the discharge could generate acute toxicity for hydrobiological organisms should be defined according to the competing authority.

- The greater of the following two values should be met in order to comply with the applicable risk reduction standard:

    - The minimum level of detection[45] for a concentration level of a regulated substance, or

    - the natural concentration level of a substance.

Only if one of the two values listed above is is greater than the concentration specified in the risk reduction standard which is used as a reference. The concentration level for a substance within the surroundings could consider anthropic sources and could also be based on evaluations of regional surroundings accepted by the corresponding authority.

The scope associated with dismantling a generation unit and the environmental remediation of a site will depend on the final use that will be given to the site after the generation unit is shut-down. Therefore, the means to reuse the existing structures and the remediation methods can be chosen according to the standards which are required for the specific use which will be given to the site, hence minimizing the costs of remediation and dismantling[46].

44 If for any circumstances this guidance is not followed the whole mixture will have to be handled as a dangerous substance.

45 The minimum level of detection in this context implies the use of non-fraudulent approved testing method which is appropriate for the specific application that is being analyzed.

46 For example, in case the marine infrastructure, particularly those in inverted siphons that are used for the capture and discharge of water, one option is to maintain and use the infrastructure as water intake system for another

7.1 For generation facility site

The minimum health and security requirements for the creation, storage, transport, treatment, reuse, recycling, disposal, and other methods to eliminate hazardous waste are defined in the Decree 148 (2003) of the Ministry of Health. In addition to Chilean regulatory compliance, the 1926- Safety and Health Regulations for Construction standard published by Occupational Safety and Health Administration (OSHA) is recommended[47].

7.1.1 Shutdown of coal storage yard

If possible, all the stored coal should be used to generate electricity at the coal facility. However, another option is to send the remaining coal to another coal facility or sell it. If contaminants which pose a health risk are not detected in the coal yard area, the layer of coal waste which has mixed with the soil should be removed and transported to the ash pond. After removing the coal residue and soil mix at the coal yard site, the removed material should be replaced with clean soil (EPRI, 2006). Otherwise, the contamination should be remediated considering the final use which is planned for the site.

