

Exhibit G

Materials Analysis

Carty Generating Station
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Prepared for



Portland General Electric Company

Prepared by



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Acronyms and Abbreviations

ASC	Application for Site Certificate
BCP	Boardman Coal Plant
BESS	battery energy storage system
Certificate Holder / PGE	Portland General Electric Company
CGS / Facility	Carty Generating Station
Council	Oregon Energy Facility Siting Council
ESCP	Erosion and Sediment Control Plan
EPA	U.S. Environmental Protection Agency
gpd	gallons per day
Li-ion	lithium-ion
MW	megawatt
O&M	operations and maintenance
OAR	Oregon Administrative Rules
ODOE	Oregon Department of Energy
RCRA	Resource Conservation and Recovery Act
RFA	Request for Amendment
SPCC	Spill Prevention, Control, and Countermeasure

1.0 Introduction

The Portland General Electric Company (PGE or Certificate Holder) is submitting a Request for Amendment (RFA) 4 to the Site Certificate for the Carty Generating Station (CGS or Facility). The Facility is located approximately 13 miles southwest of Boardman, in Morrow County, Oregon. As currently approved, the Facility is capable of generating up to 450 megawatts (MW) from the natural gas-fueled combined-cycle unit (Unit 1).

In RFA 4, the Certificate Holder is proposing photovoltaic solar energy generation with approximately 200 MW alternating current (AC) of nominal and average generating capacity and BESS with the capability of storing up to 200 MW AC. The overall CGS additions proposed with RFA 4 (including the BESS) are referred to throughout this request as the Carty Solar Farm with proposed RFA 4 changes. The solar generation is proposed in two separate solar areas referred to as the Northern Solar Area, located north of the Carty Reservoir, and the Southern Solar Area, located south of the reservoir [see Figure 2 in RFA 4's Division 27 document (Request for Amendment 4 for the Carty Generating Station)].

Exhibit G provides the information required by Oregon Administrative Rules (OAR) 345-021-0010(1)(g) in support of RFA 4. Analysis in this exhibit incorporates and/or relies on reference information, analysis, and findings found in the Application for Site Certificate (ASC), previous RFAs, and Oregon Department of Energy (ODOE) Final Orders to demonstrate that the Facility, as modified by RFA 4, continues to comply with applicable Site Certificate Conditions. OAR 345 Division 22 does not provide an approval standard specific to Exhibit G.

2.0 Materials Inventory – OAR 345-021-0010(1)(g)(A)

OAR 345-021-0010(1)(g) A materials analysis including:

OAR 345-021-0010(1)(g)(A) An inventory of substantial quantities of industrial materials flowing into and out of the proposed facility during construction and operation;

As described in Section 1.0 of the RFA 4's Division 27 document (Request for Amendment 4 for the Carty Generating Station), the layout proposed for the Carty Solar Farm with proposed RFA 4 changes with proposed RFA 4 changes includes four main areas with infrastructure improvements: two separate solar areas; an area for BESS; and a proposed collector substation with overhead electrical connection between the proposed substation and existing transmission line dead-end structure remaining from the BCP.

The Certificate Holder is requesting to permit a range of technology in order to preserve permitting flexibility and will stipulate the precise details of photovoltaic solar energy generation and supporting facilities during final design and engineering prior to construction. Therefore, this

exhibit analyzes the maximum number of materials anticipated with the Carty Solar Farm with proposed RFA 4 changes to address the maximum impact.

This section describes the materials needed to support the Carty Solar Farm with proposed RFA 4 changes including up to 200 MW of solar generation, and up to 200 MW AC BESS, and associated infrastructure. Note that the natural gas-fueled combined-cycle unit (Unit 1) is already operating at the Facility; thus, the materials associated with the constructed portions of the Facility are not repeated for the purposes of this analysis.

