Environmental Planning and Management For OTEC Pilot Projects

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Abstract–Ocean thermal energy conversion is the hydropower technology of converting the temperature differential between tropical ocean surface and deep waters into electricity. The Ocean Thermal Energy Conversion Act was signed into law in 1980, assigning a leadership and oversight role to NOAA. In 1981 NOAA promulgated regulations for the licensing of a commercial OTEC facility; interest in this technology waned and the regulations were rescinded in the 1990s. The high costs of hydrocarbon fuels and global environmental concerns awakened a new focus on OTEC and other renewable energy technologies that do not emit CO2. This new focus brings a need for new licensing regulations. We also need reliable value-added environmental impact procedures, not only to comply with new licensing regulations, but also to support OTEC Pilot Project design and implementation.

Impact analysis studies and field surveys completed in the 1970s and 80s provide a sound basis for the evaluation of potential environmental effects and causes, with a focus on the obvious, first order sources of potential impacts of OTEC. These issues include the intake, transport and discharge of large quantities of seawater, occupying an ocean location with a large industrial platform anchored to the bottom and power transmission via subsea cabling to suitable shore locations. Current plans for satisfying the requirements of modern impact analysis and permitting include the development of new computer simulations of intakes and discharges, laboratory testing of candidate intake designs, multi-year field surveys using modern oceanographic tools, and extensive monitoring of demonstration plant operations.

A progressive approach to environmental planning is presented to support OTEC technology development. This approach creates a structure to support the assessment of potential environmental impacts concurrently with the development of design criteria. The structure provides for a systematic flagging of potentially conflicting environmental and design performance criteria. Conflict resolution at this stage of early planning and design involves understanding the project scope, understanding environmental impact cause and effect relationships, evaluating existing environmental impact data and recognizing data gaps.

This approach will generate project-specific baseline information that can be used to complete environmental compliance procedures required before project implementation. The anticipated result is success for OTEC Pilot Project developers coupled with effective and efficient environmental impact management.

Introduction

Ocean thermal energy conversion (OTEC) is the hydropower technology of converting the temperature differential between warm tropical ocean surface and cold deep waters into electricity. In 1980 Congress passed two laws relating to the development and licensing of OTEC facilities. In July of that year the Ocean Thermal Energy Conversion Research, Development, and Demonstration Act (PL 96-310, July 1980) directed the Department of Energy (DOE) to develop a plan to accelerate the development of OTEC and to provide funding for research and development of a demonstration facility. The following month the President signed the Ocean Thermal Energy Conversion Act (OTECA) (PL 96-320, August 1980) into law. He assigned commercial licensing authority for OTEC to NOAA and directed the agency to help promote its development. A principal intent of OTECA was to "establish a legal regime which will permit and encourage the development of ocean thermal energy

[1] This document represents the views of the authors and does not represent the official position of NOAA or of the Government of the United States.

conversion as a commercial energy technology." [1] An exemption from full OTECA licensing requirements is available for an OTEC demonstration project which "...the Secretary of Energy has designated in writing as a demonstration project for the development of alternative energy sources for the United States which is conducted by, participated in, or approved by the Department of Energy." [2] However DOE, after consultation with NOAA would still require such demonstration projects to meet those OTECA requirements it "deems to be practicable without damaging the nature of or unduly delaying such projects." [2]

NOAA promulgated licensing regulations for a commercial OTEC facility in 1981, along with the *Final Environmental Impact Statement for Commercial Ocean Thermal Conversion (OTEC) Licensing* [3]. Despite this promising start, government financial support was reduced (including funding for a previously designed 40 megawatt electrical (MWe)[2] demonstration plant off Kahe Point, Hawaiʻi. The withdrawal of federal funding and declining conventional energy costs caused commercial interest in this technology to wane. As a consequence, in 1996, having received no license applications, NOAA disbanded its OTECA licensing program.

Over the past five years, the high costs of hydrocarbon fuels and global environmental concerns regarding carbon emissions have reawakened interest in OTEC and other renewable energy technologies that do not emit CO_2. In 2008 a number of companies approached NOAA with preliminary enquiries regarding licensing OTEC projects. As a result NOAA has established a team to develop new OTEC licensing regulations, and in consultation with DOE to assist in the development of demonstration projects. In order to develop these new licensing regulations from as informed a position as possible, NOAA has been meeting with stakeholders and holding workshops on OTEC.