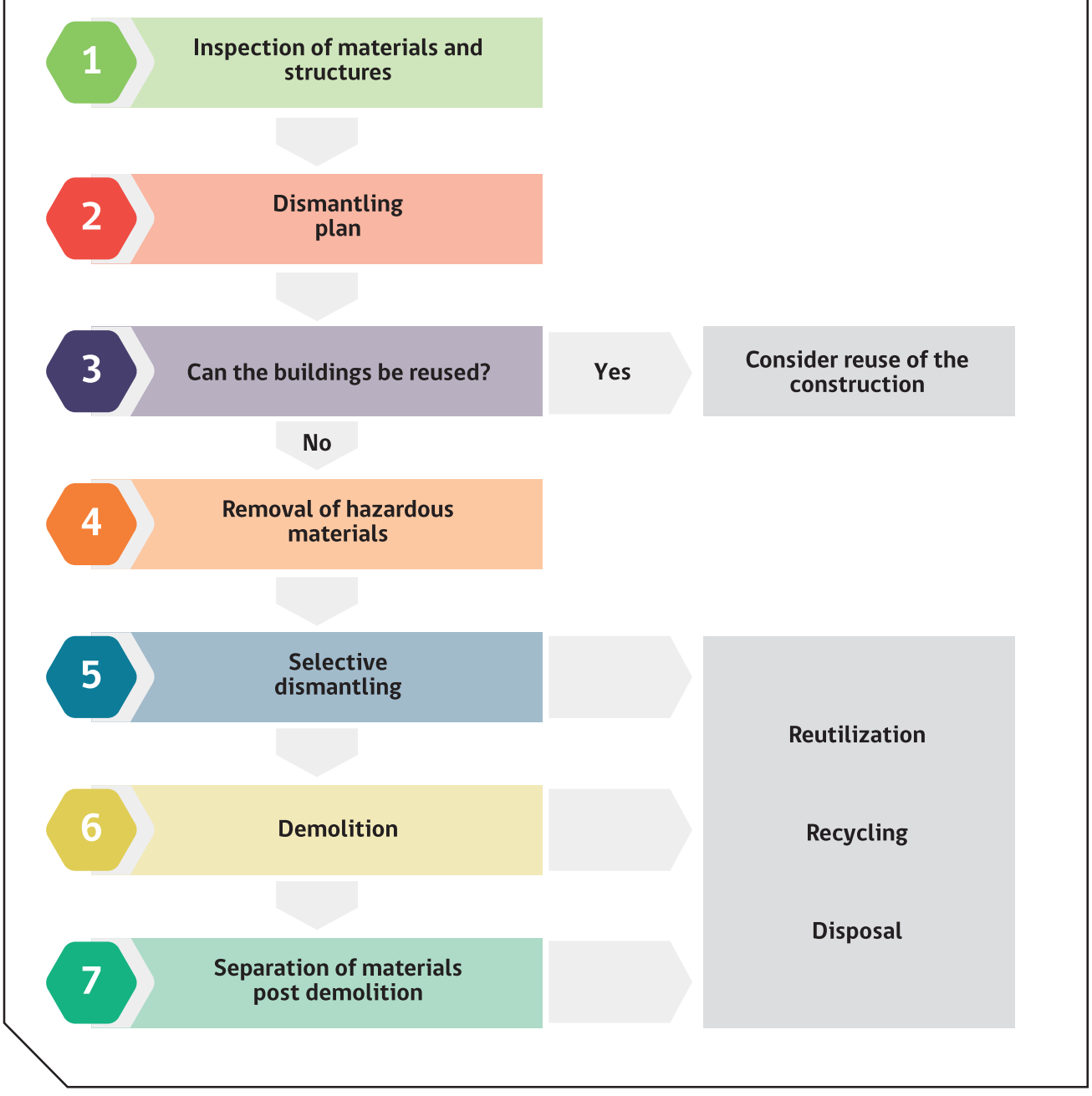
7.1.2 Dismantling of infrastructure

The dismantling of a coal generation facility must follow the several sequential steps which are shown in Figure 7.

industrial activity. Another option is to convert the infrastructure to a loading dock (in such case the final user will be responsible for the system maintenance). If the infrastructure is retired, the supports should be cut at a determined height in order to minimize the impact created to the seabed if withdrawn.

47 Available at: https://www.osha.gov/laws-regs/regulations/standardnumber/1926

Figure 7 / **Dismantling process**



Source: Adapted from the European Commission, 2016 and Joint Research Center, 2012

The start of dismantling of part or the whole coal generation facility starts with a pre-demolition audit. The pre-demolition audit starts with the inspection and identification of materials and works which are located at the site. The type, quantity, quality, and location of materials which will be produced should be identified. Additionally, the hazardous materials and substances at the site should be identified. All the materials which can be recycled or reused should be identi-

fied. An approach should be developed to handle hazardous and non-hazardous waste and the possibility of recycling and reusing the materials generated in the region. The local markets and the capacity to reuse or recycle materials should be considered (European Commission, 2016).

The second step is to develop a dismantling and demolition plan, such plan will have to be carried through in the following stages (Ministry of Public Works, 1999). The plan should detail the steps to dismantle and demolish the facility. Specifically, include who and how the steps will be executed; which materials will be salvaged, recycled, or disposed of; how and where the materials will be salvaged, where these materials will be recycled and disposed of; how and where these materials will be transported to; etc. Further, the safety and impact mitigation actions which will be taken should be included (European Commission, 2016). The Chilean Standard 3562 of 2019 provides more details about what should be included in a plan to manage the waste produced during construction and demolition.

When developing a dismantling plan, best efforts should be made to transform waste into valuable materials and sustainable manage the waste generated (Ministry of Housing and Urban Development, 2019). Hence, the reuse of existing buildings, structures, and materials should be prioritized in order to avoid the use of new resources and avoid the local environmental impact of the demolition process. First all materials that can be reused should be. Otherwise, waste should be recycled. However, if it is not possible to recycle, their energy content should be valued[48]. Finally, as a last resource the waste should be disposed of in an adequate location. The previously described process is known as a hierarchical use of waste (Ministry of Housing and Urban Development, 2019).