2.1 Construction

The two solar areas proposed with the Carty Solar Farm with proposed RFA 4 changes will be composed of photovoltaic solar modules composed of mono- or poly-crystalline cells supported on non-specular, galvanized steel racks. The modules are inert and will not introduce any hazardous materials to the Facility. Each tracker will be supported by steel posts. Other onsite equipment will include buried conduits, combiner boxes, inverters, and transformers. The solar inverters and transformer stations, as well as the associated proposed substation, will require concrete foundations made of steel reinforcing bars and concrete (gravel, sand, cement, and water), as well as additional collector line and access roads to connect to the proposed substation and existing electrical infrastructure. Note that for the construction of foundations, PGE will buy concrete directly from licensed suppliers (i.e., with a valid water use license) in the area; an on-site batch plant is not proposed at this time.

The BESS will use lithium-ion (Li-ion) batteries. Li-ion batteries are modular in that each unit contains multiple smaller battery pouch cells. The cells are the primary containment for the electrolyte materials. The module containing the cells is relatively small, generally about the size of a desktop computer processor, and serves as leak-proof secondary containment. The cells are contained within a module which is collected in a pack, and then wired into a string, and finally into the full modular unit. The quantities per modular unit could change based on the most current model procured for the Facility, but the general framework is typical for utility-scale Li-ion systems. Although module leaks are very unlikely because it would require failure of the sealed module, any material that might leak to the floor of the container will easily be contained. The BESS will be manufactured, assembled, and inspected off-site and will be shipped to the site as outdoor-rated prefabricated modules, which will be installed and electrically connected on-site. The BESS containers will also require concrete foundations made of steel reinforcing bars and concrete (gravel, sand, cement, and water). Consequently, the primary raw materials needed for the Facility's construction are rock, gravel, sand, water, cement, and steel rebar.

Although some new materials will be required for the proposed BESS, the materials used to construct the BESS and associated infrastructure are typical materials used for the construction of these facilities and are materials that the Council has already approved for other energy facilities.

Table G-1 provides a list of industrial materials that will be used during Facility construction, based on current engineering estimates. The amount of water used for concrete is discussed in Exhibit O. Solid wastes generated and flowing out of the Facility during construction are outlined in Exhibit W.

Table G-1. Materials Inventory for Construction

Material	Quantity/Units	Ultimate Disposition
Solar modules	Maximum 390,879 modules	Throughout each solar module string
Steel solar module tracker posts	72,000 posts, 12,519 tons steel (347.7 pounds per post)	Throughout each solar module string
Solar modules per string	27 modules (27 modules per rack, max 14,477 strings)	Throughout each solar module string
Aggregate (rock and gravel)	39,130 tons total	See below by location
• Battery storage	3,224 tons (6.2 acres)	On-site graveled area
• Access roads	1,996 tons (9.9 miles new road)	On-site graveled area
• Substation	3,184 tons (3.2 acres)	On-site graveled area
• O&M Building	988 tons (0.9 acres)	On-site graveled area
• Temporary construction areas	6,934 tons (21.4 acres)	On-site graveled area
Concrete	4,198 cubic yards (yd ³) total	See below by location
• Battery storage	1,148 yd ³ (330 pads)	Foundation
• Inverters/Transformers	2,360 yd ³ (44 stations solar, 58 stations BESS)	Foundation
• Substation	502 yd ³ (3.2 acres)	Foundation
• O&M Building	242 yd ³ (0.5 acres)	Foundation
Battery components	15 cells per module, 3 modules per pack, 1 pack per string (total unit: 360 cells, 24 modules, 8 packs, 8 strings)	BESS
Batteries	Approximately 330 containers ¹	BESS
Combiner boxes	660 boxes	Aboveground throughout each solar module string
Substation generator step-up transformer	Up to 1 transformer	Within the substation footprint
Collector lines (34.5 kilovolt [kV])	25 miles (underground); 2.0 miles (aboveground)	Between solar array and substation, either buried underground or aboveground
Aboveground collector line (34.5-kV) support structures	Up to 60 structures that may be either single or double circuit wood monopole structures	Aboveground structures
Transmission line (500-kV)	300 feet	Interconnecting the collector substation to existing dead-end
Transmission line (500-kV) support structures	None; connection from the rigid bus to the existing dead-end structure	N/A
Inverter/Transformers	Solar: 44 inverters and transformers BESS: Approximately 58 inverters and 30 transformers ¹	Aboveground throughout solar array

Material	Quantity/Units	Ultimate Disposition
Fencing	77,794 feet total (solar areas: 71,808 feet; collector substation: 1,472 feet; BESS: 4,514 feet)	Will remain around solar arrays, substation, and BESS
1. Estimated numbers will be finalized during pre-construction.		

