

US environmental permitting for PV manufacturing facilities – requirements and strategies for success

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ABSTRACT

As a relative newcomer to the industrial world compared to more mature manufacturing sectors, the PV industry has not yet been subject to consistent environmental regulatory standards internationally. Like all industries that have preceded it, PV manufacturing is seeing its regulatory future evolve as PV producers migrate to different regions of the world. With this global expansion come significantly different levels of regulatory stringency, reflective of local conditions and cultures.

Introduction

Despite the clean-energy products made by the PV manufacturing industry, PV manufacturing processes and support systems can generate pollution [1,2]. As PV manufacturing facilities continue to become more widespread around the world, history suggests that the trend of tightening environmental regulations will accompany the industry's global growth [3]. For that reason, this paper uses its analysis of US environmental permitting criteria and processes as a basis of comparison that, it is believed, can be useful for solar manufacturers in other parts of the world, since the tightening of US environmental standards for manufacturers often foreshadows the imposition of more demanding regulations in other countries.

“If manufacturers can plan their PV manufacturing projects accordingly, they may be spared the negative consequences of finding their manufacturing facilities unable to comply with future permitting standards.”

Several factors that can influence a more favourable and expeditious environmental permitting process for PV manufacturing projects outside the US will also be discussed in this paper. However, PV manufacturers can expect the demands of the US-based permitting issues identified below to become increasingly common as the industry matures. This paper aims to share these permitting particulars in the spirit of ‘forewarned is forearmed’, to help PV manufacturers anticipate this expected trend of increasing permitting rigour. If manufacturers can plan their PV

manufacturing projects accordingly, they may be spared the negative consequences of finding their manufacturing facilities unable to comply with future permitting standards.

The US model for PV manufacturing environmental permitting

Before regulated pollutants can be discharged to the environment from an industrial source, US state and local environmental laws and regulations require the source to obtain environmental permits. Even before manufacturing operations commence, environmental

permits must be sought by greenfield developments that might impact sensitive environmental resources (e.g. wetlands, endangered species, nesting migratory birds and archaeological/cultural/historical resources). Permits associated with such sensitive resources generally trigger review and approval periods that exceed the time-to-market goals of a new PV manufacturing facility. In this case, site selection efforts should seek to avoid areas where such sensitive resources may exist.

This section describes the four primary environmental permits anticipated for nearly any large-scale industrial development to establish a PV

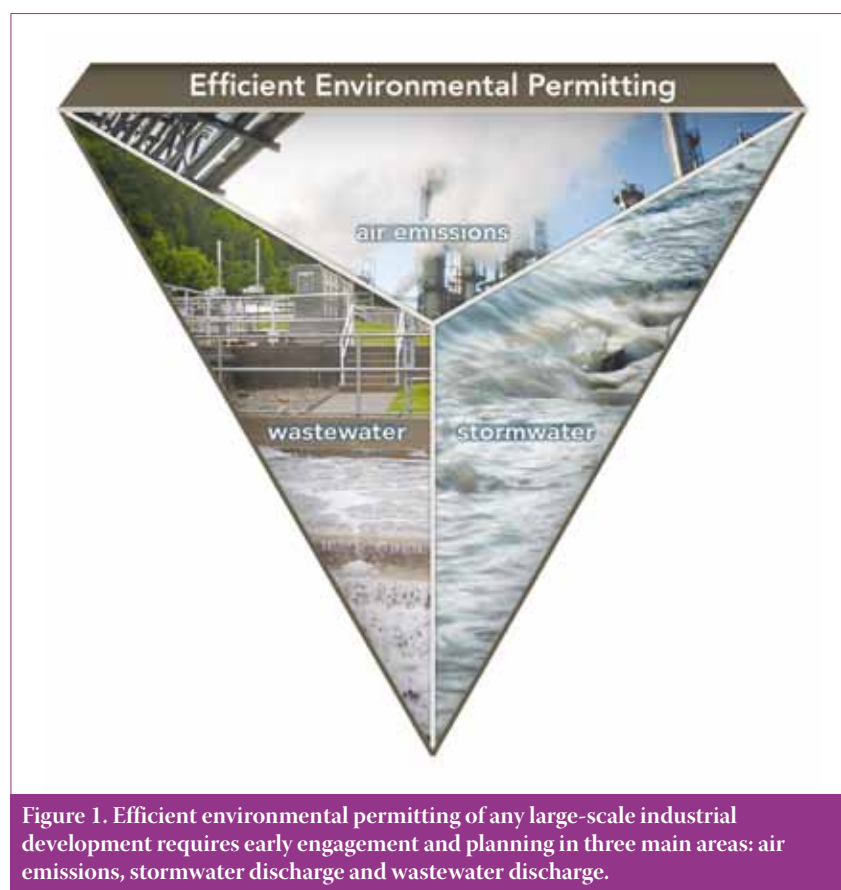


Figure 1. Efficient environmental permitting of any large-scale industrial development requires early engagement and planning in three main areas: air emissions, stormwater discharge and wastewater discharge.