The primary objective of the plan is to dismantle, reuse, recycle, transport, value, and dispose of only if necessary, of the materials generated in a secure and legal fashion, without generating impacts to the environment and without risking the health of the workers or the adjacent communities (European Commission, 2016). The dismantling of buildings, machinery and structures impacts the location environmentally and socially. The impacts and the actions which can be taken to minimize them are the following (Joint Research Center, 2012):

1 Dust is produced. Dust can cause damages to health and property; therefore, the generation of dust should be minimized. Prior to the start of demolition and during the demolition, dust should be removed, and water should be applied to the location to reduce the amount of dust produced during demolition. The use of water should be minimized by using spraying techniques.

48 Considers the use of a residue with the primary objective of using its energy content (Ministry of Housing and Urban Development, 2019).

2 The rubble and debris produced can be a problem for the areas surrounding the site, especially roads. To prevent the incorporation of rubble or debris to the surrounding areas, the perimeter should be fenced.

3 Noise produced in the dismantling and demolition. To reduce the among of noise generated, less noisy demolition methods, low noise machinery or noise isolating structures can be used. The site should comply with the noise levels established in the existing regulation[49]. The existing regulation includes the guidance defined in Decree 38 of 2012 of the Ministry of Environment[50], which regulates the noise from various sources. Further, the acceptable noise levels at the workplace[51] are defined in Decree 594 of 2000.

4 Vibrations transferred through the ground to adjacent structures produced by explosions and the collapse of structures. Such impact can be more relevant if there is population in the surrounding areas. The vibration levels which the site workers will be exposed to during the dismantling and demolition should meet the limits defined in Decree 594 which define the acceptable environmental conditions at the workplace.

5 Disposal of waste at landfills. To avoid the loss of materials and the increase of waste at landfills, most of the materials should be reused or recycled, leaving disposal as the final option.

The third step in the process includes the selective dismantling of the components of a building in order to simplify reuse or recycling. The building should be systematically disassembled by separating the materials at the origin prior to demolition, with the objective of maximizing reuse and recycling of materials. The systematic disassembly could be performed with manual labor or light machinery (Joint Research Center, 2012).

Conducting a total selective dismantling is not always possible because of the high costs associated with this procedure. Therefore, a combination of selective dismantling and demolition (fourth stage) should be applied to achieve a high percentage of material separation which leads to reuse or recycling and which minimizes effort and costs. Both techniques are complementary, once the selective dismantling is finalized the demolition starts (Joint Research Center 2012).

If in the demolition phase only cost efficiency and safety is sought out without paying attention to reuse of the materials generated leads to the mixing of various materials which makes recycling and reuse more difficult. Therefore, the plan should consider both recycling and reuse and

49 Including municipal ordinances, which contain specific related requirements.
50 Available at: http://bcn.cl/1vehh
51 Available at: http://bcn.cl/1uuj6

demolition to achieve an optimal handling of materials, hence achieving high levels of materials recovered in a cost-efficient manner.

The dismantling plan should be constructed by assessing how much selective dismantling will be conducted prior to demolishing. The decision will depend on the following: local cost of disposal, local cost of labor (more labor is required to dismantle selectively), feasibility to dismantle (affects the required labor), value of salvaged material (for reuse or recycling), time available (more time is required to dismantle selectively), transportation costs of material (to disposal or recycling sites), location of disposal or recycling sites, type, design and construction method used for building, materials present and presence of dangerous substances (Joint Research Center, 2012).

When developing a cost-benefit analysis to decide what to dismantle and demolish all the associated costs and benefits should be included. Conducting a selective dismantling can increase some costs but decrease others (Joint Research Center, 2012). In Figure 8, some of the variables which impact the decision to demolish or dismantle are included. Further the figure shows, how these variables are affected either positively or negatively when selecting amongst techniques. The ways and levels which these variables will impact the decision will depend on costs, distances, location, construction distances and other characteristics.