2.2 Operational

No substantial quantities of industrial materials will be brought into or removed from the Facility during the operation of the Carty Solar Farm with proposed RFA 4 changes. The materials that will be brought into or removed during operations are those needed for maintenance or replacement of damaged equipment (e.g., solar array components, electrical equipment). Materials for operations will be delivered to the required location as needed.

Transformer oils will be present within the Carty Solar Farm with proposed RFA 4 changes but will be fully contained within the electrical transformers. Fuel or oils needed for maintenance will be delivered by a licensed maintenance contractor on an as-needed basis, and no substantial quantities will be stored on-site.

During the Facility's lifetime, major maintenance issues may require the replacement of solar modules or other associated components; however, due to the unpredictable nature of major maintenance problems, no estimate has been provided for the number of major components that may be needed. Minor maintenance may also require the replacement and removal of smaller components, which are not expected to constitute substantial amounts of industrial materials.

Batteries may require periodic replacement if a component is found to be faulty; otherwise, the batteries are not expected to be replaced during the life of the Carty Solar Farm with proposed RFA 4 changes. Modules lose their effectiveness through repeated charge/discharge cycles. The BESS will require augmentation to compensate for degradation. Augmentation will add additional batteries to maintain a 200 MW output, but degraded batteries would not be removed from service. For this analysis it is assumed that batteries are only removed due to needed repair or replacement during operations, and replacement of batteries for degradation would only happen at decommissioning. Due to the unpredictable nature of needed repair or replacement, no estimate has been provided for the number of batteries that will flow into and out of the Facility.

Table G-2 lists the cumulative materials and amounts used for operations and maintenance of the Facility.

Table G-2. Materials Inventory for Operations

Material	Quantity/Units	Ultimate Disposition
Spare solar modules	2,000 modules	Stored at the proposed operations and maintenance (O&M) building.
Transformer oil	Substation generator step-up transformer: 35,000 gallons Solar array inverter step-up transformers: approximately 28,000 gallons (640 gallons per transformer) BESS inverter step-up transformers: approximately 21000 gallons (640 gallons per transformer)	Within transformer boxes for cooling (No extra oil stored outside of transformers. Additional oil only required due to failure, provided on an as-needed basis.)

3.0 Hazardous Materials Handling and Management – OAR 345-021-0010(1)(g)(B)

OAR 345-021-0010(1)(g)(B) The applicant's plans to manage hazardous substances during construction and operation, including measures to prevent and contain spills; and

During the construction or operations phases of the Carty Solar Farm with proposed RFA 4 changes, it may be necessary to use minor quantities of hazardous substances (materials requiring Material Safety Data Sheets). In compliance with Site Certificate Condition 9.10, all potentially hazardous substances will be handled in a manner that is protective of human health, protective of the environment, and that complies with all applicable local, state, and federal environmental laws and regulations.

Extremely hazardous substances in excess of threshold planning quantities, highly toxic substances, or explosive materials will not be necessary to support either the construction or the operations phase of the Carty Solar Farm with proposed RFA 4 changes. Additionally, materials used during construction and operations will be selected so that they minimize the potential for producing “hazardous waste,” as defined by the Resource Conservation and Recovery Act (RCRA). Accidental releases of hazardous materials will be prevented or minimized through proper containment of these substances during use and transportation to the Facility as described in the Spill Prevention, Control, and Countermeasure Plan (SPCC) Plan, required by Site Certificate Condition 5.9.