Because the needed thermal gradients are relatively close to shore and because the necessary infrastructure support is available locally, Hawaiʻi is the most likely location for the first demonstration and/or commercial OTEC facility in United States waters. In 2009 and 2010 NOAA held three series of meetings with potential stakeholders from the Hawaiʻi state government, academia and the private sector. To gain a better understanding of the current status of OTEC technology and environmental concerns NOAA, in conjunction with DOE, sponsored two workshops. The first, in November 2009, consisted of industry and government experts who reported on the current status of OTEC technology. The second, in July 2010, consisted of scientists and engineers who NOAA consulted to help identify the most important environmental concerns, to make suggestions on the type of baseline and monitoring data needed to evaluate these concerns and to suggest possible measures to address these concerns. NOAA is currently in the process of developing a research plan for collecting needed baseline data. It is the understanding of the authors that NOAA will issue interim guidelines to give OTEC developers an idea of the type of information that will need to be included in a license application so they can proceed with planning and preliminary data collection without having to wait for the promulgation of new licensing regulations.

The November technical workshop concluded that while a pilot scale 10 MWe or smaller floating close-cycle OTEC facility is currently technically feasible. The feasibility of a 100 MWe or greater OTEC facility (the size that is generally thought to be the smallest that will be commercially viable) is less clear [4]. The proceedings report of the July 2010 environmental workshop is yet to be published [5]; however, it is clear that a number of knowledge gaps remain. These gaps involve the potential effects of an OTEC facility on the marine environment, particularly with regards to the movement of the large volumes of water required for the operation of such a facility. Before a commercial plant is licensed the technology and environmental effects must be demonstrated in a scaled and operational OTEC Pilot plant. Monitoring of such a facility is the only way to obtain the information needed to fully assess and manage the potential environmental impact from a commercial scale plant.

Early Field Studies And Impact Analysis In Hawai'i

At this time, we know of no firm commitments by private or government parties to develop any OTEC systems. However, intense R&D efforts are underway that are at present focused on moored, offshore, closed-cycle OTEC systems, based somewhere in Hawaiian waters, and the impacts of these were discussed at the recent technical workshop supported by NOAA [5] While many of the potential effects of an OTEC facility can be evaluated based on experience with other types of ocean platforms and activities, the large water volume requirements are truly unique to OTEC.

During the 1970s and 1980s the U.S. Department of Energy (DOE), NOAA, and other government agencies supported several studies relevant to OTEC environmental impact analysis. These included specific studies of potentially affected biological communities (e.g. [6]-[13]), and baseline data collections of chemical, physical, and geological information from several sites within U.S. jurisdiction, including Hawaiʻi (e.g. [14] – [27]). They also included theoretical studies suggesting data requirements for engineering system design (e.g. [28]), environmental impact analysis (e.g. [29]) and numerical simulations of potential discharge plumes (e.g. [30], [31], and [32]). The results of these studies were used in the drafting of general/programmatic environmental impact statements and studies (e.g. [3], [33], and [34]) and at least four site-specific impact analysis studies for the installation of OTEC facilities at or offshore from Kahe Point, O'ahu, Hawai'i ([35] – [38]).

[2] MWe is used to distinguish electrical power from thermal power, MWth.

Key Impact Topics

TABLE 1
KEY BIOLOGICAL IMPACT ISSUES FOR AN OFFSHORE OTEC PLANT IN HAWAI'I

Resource	Project Activity/Component That is the Source of Impact			
	Construction & Decommissioning	Platform Presence (e.g. shade, noise, lighting)	Water Intakes (entrainment & impingement)	Water Discharges (secondary entrainment & contamination)
Plankton & Micronekton	○○○	○○○	■■■	■■■
Nekton	○○○	■■■	■■■	■■■
Marine Mammals	○○○	■■■	■■■	■■■
Sea Turtles	○○○	■■■	■■■	○○○
Birds	○○○	■■■	○○○	○○○
Benthos	■■■	■■■	○○○	○○○

Source: Extracted from common elements presented in [3], & [33] – [38]
Key: ■■■: potentially significant impacts
○○○: probably insignificant

Environmental impacts are always specific to the project and site proposed. However all OTEC proposals must consider in detail the biological impact issues identified in Table 1. This list is not intended to be comprehensive, as any project-specific impact analysis must consider issues unique to the site and technology implementation; however, it does identify the key issues that merit early and rigorous consideration in virtually all circumstances. Readers should note that social, cultural, historic, and economic factors that can be critical to the success of individual projects are not included, since they are inherently very site-specific and project-specific.