Figure 8 / **Variables which affect the decision to dismantle or demolish**

		Conventional demolition	
		Conventional demolition	Selective dismantling
1 Environmental	Quality of material to recycle	X	✔
	Recycling rate	X	✔
2 Economic	Demolition / dismantling costs	✔	X
	Disposal costs	X	✔
	Transportation costs	!	!
	Sale of materials	X	✔
3 Others	Space required	✔	X
	Time required	✔	X

✔ Better X Worse ! Depends

Source: Adapted from Joint Research Center, 2012

The level of selective dismantling will depend on environmental, technical, and economic criteria. Selective dismantling is mandatory if hazardous materials or substances are found in the building. The first step in the dismantling process is to remove the hazardous materials or substances in order to prevent potential accidents or the risk of these mixing with other materials. If hazardous materials of substances mix with other materials it makes their recycling or reuse practically impossible (Joint Research Center, 2012). Hazardous waste include asbestos, tar,

PCBs, lead, electrical components which contain mercury, hazardous insulation material, etc. (European Commission, 2016). In Sections 7.1.2.1, 7.1.2.2 and 7.1.2.3 some of the hazardous substances and recommendations for handing them are presented. A demolition plan should also include measures which could be taken if additional hazardous materials are found during demolition (European Commission, 2016) or other requirements are imposed by the municipality. Decree 148 (2004) of the Ministry of Health which defines the health rules to handle hazardous material must be followed when removing, storing, transporting, and discarding the hazardous materials[52].

If the buildings or structures cannot be reused, usually, the valuable components inside such as wood, boilers, machinery, or sanitation equipment are salvaged. Floors, roofing, windows and doors, and other non-structural parts are removed. When it is not possible to continue to dismantle the building cost-effectively and selectively, the building must be demolished in a conventional way following the existing regulation. The requirements defined in NCh347 "Secure Demolition Standards" should be followed (Ministry of Public Works, 1999). If applicable, the structure is demolished floor by floor. Finally, the foundation should be removed (Joint Research Center, 2012).

When the materials are recycled an excessive purity level is not required, the waste could be separated manually after the demolition. Sometimes such approach can be less expensive than selective disassembly, however the material can still be recycled. There are other techniques which can be used to separate materials, for example using water with additives to separate materials by density or air streams to separate lighter materials from the rest. Such methods are less costly, but less effective. However, since the main objective is to reuse and recycle as much material possible, any of these techniques can be used. The technique of preference should be the one that leads to a cost-effective operation. The more is dismantled prior to demolition the easier it will be to separate post demolition since materials will already be separated (Joint Research Center, 2012).

7.1.2.1 Identify presence of asbestos

If any of the equipment or structures have asbestos they must be removed prior to demolition or dismantling (EPRI, 2006).

According to Decree No 17 of 2009 of the Ministry of Health, which modifies the Decree No 656 of 2000 which prohibits the use of asbestos[53], demolition, dismantling and modifications of buildings, equipment, installation, or machinery with asbestos requires previous authorization

52 Available at: http://bcn.cl/1uzdc

53 "EPA defines asbestos-containing material (ACM) as material that contains more than 1 % asbestos. Building products containing ACM are often referred to as asbestos containing building materials (ACBM). Undisturbed ACBM generally does not pose a health risk. However, ACBM may pose an increased risk if damaged, disturbed in certain manners, or if it deteriorates so that asbestos fibers can be released into building air (ASTM 1527 - 13)... EPA banned the use of asbestos in several products in 1993."

from the relevant sanitary authority. To obtain an authorization, the owner of the respective buildings, machinery, equipment, or installation must present a work plan which describes the measures that will be adopted to protect the health of the workers and the nearby population.

If during the dismantling process, friable asbestos is found without prior knowledge it existed at the start of the work, authorization to continue must be solicited and the work must stop until authorization is received.

If the asbestos found is non-friable then the owner must notify the relevant sanitary authority prior to the start of the works or as soon as found. A work plan must be delivered to the relevant authority.