3.1 Construction

During construction of the Carty Solar Farm with proposed RFA 4 changes, small quantities of potentially hazardous materials may be used including cleaners, insecticides or herbicides, paint, solvents and spent vehicle and equipment fluids and components (e.g., used oil, used hydraulic fluids, spent fluids, oily rags, and spent lead-acid or nickel-cadmium batteries). Potentially

hazardous substances will not be permanently present within the construction areas in quantities that exceed Oregon State Fire Marshal Reportable Quantities.¹

Fuels will be the only hazardous material that may be stored in substantial quantities on-site during construction. The Certificate Holder anticipates that up to five 1,000-gallon diesel fuel tanks may be kept on-site for fueling of construction equipment, 5,000 gallons total. These will be stored in temporary aboveground tanks in the construction yard(s), within an area that provides for secondary containment. No gasoline tanks will be kept on-site during construction. It is anticipated that each diesel tank will be filled once per month. Secondary containment and refueling procedures for on-site fuel storage will follow the contractor's Hazardous Materials Management and Monitoring Plan (Condition 10.37). Secondary containment will be compliant with requirements in 40 CFR §112.7(c), which requires secondary containment for all above-ground, buried, and partially buried containers. It is anticipated that the majority of fuel containers will have self-contained secondary containment (e.g., double-walled containers) that provide capacity for the entire container plus precipitation, but in some cases smaller containers (e.g., drums) will be placed in a constructed secondary containment area that is impervious and is diked or otherwise contained to provide the required fuel and precipitation capacity.

Construction-based equipment will be regularly inspected to detect potential leaks or other issues that may require maintenance. Potentially hazardous substances related to the maintenance of the construction equipment will only be brought to the construction site by a maintenance technician on an as-needed basis, and any unused or waste substances will be removed during the same service call. Refueling will take place a substantial distance from waterways or wetlands to prevent water quality impacts in the event of an accidental release.

As required by Site Certificate Condition 6.3, the Certificate Holder will implement a Construction Waste Management Plan for the Carty Solar Farm with proposed RFA 4 changes. The plan will include measures to segregate all hazardous and universal wastes such as used oil, oily rags, mercury-containing lights, and lead-acid and nickel-cadmium batteries for disposal by a licensed firm that specializes in their proper recycling/disposal.

Additionally, as required by Site Certificate Condition 10.37, a Hazardous Materials Management and Monitoring Plan will be implemented for the Carty Solar Farm with proposed RFA 4 changes. This Plan shall contain the same information required for a SPCC Plan. The SPCC Plan will address spill prevention, and the Hazardous Materials Management and Monitoring Plan will address hazardous substances specifically. The Hazardous Materials Management and Monitoring Plan shall include operating procedures to prevent hazardous substances releases, control measures to contain hazardous substance releases, countermeasures to contain, cleanup, and mitigate hazardous substance releases, and procedures for required inspections and testing. The SPCC will

¹ "Reportable quantity" refers to the amount of hazardous substance that has to be released into the environment before the U.S. Environmental Protection Agency requires notification of the release to the National Response Center pursuant to the Comprehensive Environmental Release, Compensation, and Liability Act, also known as Superfund. These numerical designations are listed under 49 Code of Federal Regulations 172.101 Appendix A, Table 1 and Table 2

outline preventative measures and practices to reduce the likelihood of an accidental release of a hazardous or regulated liquid and, in the event such a release occurs, to expedite the response to and remediation of the release. Per Site Certificate Condition 10.38, if any inspection performed in accordance with the Hazardous Materials Management and Monitoring Plan identifies improper handling or storage of hazardous substances (as defined by ORS 465.200) or improper record keeping procedures, the Certificate Holder must correct such deficiencies promptly and must report the corrective actions.

In the unlikely event that an accidental spill occurs, the Certificate Holder will report the spill within 72 hours and any spilled or released substances will be cleaned up according to applicable regulations (Site Certificate Conditions 9.11 and 10.39). Consistent with Site Certificate Condition 9.11, spill kits with absorbent pads will be located on equipment, near storage areas, and in the administrative or maintenance areas of the Facility. Employees will be instructed about proper handling, storage and cleanup of hazardous materials. Any reportable spills will be immediately called in to the Oregon Emergency Management Division's Oregon Emergency Response System, per OAR Chapter 340 Division 142. See Exhibit CC for a listing of applicable regulations.

