



Integrating technical, economic and cultural impacts in a decision support tool for energy resource management in the Navajo Nation

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ABSTRACT

Energy resource management decisions will encounter situations where the interaction of culture and the environment play an integral role in management decisions. These decisions are highly complex, requiring tradeoffs among multiple objectives and supported by science that is often uncertain and incomplete. Decision aids can facilitate informed choices across a range of domains and levels of user skills. This paper focuses on the Navajo Nation, exploring a range of energy-development options, estimating their impacts on natural resources and the environment, and connecting these effects to impacts on Navajo cultural resources through an interactive decision support tool for Navajo citizens and leadership. We provide an alternative to methods based solely on economic valuation, willingness-to-pay, or related monetization methods that may be incompatible with some cultural values and may strip meaning or misrepresent the culture under consideration. The tool allows the user to make adjustments regarding fossil fuel and renewable resource development from nine pre-determined energy-development scenarios. Displayed in the outcomes to the user are environmental impacts on land, water, and emissions, the associated utility costs on the reservation, and impacts on cultural resources such as grazing lands, medicinal herbs, and sacred sites. The tool may serve as a point of reference for energy and environmental decision support aids in communities where important cultural resources, values, and traditions are potentially impacted by energy management decisions.

1. Introduction

Decision-making about appropriate pathways for energy resource management is complicated by difficult tradeoffs presented in the options available to decision makers. These decisions require high quality, trustworthy information about processes and flows in the systems affected and the human-environment interactions within them [64]. For example, difficult tradeoffs could occur between acceptable levels of environmental impact, energy costs, and human-environment interactions. Management plans that receive input from a broad range of stakeholders, concerns, and disciplines are those that are more likely to succeed by generating shared understanding and acceptance among affected parties [1]. Stakeholders are able to more fully participate in the decision-making process when they are well informed about the benefits, risks and uncertainties of options, so that they can make decisions that are consistent with their preferences and values [2,3,64]. Toward this goal, it is critical that the information and criteria used to assess the outcomes of available decision options are made available and accessible to a range of stakeholders [4].

Decision aids have been shown to help people make informed decisions across a range of domains such as health, consumer preferences, natural resource management, and climate change [4–7,65]. Previous studies of energy resource management decision aids for lay users have focused on respondents creating electricity portfolios to meet low-carbon goals and facilitating dialogue between stakeholders with different idealized energy futures [9,65]. Initial usability studies found a tool developed by Mayer et al. [65] which presented information about CO₂ emissions, electricity costs, health costs, and impacts to land and water helped participants create low-carbon electricity portfolios, encouraged participants to design diverse portfolios, and enabled them to make more informed decisions about technologies [65]. Trutnevyte [9] used stakeholder visions of an idealized energy system to develop energy scenarios with analytical outcomes and multi-criteria assessment of outcomes associated with those visions. As a result, most moderated their initial visions to more balanced and economically viable energy portfolios [9].

Decision aids tailored to the unique cultural context within which a

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decision is being made may engender trust and promote stakeholders' understanding of the tradeoffs involved in energy resource management [10,11]. Making the connection to culture is of particular interest to many indigenous communities where cultural and spiritual values are tied to the environment and may also differ from those of the rest of society [12–14]. The challenge here is how to operationalize this so that useful information is conveyed in an inherently technical decision aid to stakeholders, allowing them to make informed decisions in light of their own culture and values.

The definition of culture and how it relates to environmental management is hardly settled. There remains significant debate about proper characterizations of these relationships as important cultural factors can be easily missed [15]. The complex interaction between culture and the environment exists within overlapping material and non-material domains [15–18]. The cultural elements within the material sphere of the environment can include those of provisioning and regulating, such as subsistence activities or medicinal and religious practices [16,19]. These practices often exist in a complementary relationship with non-material elements of culture such as spiritual enrichment, aesthetic experience, recreation, education and learning, and maintenance of social relations [20]. However, these non-material experiences of culture may only exist in the presence of specific (material) cultural sites and the continuation of these practices depend on their preservation [15,21].