Fab & Facilities

Materials

Cell Processing

Thin Film

PV Modules

Power Generation

Market Watch

Potential pitfall	Mitigation measure
Site layout and thus civil plans remain undefined, making preparation of E&SC plans difficult.	Go with the best available information given the time frames to get through the regulatory process. Most authorities have procedures for updating construction plans, without having to reapply for a permit.
A construction SWPPP requires details such as name and telephone number of site E&SC inspector that are not known at the time of permit application submission.	The site developer or engineer of record may need to be identified as the inspector until such time that the grading contractor has been identified.
The duty to comply with the construction stormwater permit usually falls on the 'owner/operator'. Therefore the PV developer can be culpable for violations made by an on-site contractor.	Have processes in place to monitor contractor activities during construction.

Table 1. Overcoming difficulties in obtaining construction stormwater permits.

manufacturing facility in the United States, specifically permits for:

- Construction stormwater discharge
- Air emissions
- Wastewater discharge
- Industrial stormwater discharge

In addition, strategies for obtaining, in a timely manner, permits that have reasonably attainable compliance requirements are reviewed. Permitting applicability, general steps involved in obtaining the permits and schedule considerations are briefly discussed, and a series of potential pitfalls and avoidance manoeuvres are provided. Environmental permitting outside the US is then considered in a subsequent section.

Construction stormwater permits

Under the US Federal Clean Water Act, stormwater discharge permits are required for construction activities, including clearing, grading, excavation, materials or equipment staging, and stockpiling that will disturb one or more acres of land. This permitting programme also applies to construction activities that will disturb less than one acre when they form part of a common plan of development or sale, if the larger common plan of development or sale will ultimately disturb one or more acres. One acre comprises 43,560 square feet, so most PV manufacturing development projects trigger this permit requirement. The permit is required prior to commencing earth-disturbing activities. While a few US states have not been delegated authority to administer this federal programme, most often the permit is obtained from the state or local environmental authorities. The majority of construction stormwater permits are 'general' permits, meaning that there is one permit in the jurisdiction to cover all potential permittees.

In general, the steps associated with obtaining this permit include:

1. Develop a site civil grading, and an erosion and sediment control (E&SC) plan.
2. Dovetail the civil plan into a construction stormwater pollution prevention plan (SWPPP).
3. Develop a construction SWPPP. The plan includes inventorying all 'significant' materials, describing best management practices to prevent stormwater pollution, and preparing detailed spill response procedures.
4. Submit a notice of intent (NOI) (after the SWPPP has been developed) to the permitting authority to obtain permit coverage.
5. Permit coverage is usually obtained within 15–60 days, depending on local agency processes.
6. Submit a construction completion report within 30–60 days (depending on local agency processes) to the permitting authority once construction is complete and the site has been permanently stabilized in accordance with the general permit.

Because of the large number of construction projects and NOIs submitted under this programme, there is usually little, if any, 'back and forth' with the permitting authority in obtaining a construction stormwater permit.

Air emission permits

For a PV manufacturing facility, air emission permits are typically required for process sources, e.g. etch processes releasing acid gases or screen-printing operations releasing volatile organic compounds (VOCs), and for process support systems, such as natural gas-fired boilers or diesel-fired emergency standby generators. Broadly speaking, air permits can be divided into 'major' source permits and 'minor' source permits. 'Major' source air permits can be required when facility emission rates are more than 100 tons per year (tpy)

of criteria pollutants (particulate matter, carbon monoxide, oxides of nitrogen, sulphur dioxide or VOC), or exceed 10 tpy of an individual hazardous air pollutant or 25 tpy of combined hazardous air pollutants (HAPs – there are 188 of these listed in the Clean Air Act). Recently, the US Environmental Protection Agency (EPA) promulgated regulations that also define a 'major source' as one that can emit 100,000 tpy or more of greenhouse gases (as carbon dioxide equivalents – CO₂e). Minor sources have the potential to emit regulated air pollutants at rates less than these major source thresholds [4]. All but the very largest PV manufacturing operations will most likely be 'minor' sources of air pollutants.