7.1.2.2 Identify presence of lead

The EPA has determined that lead concentrations in the soil which exceed 400 ppm in a play-ground and 1200 PPM in other residential areas where children younger than 7 are present can lead to serious health risks and can justify remediation actions (ASTM 1527 -13, Section X5.3) (US EP, 2019). If lead is identified on the ground, the site must be remediated to meet the final use requirements.

If there is equipment or structures which contain paint with lead, or other substances with lead, these must be removed prior to starting the dismantling or demolition (EPRI, 2006). These must be stored, transported and eliminated according to Decree 148 (2004) of the Ministry of Health which defines the health rules for handling hazardous waste.

7.1.2.3 Identify presence of Mercury and PCBs

Polychlorinated biphenyls (PCBs) are used because they can insulate, are not flammable and have chemical stability. They have been used in various applications and industries such as electric equipment, motor oil, hydraulic equipment, cable insulation, thermal insulation, paint, liners, flame-retardants, adhesives, transformers, capacitors, amongst others (EPA, no date). PCBs are persistent, bio accumulative, semi volatile (which facilitates its transport by air or water) and toxic. PCBs generate various carcinogenic and non-carcinogenic effects on the health of people, both for an acute and chronic exposure (CONAMA, 2004).

In 1982 the use of PCBs was prohibited in Chile, however some of the older facilities could have components with PCBs contain or could have soil contamination product of oil leaks which

contains PCBs. The materials which contain PCBs are considered hazardous waste and should be removed prior to demolition or eliminated considering the guidance defined by the current legislation (DS 148/2004 Ministry of Health). The waste should be removed from the site or installations prior to being demolished as defined in the existing legislation. The instructions for the detection, handling, transportation, and disposal of PCBs in the "Instruction Guide to handle Polychlorinated biphenyls in Chile (PCBs, Askareles) published by CONAMA[54] in 2004 should be reviewed and followed. The indications in the DS 148/2004 of the Ministry of Health should also be followed.

Mercury is classified as a hazardous substance according to the DS 148/2003 of the Ministry of health. The older facilities could contain instruments and pressure equipment which contain mercury. These should be removed and disposed of following the regulation prior to the demolition of structures (EPRI, 2006).

7.2 Shutdown of ash pond

In general, the Coal Combustion Residuals (CCR) are classified non-hazardous solid waste[55] and include all the solids associated with burning coal: fly ash, bottom ash, boiler slag and flue gas desulfurization materials.

The EPA 40 CFR 257.102[56] establishes alternatives for the procedures and requirements associated to the shutdown of CCR landfills, they are as follows:

- Leave the CCR in the landfill and install a cover during the final shutdown, or
- Remove the CCR to dispose of them in another area and clean the original landfill[57].

The initial step is to develop a written shutdown plan which contains at least the following information:

- Depending on the option selected, a description of the landfill shutdown process or the procedure which will be used to remove the CCR.

54 Available at: http://www.gecop.cl/wp-content/uploads/2018/02/Manual-de-Chile-sobre-el-Manejo-de-Bifenilos-Policlorados.pdf

55 In Europe and the US. In Chile, "fly ash from coal-fired power plants" is defined as hazardous waste only if it contains certain elements "in concentrations that make the waste present some dangerous characteristic" (DS 148 of 2003, Art. 90). According to the Environmental Impact Studies and associated appendices of all coal-fired power plants in Chile, laboratory tests verify that the ash produced is not dangerous (inodú, 2018).

56 80 FR 21301, April 17, 2015, which, later, entered a litigation and review process.

57 Although this is valid alternative, it is not recommended. Translating the CCR to another site only to dispose of them usually generates more impact than leaving them in the original location.

- An estimation of the maximum CCR quantity which will accumulate in the landfill.
- An estimation of the maximum area which will have to be shutdown.
- A schedule which contains the required activities to meet the shutdown criteria.

As shown in Section 3.2.1, the ash ponds have procedures in the REAs which must be followed when shutting down. It's possible that the company opts to modify the plan, however it will have to follow the same approval process[58]. The shutdown plan must be approved by a qualified engineer. The engineer must ultimately certify that widely adopted best practices are met.