A number of economic approaches exist that attempt to quantify environmental values, such as willingness-to-pay, willingness-to-accept, and contingent valuation, however when applied to cultural values they risk stripping meaning or misrepresenting the culture under consideration [15,22]. For example, quantifying cultural and environmental impacts of energy resource development by monetizing these outcomes may be incompatible with certain cultural values [13,15,23]. Other approaches, such as Cultural Ecosystem Services (CES), can provide a framework in which the non-material attributes of the environment can be captured, however defining and measuring these factors remains a significant challenge [15,17,18]. Some indigenous groups may not view energy resources as strictly economic commodities, but instead as culturally or spiritually significant resources that must be left undisturbed and undiminished for future generations [24–27]. Focusing solely upon economic outcomes and impacts on the physical environment, in these contexts, may not address all of a community's concerns (e.g., preservation of environmental resources that support cultural resources and subsistence economies) and may be secondary to these cultural and spiritual outcomes [13,25,26]. Not surprisingly, in this context many indigenous communities are uncomfortable with environmental decision-making processes [15]. A number of disciplinary, legal and institutional barriers may prevent or slow the inclusion of social and cultural impacts in the evaluation and selection of energy options, even in situations where these factors are clearly the concerns that matter [28,29]. Despite these challenges, new methods to incorporate and communicate social and cultural values in decision-making are critically needed to maintain and revive cultural practices and indigenous systems of knowledge, and to ensure that values are systematically considered within these processes [30].

In this paper we detail the development of an energy-development decision aid for the Navajo Nation for the purpose of informing decision-making that is reflective of available technical options, economic constraints, and cultural values. The design of the aid was informed by previous research on the Navajo Nation conducted by the authors that used open-ended interviews to understand Navajo values and beliefs about energy [13]. From what we learned from the interviews, we developed a decision aid that provides environmental, economic, and cultural impacts deemed important and relevant by the Navajo public. The aid provides information that can lead to a valuation method that goes beyond current cost-benefit techniques that rely on monetization and related willingness-to-pay estimates, encouraging a more holistic

and integrated approach to values, valuation and reflective decision support. Such an approach may have broad application to communities or nations where important cultural resources, values, and traditions are potentially impacted by energy and related resource management decisions. Here we demonstrate how this alternative approach can be used to connect impacts on Navajo cultural resources to environmental impacts that affect them, by creating an ordinal index to reflect the relative magnitude of cultural impact. We designed the aid to be realistic and representative of potential paths for energy resource management for the Navajo Nation. These paths have been developed based on proposed and current projects for electricity and natural gas generation and distribution explored by the Navajo Nation government, Navajo Tribal Utility Authority (NTUA), and the US Department of Energy's Office of Indian Energy.

In the following section, we describe our methods including the development of the energy-development decision aid and its underlying assumptions. Then, we present the results of nine energy-development scenarios involving increasing amounts and mixes of fossil fuel and renewable energy-development. Finally, we discuss the implications and value of developing a decision aid that includes cultural impacts. First, however, we provide a brief overview of the importance of including non-monetized cultural impacts in a development decision aid.

1.1. Historical legacy of energy, environmental and cultural impacts on the Navajo Nation

“If we don't have a clean, stable environment, pretty much my culture would be non-existent”

A Navajo citizen describing the effect of environmental impacts from energy development (p. 7 [13])

Navajo stakeholders have expressed significant concern about intergenerational environmental impacts from energy-development and the effect that they could have on cultural resources, transmission of cultural values, and clean water for future generations [13,23]. The value of these cultural ecosystem services often extends beyond their direct use: providing a framework for mental wellbeing, identity education, spiritual connection, and social cohesion [13]. Further references and discussion on energy-related Navajo history and culture is found in [Supplementary Information S1](#).

2. Methods

2.1. Development and testing of the energy-development decision aid

Our aid allows users to adjust how much energy development of (1) RE: renewable energy resources (low, medium, and high) and (2) FF: fossil fuel resources (low, medium, and high) on the Navajo Nation, with a total of nine possible scenarios considered ([Fig. 1](#) and [Table 1](#)). Associated with each of these scenarios are estimates of the environmental impacts (e.g., land transformation, air pollution, water use, water quality, etc.), economic outcomes (e.g., cost of electricity, exported electricity, etc.) and cultural impacts (e.g., landscapes & sacred sites, plants, animals, traditional food & medicine, grazing lands) ([Table 2](#)).

Through an iterative process, we performed in-person individual user-testing of the decision aid with 15 volunteers between May and June of 2015. User-testing was performed following the Think Aloud Protocol [31] where people were asked to express what they were thinking, doing, and feeling as they walked through the aid. Participants represented the following backgrounds: 6 participants from the Navajo Nation, 5 Carnegie Mellon University graduate students, 4 Native American (non-Navajo) graduate students focusing on American Indian topics such as energy or culture, and one program manager at Sandia National Laboratories who focuses on American Indian energy

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