The tipping point for when an air permit needs to be in place for a minor source is not often defined in state regulations and may only be understood in a written or an unwritten policy. Some agencies request, without exception, that the permit be in place prior to construction activities, such as ground breaking or the pouring of foundations, while other agencies may allow a project to proceed 'at risk' up to the point where an emission source gets connected and becomes operable. Either way, early regulatory agency involvement and planning can circumvent schedule surprises. Typical agency review and approval periods for minor source air permits are 4–6 months.

In general, the steps necessary for obtaining an air permit are:

1. Prepare a preliminary air emissions inventory to estimate the annual emission rates of regulated air pollutants.
2. Hold a pre-application meeting with the regulatory agency to define permit application expectations and processes, including triggers for public comment periods, which often accompany air permit applications.
3. Collect additional details from the design team about air emission sources (parametric monitoring capabilities,

Potential pitfall	Mitigation measure
The availability of detailed design information falls well behind the due date for the air permit application.	Go with the best available information. Be creative and conservative with estimates of chemical and fuel use and thus emissions. Making a future permit modification will be easier if more emissions rights are not requested.
The project is phased, but the timing and capacity of each phase is not well defined.	Always attempt to permit for maximum projected full build-out. Arguably, permitting for anything less could be considered 'sham' permitting that contravenes the Clean Air Act. Permitting for full build-out usually leads to maximum operating flexibility.

Table 2. Overcoming difficulties in obtaining air emission permits.

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| | chemical and fuel consumption rates, stack parameters, etc). | for five years and are not always easily modified! | and scrubber or cooling tower blow-down. Wastewater discharges can be 'direct', i.e. direct to surface waters, or 'indirect', such as when wastewater is discharged to the local municipal wastewater treatment plant. |
| 4. | Refine the air emission inventory, prepare the agency forms and submit. | Wastewater discharge permits
A variety of PV module manufacturing activities generate wastewater, including acid-etch processes and rinses, chemical bath deposition and rinses, electroplating, | Direct discharges normally require a national pollutant discharge elimination |
| 5. | Carefully review the draft permit and conditions. Air permits can be issued | | |