As shown in the table, potentially significant impacts could result from each of these sources on some environmental resource. However, the construction, decommissioning and platform issues have relevant precedents in the oil and gas industry (e.g. [39]); while the impacts associated with the water intakes and discharges are unique. Very large flow rates of surface warm water will be required for the evaporator cycle of the system and similar flow rates of deep, cold water will be necessary for the condenser cycle of OTEC systems. The intakes and discharges of these water flows are the most important sources of potential environmental impact for OTEC.

Fig.1 presents the estimated warm water intake flow rates estimated for different power outputs ([3], [6]). As shown in this figure, the intake and discharge flow rates from the warm water circulation required for a 100 MWe plant are similar to the mean flow rate of the Potomac River, and the water flows from a 400 MWe plant would rival the Snake River [40]. The flow rates from a 200 MWe plant would be similar to the all time record flow recorded for the Waikele Stream in 2008 [41], the largest freshwater stream on O'ahu. Research and regulatory efforts devoted to OTEC development must focus on these large flows of seawater.

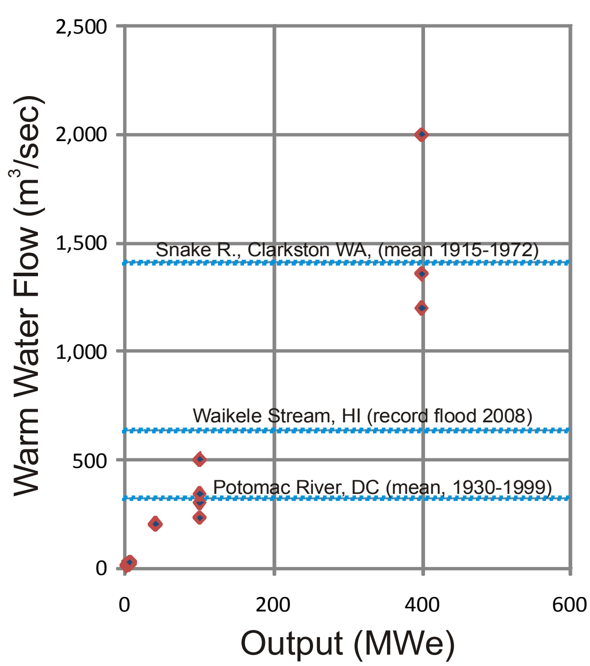

Fig. 1 OTEC Water Flow Rates vs. Energy Production

Progressive Environmental Impact Management

OTEC is a promising technology. It now appears that the technical and economic challenges that have held it back may soon be resolved. But OTEC will become part of the solution to the world's energy supply challenges only if environmental issues can be dealt with satisfactorily, and this will require a progressive approach to environmental impact management. OTEC developers and financial supporters are faced with uncertainty due to the lack of contemporary environmental and regulatory precedent and new and incomplete regulatory guidance. As discussed, there is an abundance of existing conditions information and predictive analyses of OTEC environmental impacts. However, information gaps remain that must be filled so that OTEC facility designers can make informed choices and those charged with ruling on permit applications can say with greater certainty that they fully understand the environmental impacts that would be caused by implementing a specific OTEC Pilot facility.

This paper outlines a methodology that, if applied diligently, will lead to environmental management programs becoming an integral part of OTEC Pilot Plant development and operation. In a long-term and large-scale technology development such as OTEC, operation of a pilot plant generates information that is used to evaluate and formulate improvements to plant facilities and operational methods. Following the procedures proposed here will produce the same benefits for environmental impact assessment and impact management. Information gained from initial monitoring can be used to modify equipment, facilities and operations in a way as to lessen any adverse environmental effects and avoid depleting environmental resources.

Ultimately, the goal is achieving a *sustainable* OTEC. Involving environmental disciplines as an equal partner in design is a business model that will add sustained value. Sustainable development involves meeting the needs of the present without compromising the ability of future generations to meet their own needs [42]. This is a progressive role for environmental management which assembles the appropriate and relevant environmental information, achieves environmental compliance, and manages environmental impact throughout technological development sequences. Value is added when the proposal submitted to environmental regulators has already considered environmental impact and incorporated appropriate minimization features. Value is also added when there is a clear pathway for the environmental lessons learned in one test to result in revised operation and/or monitoring during subsequent phases.

Progressive environmental management recognizes the importance of building environmental impact management into the technology development process instead of treating the need to comply with environmental regulatory standards as something separate and apart [43]. A core benefit of the approach is its superior ability (relative considering environmental standards solely as constraints rather than as both constraint and opportunity) to incorporate relevant environmental goals into the design process at a time when they can best be balanced against financial and technological realities. The early and thorough consideration of environmental factors can allow changes to be incorporated into design early in the design cycle when they are most easily accomplished. From experience, we have seen such planning avoid the duplication of effort, design rework and cost and schedule extensions that occur when environmental regulatory considerations remain peripheral until late in the design development process.