3.2 Operations

The Carty Solar Farm with proposed RFA 4 changes will not include substantial quantities of fuels, lubricating oils, hydraulic fluid for construction equipment, or other hazardous materials maintained on-site during operations. Small quantities of a few hazardous materials may be utilized; such materials may include cleaners, insecticides or herbicides, paint, or solvents. The Carty Solar Farm with proposed RFA 4 changes will not require a significant increase in use of these items, and none will be present in substantial reportable quantities. When not in use these will be stored in a secure location within the proposed O&M building. In compliance with Site Certificate Condition 10.22, an Operational Waste Management Plan will be implemented for management of both hazardous and non-hazardous waste during operations, which will include handling procedures for lithium-ion batteries.

The BESS may include hazardous substances within internal battery components; however, batteries are integrated to safely operate when used according to the recommendations of the manufacturer and when their integrity is maintained (not damaged and internal seal is intact). Li-ion batteries specifically present a flammability hazard and require cooling systems to prevent overheating. The BESS will have integrated safety systems that monitor battery performance to detect malfunctions and implement response measures. Batteries will be housed in leak-proof containers to prevent inadvertent releases of hazardous materials. O&M staff will conduct inspections of the battery cells for damage. Li-ion batteries may contain hazardous waste and will be handled and disposed of per the most up-to-date guidelines at the end of their life.

For the replacement of Li-ion batteries specifically, the Certificate Holder will follow the handling guidelines of 49 Code of Federal Regulations 173.185 (Department of Transportation Pipeline and Hazardous Material Administration) related to the shipment of Li-ion batteries. The regulations include requirements for prevention of a dangerous evolution of heat, prevention of short circuits,

and prevention of damage to the terminals. They also require that no battery will come into contact with other batteries or conductive materials. A licensed third-party battery supplier will transport batteries to and from the Facility in accordance with applicable regulations. Spent batteries will be disposed of at a facility permitted to handle them in compliance with applicable RCRA and Toxic Substances Control Act regulations administered by the U.S. Environmental Protection Agency (EPA) or Oregon Department of Environmental Quality. Adherence to the requirements and regulations (including personnel training, safe interim storage, and segregation from other potential waste streams) will minimize safety hazards related to transport, use, or disposal of batteries.

As required by Site Certificate Condition 9.10, gasoline that is intended for fueling vehicles cannot be stored on-site at the Facility during operations, and the Certificate Holder will continue to comply with this for operation of the Carty Solar Farm with proposed RFA 4 changes.

Additionally, as identified in Site Certificate Conditions 5.9 and 10.37, an operational Hazardous Materials Management and Monitoring Plan and SPCC Plan will be implemented. In the unlikely event of an accidental hazardous materials release, any spill or release will be cleaned up and the contaminated soil or other materials disposed of and treated according to applicable regulations (per Site Certificate Conditions 9.11 and 10.39). Employees at the Facility will be trained to be aware of the potential hazards through the availability of Material Safety Data Sheets, and to handle such releases in accordance with applicable regulations. See Exhibit CC for a list of applicable regulations. Spill kits containing items such as absorbent pads will be located on equipment and in on-site temporary storage facilities to respond to accidental spills, if any were to occur. Employees handling hazardous materials will be instructed in the proper handling and storage of these materials, as well as where spill kits are located. The Certificate Holder will report spills or releases of hazardous materials during construction or operation as noted above to the Oregon Emergency Response System, per reporting requirements detailed in OAR Chapter 340 Division 142.

4.0 Non-Hazardous Waste Management – OAR 345-021-0010(1)(g)(C)

OAR 345-021-0010(1)(g)(C) The applicant's plans to manage non-hazardous waste materials during construction and operation.