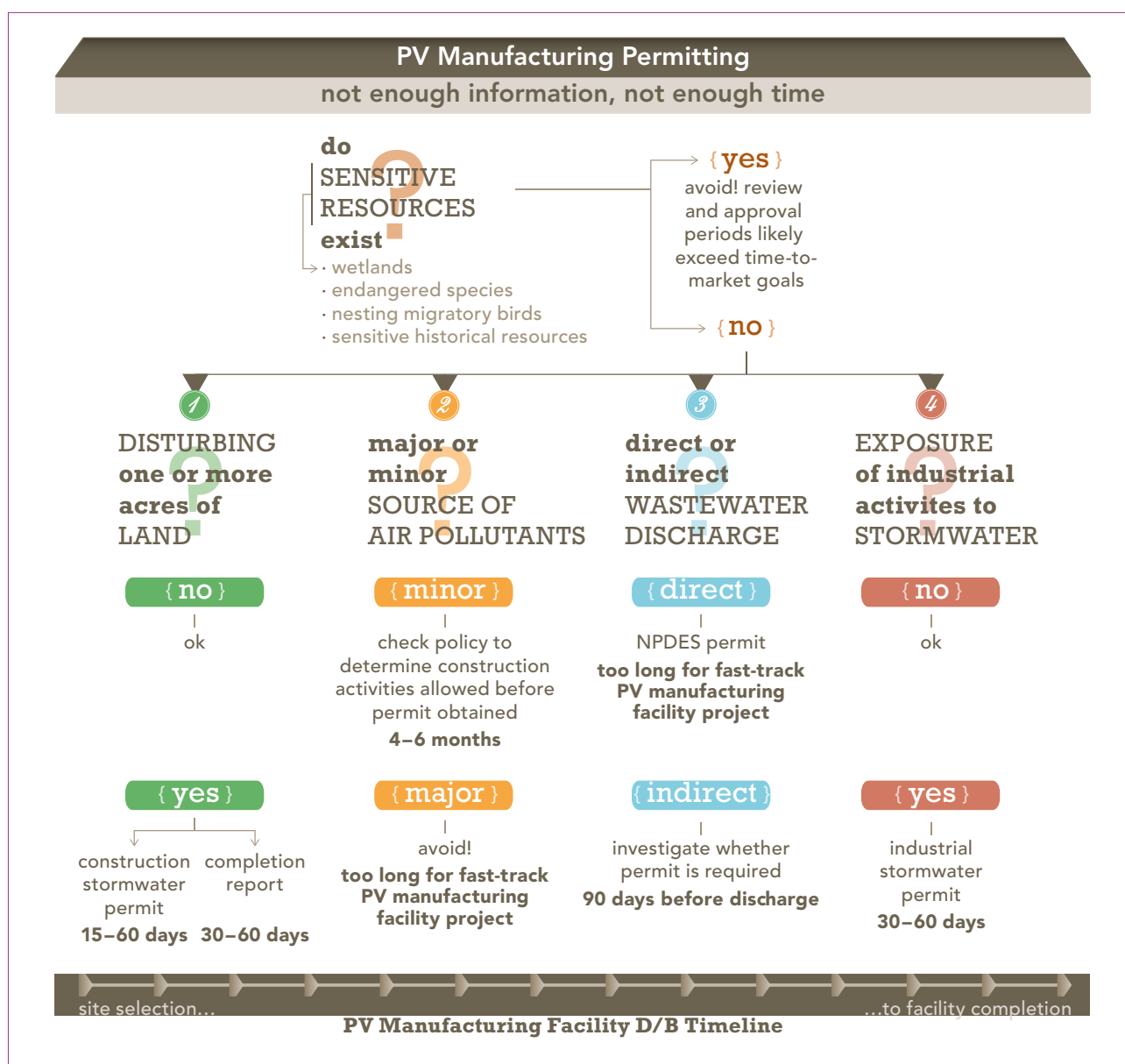


Figure 2. Permitting in PV manufacturing necessitates the collection and preparation of information in four main areas, each with its own timeline during the design-build process. Early planning will help ensure that permitting is well integrated into that timeline.

Potential pitfall	Mitigation measure
In addition to a permit application, the wastewater authority requires an 'Engineer's Report' with final, stamped engineering drawings of the pre-treatment system. The project is fast track, and the wastewater collection and treatment system is designed by multiple entities.	Scheduling and coordinating the preparation of an 'Engineer's Report' can be a challenge for a fast-track project. Advise the agency on how the system is being designed and check if early reviews of system components can be performed.
No representative sampling data for characterizing the wastewater effluent exists, because the process operations and chemistry are still evolving.	Use mass-balance engineering calculations to generate estimates. These will very likely be conservative, but they offer a way of initially evaluating how operations may bump up against permit limits.
The permit application demonstrated compliance with known wastewater discharge limits, but additional parameters were identified during the review process.	Local treatment plants also have discharge permits with which they must comply. Reviewing these permits and, of course, asking the agency for any 'off-the-books' parameters that may be regulated is important. Such typical parameters that may affect the PV industry include nitrogen compounds, fluorides or phosphorus compounds.

Table 3. Overcoming difficulties in obtaining wastewater discharge permits.

system (NPDES) permit, and, as in the case of the aforementioned sensitive resource permits, have long lead times that are not amenable to fast-track PV manufacturing facility projects. Consequently, these types of permit are not discussed in this paper.

For indirect wastewater discharges, there are a number of triggers that would require a facility to obtain industrial wastewater discharge permits from a local municipality. These triggers include:

- The facility's activities are subject to Federal EPA 'Categorical Source' requirements. Historically, certain PV manufacturing technologies have been subject to the EPA's 'Electrical and Electronic Components Point Source Category' and/or the 'Metal Finishing Point Source Category'.
- Wastewater flow rates are expected to exceed 25,000 gallons per day.
- Pre-treatment activities are required to meet discharge limits.
- The wastewater authorities perceive that operations at the facility may have an adverse effect on the municipal system, and therefore request that the facility go through the permitting process.

Typically, for an industrial source discharging wastewater to a local treatment plant, the municipality is also the permitting authority. A wastewater discharge permit application should

be submitted at least 90 days prior to discharging wastewater; however, certain US states also require a state permit to be obtained and this can increase the required lead times for obtaining a permit.

In general, the steps required to obtain an industrial wastewater discharge permit include the following:

1. Inventory all wastewater sources, including flow rates and potential chemical concentrations.
2. Identify 'local limits' or other regulatory limits such as EPA Categorical Source limits.
3. Work with wastewater treatment vendors in designing a pre-treatment system as necessary.
4. Hold a pre-application meeting with the wastewater authority.
5. Compile and submit a permit application (common elements include a water balance diagram, a mass balance or analytical testing to determine constituent concentrations, and engineering details of the pre-treatment system).

Industrial stormwater permits

Probably the final permit received prior to the start-up of a new PV manufacturing facility is the industrial stormwater permit. Under the Clean Water Act and the associated NPDES programme,

certain industrial sectors must obtain a stormwater discharge permit for their 'industrial activities' unless they can demonstrate and certify that there is 'no exposure' of those activities to stormwater. This permitting programme applies to numerous types of industrial source categories, including those with a Standard Industrial Classification (SIC) code of 36, which many PV manufacturing facilities have been designated.