Fig. 2 illustrates the process. The program is initiated with the developer assembling baseline information from existing environmental information, project design criteria, existing conditions (field) data and synthesized environmental impact predictions. See the work flow section labeled 1.1 Planning and Permitting in Fig. 2. Much of the baseline information and conclusions would be proprietary and documented in a limited-distribution proposal for use by the Lead Agency. Baseline information would include:

- Description of the proposed OTEC Pilot project
- Environmental objectives and system requirements
- Ecological resources geographically identified for the proposed project site
- Environmental information gap analysis based on literature review
- Existing conditions measurements for the proposed project site
- Preliminary impact assessment addressing cause and effect relationships and impact uncertainties

Our strategy calls for integration of environmental disciplines in design as an equal partner in a value-added approach for decision-making. Systems engineering during Front End Engineering Design (FEED) is supported by the consideration of relevant and applicable environmental objectives that are expressed in the same quantitative fashion as other engineering factors. At sub-system levels, environmental analysis considers alternatives which would avoid or minimize adverse effects and enhance the quality of the environment. At a minimum these considerations ensure compliance with environmental regulations, but they may include more ambitious targets decided upon by project proponents who wish to exceed the minimum requirements. During this time the developer has the opportunity to weigh development objectives against adverse environmental effects and to identify solutions compatible with the performance objectives.

Design requirements that exceed applicable environmental significance criteria are identified and design modifications are considered that will avoid or reduce impacts to less-than-significant levels. If this is not possible, the developer can weigh environmental impact against development objectives, documenting for the record consideration of design alternatives. The documentation would demonstrate for any unavoidable significant impact that no practicable alternative exists in the light of engineering, logistic and financial considerations.[3] Upon completion of this exercise, the developer would have a complete understanding of the potential environmental effects of the proposal; that understanding will allow it to respond effectively to agency inquiry during the NEPA documentation, permit and licensing procedures.

We envision a federally funded OTEC Pilot project. In this scenario, the developer submits baseline information to the Lead Agency following the procedural model developed by the Department of Energy, Federal Energy Regulatory Commission (FERC) for its pilot licensing process. In the FERC model, the developer assembles environmental baseline data tailored to its

[3] This is the “no practicable alternative” standard from the Clean Water Act §404(b)(1).

proposed proprietary systems and submits it to FERC which then uses that information to complete Federal environmental compliance.

During permitting procedures, the developer can also prepare project-specific permit applications and protected environmental resource assessments for use by the Lead Agency. The Lead Agency is the federal agency responsible for environmental permitting and consultation such as Rivers and Harbors Act, Section 10 authorization from the US Army Corps of Engineers (USACE); Endangered Species Act, Section 7 consultation with the National Oceanic and Atmospheric Administration (NOAA) Fisheries service; and Clean Water Act, Section 403 National Pollution Discharge Elimination System (NPDES) point source discharge authorization from the US Environmental Protection Agency (EPA). Although OTECA assigns licensing lead to NOAA and demonstration oversight to DOE, it is not clear at this time whether a federal agency that funds a specific project (e.g., the Department of Defense) would take on the role Lead Agency as an applicant for an OTEC Pilot project or if NOAA would retain complete responsibility as both proponent and regulator. The progressive environmental impact management strategy functions in either case.

Once permits have been granted and the OTEC Pilot project is underway, the environmental monitoring framework incorporated in them is used by the developer to establish monitoring procedures at the operational level. See the work flow section labeled 1.2 Operations and Monitoring in Fig. 2. These operations and monitoring activities use an adaptive management approach very similar to typical process improvement activities. The environmental permits will tell the operations team what environmental conditions (emissions and ambient) to monitor and the frequency of monitoring. Project-specific environmental goals and absolute limits also will be available. The objective of an adaptive management approach is to measure actual environmental impacts and compare these findings to previously established targets, both regulatory and internal. The operations team will develop plans for responding to any exceedances that occur. In some cases the response will involve no more than regulatory reporting. In other cases, immediate changes in operational procedures may be required. In all cases the data will feed into the same engineering reviews to which other operational results contribute so that the lessons learned can be used to improve future performance.

The cycle of monitoring, assessment, corrective action, approval and execution would continue throughout the OTEC Pilot operation. At each cycle, the Lead Agency, regulatory agencies and other stakeholders would have opportunity to review the status of the program. The Lead Agency would likely have the authority to approve or deny implementation of any particular corrective action and to stop the OTEC Pilot project in extreme cases.