The Certificate Holder will continue to fully comply with all applicable waste handling and disposal regulations on all lands associated with the Facility, during both construction and operation of the Carty Solar Farm with proposed RFA 4 changes. Solid waste will be stored in a manner that does not constitute a fire, health, or safety hazard until such time as it can be hauled off for recycling or disposal, as appropriate. Exhibit W provides details on the types and amounts of waste, and procedures and systems for the handling and disposal of waste materials.

4.1 Construction

Construction of the Carty Solar Farm with proposed RFA 4 changes will generate the same types of nonhazardous solid and liquid waste as the previously approved Carty Solar Farm, which the Certificate Holder will manage according to the Construction Waste Management Plan (Site Certificate Condition 6.3). Waste construction materials generated from construction may include scrap steel, wood, concrete waste, excavated soil, and packaging material waste. When feasible, the waste generated during construction will be recycled. Steel scraps will be separated and recycled to the extent feasible. Wood from concrete forms will be reused when practicable and then recycled. Excess excavated material will be used to restore ground contours after construction, and to provide fill on-site or be transported off-site for disposal. Construction will not require the use of specialized structures, systems, or equipment for waste management or disposal. Standard construction waste bins will be kept on-site to keep construction debris until it is hauled off-site by a licensed waste hauler (see Exhibit U for waste service provider information). Further information regarding waste materials is included in Exhibit W.

The only material that has the potential to be disposed of on-site will be waste concrete generated during construction. Waste concrete will consist of concrete solids contained in the concrete chute washout water. Washdown methods will be determined by the contractor, and may occur at off-site contractor-owned batch plants, within each foundation excavation and/or a designated concrete washout area (per Site Certificate Condition 6.3). Any excess concrete may be incorporated into foundations, rather than disposed of.

Packaging waste (such as paper and cardboard) and refuse will be separated, accumulated in dumpsters, and periodically removed for recycling or disposal at the Finley Buttes Landfill or Columbia Ridge Landfill (see Exhibit U). In compliance with Site Certificate Condition 6.2, portable toilets will be provided for on-site sewage handling during construction and will be pumped and cleaned regularly by the construction contractor.

Construction stormwater will be generated at the location of the solar array and battery energy storage construction sites. Such stormwater will be covered under the Facility's National Pollutant Discharge Elimination System 1200-C construction permit and its associated Erosion and Sediment Control Plan (ESCP) consistent with Site Certificate Condition 9.1. The draft ESCP for the Carty Solar Farm with proposed RFA 4 changes is included as Attachment I-1 to Exhibit I.

4.2 Operations

Waste generated by operation of the Carty Solar Farm with proposed RFA 4 changes will be negligible. Operation of the Carty Solar Farm with proposed RFA 4 changes will generate the same types of nonhazardous solid and liquid waste as previously approved for the Facility, which the Certificate Holder will manage according to the Operational Waste Management Plan (Site Certificate Condition 10.22). The Operational Waste Management Plan which will include handling procedures for lithium-ion batteries (addressed in Section 3.2 above).

Administrative activities related to Carty Solar Farm with proposed RFA 4 changes will be conducted at the proposed O&M building. Office waste generated at the proposed O&M building will be disposed of at the Finley Butte Regional Landfill or Columbia Ridge Landfill. The building will include potable water and a sewer connection for toilets. The sanitary sewer will be collected and treated by the Facility's existing Carty septic system, as discussed in RFA 2. Once the number of additional employees is determined, if the existing system capacity is not sufficient a septic system alteration permit would be obtained from the Umatilla County Public Health Department, which issues alteration permits for septic systems in Morrow County, to increase the capacity of the existing septic system.

Solar panels will be washed, but no chemicals will be mixed with the wash water and it will evaporate or will infiltrate into the ground near the point of use, consistent with Site Certificate Condition 10.28 (see Exhibit W). The solar panel wash water will be sourced from the Carty Reservoir under PGE's existing water right. No additional industrial wastewater streams will be generated by the Carty Solar Farm with proposed RFA 4 changes.