“It is vital to have someone on your facility development project team who has expertise in permitting issues in international locations.”

As a rule, the state environmental authority is the permitting agency for this type of permit; the review and approval periods can be 30–60 days. Similarly, the construction stormwater permit is typically a 'general' permit.

The steps associated with obtaining this permit usually include:

1. Review a copy of the general industrial stormwater permit applicable to the project.
2. Develop an operational industrial stormwater pollution prevention plan (SWPPP). This is the most extensive

Potential pitfall	Mitigation measure
The criteria for certifying the facility for 'no exposure' seem vague.	Carefully evaluate the 'no exposure' criteria for your state. Even something as simple as an outdoor loading dock can invalidate 'no exposure' certification. Go ahead and apply for permit coverage.
The start of 'industrial activities' is difficult to define for a new facility start-up.	Apply for permit coverage as soon as an SWPPP can be reasonably drafted for the new facility. Have the permit in place in advance of process chemicals arriving on site.

Table 4. Overcoming difficulties in obtaining industrial stormwater permits.

activity associated with the permit. The plan includes inventorying all 'significant' materials, describing best management practices to prevent stormwater pollution, and preparing detailed spill response procedures.

3. Submit an NOI to the permitting authority to obtain permit coverage.
4. Permit coverage is usually obtained within 30–60 days, depending on local agency processes.

International considerations

With the exception of the stormwater discharge permitting programme, similar environmental permitting programmes exist for industrial projects outside the US. While a complete description and comparison of non-US environmental permitting programmes is beyond the scope of this paper, here are some general observations related to international environmental permitting derived from the author's direct experience:

- In general, there is less opportunity for public involvement in many international locations.
- There tends to be a greater prevalence of numerical discharge standards 'on the books' that can be used to understand requirements before the permitting process begins.
- Environmental authorities have significantly more opportunities to subjectively interpret regulations during the permitting process, potentially generating ambiguity and increasing permitting durations.
- In some locations, multilayered regulatory bureaucracies can protract permitting processes and jeopardize a project's schedule. Be aware of the permitting climate in the country of interest so that the amount of time that the permitting process may require in a given location can be factored in.
- In many locations (including the US), it is vitally important to work collaboratively with regulatory officials in the knowledge that regulatory issues pertaining to advanced technology manufacturing facilities can evolve as rapidly as the processing technologies

used in these facilities. There have been many instances in which a jurisdiction's permitting criteria were revised in response to a new type of processing technology, once the environmental circumstances related to that technology were shared with local regulatory officials. Officials around the world are often very accommodating to regulatory flexibility as long as these issues are addressed respectfully and honestly.

- Understand the 'environmental climate' of the country in which a development is planned. There have been cases in which owners have built a manufacturing facility compliant with existing permitting criteria, only to experience repercussions later when regulatory criteria tightened. Before committing to a specific location, owners should seek to determine, to the extent possible, any trends of tightening local environmental regulations related to particular manufacturing processes. In some cases, insight into the local level of environmental sensitivity can become the central determining issue of how or if you should choose to develop your facility in a specific location.
- For the reasons noted above, as well as many others, permitting processes are notorious bottlenecks that can impede a facility development schedule. It is vital to have someone on your facility development project team who has expertise in permitting issues in international locations. Permitting experts have proved countless times to be 'unsung heroes' who used their understanding of regulatory issues and the negotiation of permitting timelines to expedite permitting processes that would otherwise have seriously delayed project schedules.

**“Engage regulatory
authorities in good time.”**

Conclusion

Most new PV manufacturing facilities will need to obtain construction stormwater, air emission, wastewater and industrial stormwater permits. For fast-track projects, one major constraint on preparing the permit applications is having available information on what is to be built, and thus

what the environmental discharges will be. While multiple mitigation strategies exist, several stand out:

1. Engage regulatory authorities in good time.
2. Maintain close access to the design team to get the latest information.
3. Be proactive and resourceful in closing information gaps.

References

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About the Author

John Browning, P.E., has over 17 years of experience providing environmental consulting services for a wide range of international projects, including performing chemical mass balances of manufacturing facility process and support systems, characterizing environmental discharges from industrial facilities, obtaining environmental approvals and permits, and evaluating environmentally related operational plans. He has helped regulatory officials prepare environmental permits for advanced-technology manufacturing industries and approvals for a broad variety of manufacturing facility developments.

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