We have briefly presented an impact management procedure by which developers and agencies can collaborate within their respective authorities and achieve the development goal. The procedure we propose would provide for effective and efficient mitigation for to avoid and minimize potential adverse environmental impacts. Early planning would provide a route by which environmental uncertainties can be identified, monitored and resolved. Our process provides opportunity to adapt to unforeseen adverse significant environmental effect. Most importantly, the procedure provides a progressive approach to developing a relevant information base for OTEC commercialization.

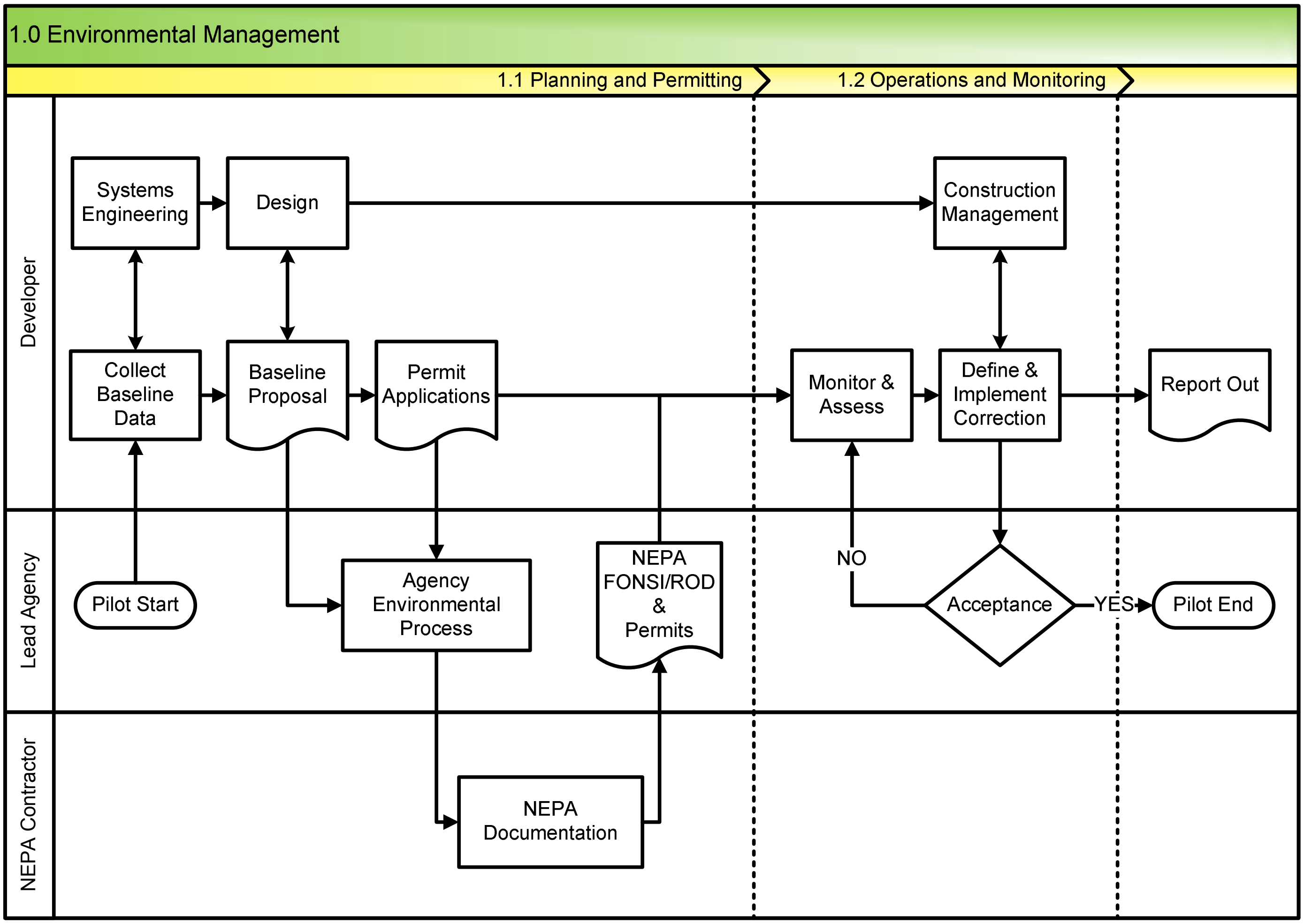

Fig. 2 Progressive environmental management process for an OTEC Pilot Project

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