To leave the CCR in the landfill and install a cover when shutting down, a shutdown plan should meet the following requirements:

- If possible, control, minimize or avoid infiltration of liquids into the CRRs or the infiltration of the CCRs into the subsoil, surface water or the atmosphere.
- Stop the accumulation of water, sediment, or mud on the surface of the ash pond[59].
- Ensure the physical stability of the embankment and the landfill cover.
- Minimize the need for maintenance.
- Completed in the least amount of time possible following best practices and commonly used standards.

The specific requirements of the final cover are:

- The permeability of the bottom of the landfill should be less than or equal to the minimum value of the following:
  - The permeability of the landfill lining.
  - The permeability of the natural subsoil.
  - $1 \cdot 10^{-5}$ cm[60]
- A layer of at least 18 inches of soil (approximately 45 cm) should be present in order to prevent the infiltration of liquids.

58 However, the new plan must be consistent with the conditions and requirements in the approved plan.
59 For example, a runoff water draining system which separates the water which was in contact with the materials in the landfill from water which wasn't can be designed and maintained.
60 As a reference, clay without being compacted has a permeability of between $5.5 \cdot 10^{-7}$ cm/s and $5.5 \cdot 10^{-4}$ cm/s.

- A top layer of at least 6 inches of dirt (approximately 15 cm) which can sustain grown of local flora to avoid erosion of the region.

- The design must minimize integrity loses which avoid the accumulation of sediment and sinking.

However, the cover does not need to exactly meet the requirements defined above. The owner of the landfill can propose another cover for shutdown which achieves the same purpose. In this case, a qualified engineer must certify that the design meets the previously defined objectives.

The following are landfill shutdown activities, depending on the landfill use situation, should be considered:

- If the landfill received a final delivery of CCR then the shutdown activities should be started within 30 days.

- If the landfill has not received waste delivery and CCR has not been removed for beneficial use in other industries within two years, then the shutdown activities should be started.

- This last deadline can be extend by two-year periods repeatedly, only if documentation can be shown that there is a high probability that the landfill will receive waste in the foreseeable future, or the waste will be removed for a positive use (reuse or recycling).

Once the cover for final shutdown has been constructed, the following obligations should be met:

- Maintain the integrity and effectivity of the cover by conducting maintenance in case of sinking, sedimentation, erosion, or other events.

- Monitor periodically the groundwater to measure the concentration of the substances defined in article 257.95 of 40 CFR 257.

The owner will have to elaborate and communicate a written plan which describes the monitoring and maintenance activities post-shutdown. These must be executed for a 30-year period. The plan should also describe possible future uses for the site and must demonstrate that these uses will not alter the integrity or effectivity of the cover or generate a threat to human or environmental health.

7.3 No further action letters

A declaration or letter which states that new actions will not be taken by the competent authority could be emitted. Hence, the competent authority can provide certainty that they are satisfied with the developed measures and will not require new corrective action for the site. The letter or declaration does not generally take away additional responsibility associated for the site. Therefore, the letter does not provide a similar level of certainty as an agreement which describes the covenants not to sue (ASTM 2081 – 00, Section X1.7.5.3 and X1.7.5.7)

8 APPENDICES

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ACRONYMS AND ABBREVIATIONS 8.2

ACBM	Asbestos Containing Building Materials
ASTM	American Society for Testing and Materials
CFR	Code Of Federal Regulations
HBCR	Health-Based Criteria Referral
CCR	Coal Combustion Residues
DDU	Urban Development Division (Ministerio de Vivienda y Urbanismo)
DIA	Environmental Impact Statement
EIA	Environmental Impact Study
EPA	U.S. Environmental Protection Agency
EPD	Environmental Protection Division
MCL	Maximum Contaminant Level (Niveles Máximos de Contaminantes).
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated biphenyls
RAGS	Risk Assessment Guidance for Superfund
REA	Resolution of Environmental Acceptance
RRS	Risk Reduction Standard
SEIA	Environmental Impact Assessment System
SPCP	Soils with Potential Contaminant Presence

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On behalf of:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany