Workshop on Human Well-Being
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COLLEGE PARK MARRIOTT HOTEL & CONFERENCE CENTER | 3501 University Blvd E | Hyattsville, MD

Themes and Recommendations from Pacific Northwest National Laboratory's Human Well-Being Workshop

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Executive Summary

1. Workshop Motivation

Human well-being has been defined as an inherently multidimensional concept that broadly refers to what constitutes the "good life" (Stiglitz et al., 2009). Decision-makers have an increasing need for analysis of human well-being outcomes and how they are impacted by policy measures and changes to the climate, land, energy, water, and socioeconomic systems (Independent Group of Scientists appointed by the Secretary-General, 2023; White House, 2022). Three major science gaps in the ability to model and analyze these impacts on human well-being motivated this workshop. (1) There is a need to formalize the definition of human well-being that can be used across academic disciplines and policy arenas. (2) Scientists lack a framework for analyzing measures of well-being that can be used both to model potential future outcomes and to measure progress toward policy goals. (3) The multi-dimensional nature of this problem, along with the many uncertainties in measuring and modeling outcomes, requires improved tools for communications of the multiple and interacting metrics of human well-being.

2. Workshop Structure

This in-person workshop was held over two days (September 27 – 28, 2023) in College Park, MD, and was held under the Chatham House Rule to facilitate open communication across researchers from many academic disciplines and policy makers across many fields, from both public and private entities. Day one focused on the energy security aspect of human well-being to take a deeper dive into the complexities of one domain. Day two focused on research challenges and other dimensions of well-being and their interconnections, including food security, health, poverty, conflict, and national security.

3. Research Themes

The Science of Human Well-Being

Understanding well-being requires assembling both quantitative and qualitative data at multiple scales in time, space, and other dimensions to identify and articulate relationships using tools and techniques, drawing from multiple disciplines and applying them to both understand the past and explore the consequences of alternative decisions for the future. Participants identified specific challenges around defining human well-being (3.1.1), modeling (3.1.2), accessibility and reliability of data (3.1.3), incorporating qualitative information (3.1.4), defining measurable and meaningful metrics (3.1.5), and connecting these through decision-relevant scenarios exercises (3.1.6).

Applications of Human Well-Being Research

The science and application of human well-being research utilizes a "Research to Operations to Research" design. Applying scientific methods and modeling to multi-dimensional, multi-disciplinary policy questions will enable better decisions. Applying lessons from the use of well-being science to inform decisions can improve the direction of research and its quality. Participants identified challenges with policy design and implementation (3.2.1) and with connecting decision-makers and researchers (3.2.2).

Communication of Human Well-Being Outcomes

The interdisciplinary nature of well-being science can create barriers within and between the science and stakeholder communities. Participants discussed challenges with engaging with and identifying the "correct" stakeholders for different questions (3.3.1) and communication across groups (3.3.2).

4. Recommendations

Establish a new field of human well-being science and research: Opportunities include (1) developing a community of practice on human well-being for researchers and policy makers from different academic and policy domains; (2) holding additional workshops to connect researchers and end users; and (3) writing a commentary piece for an academic journal describing the need for this type of research.

Develop and communicate human well-being applications for decision-making: There is currently a mismatch between the types of questions being asked by decision-makers and the ability to model those outcomes. Participants identified the need for significant model developments and research tailored to these questions.

Develop long-term, sustainable funding to support this multi-disciplinary, multi-scale research: The most important recommendation was to increase funding for research and model development. Without this funding, researchers will not be able to provide the analyses and results that decision-makers need to account for in order to include aspects of equity and justice in their decisions.

Report

1. Workshop Motivation

Human well-being is an inherently multidimensional concept that broadly refers to what constitutes the "good life" (Stiglitz et al., 2009). Increasingly, decision-makers are concerned with the implications of policy, and the averted consequences of not taking policy actions, on measures of human well-being (Office of Management and Budget, 2021; White House, 2022). Human well-being is influenced not only by policy measures, but any changes to the climate, land, energy, water, and socioeconomic systems. These can include both positive and negative changes from societal and economic development and environmental change. Human responses to these changes will also influence the future evolution of both human and Earth systems.

These issues are often framed around qualitative concepts, such as equity, environmental justice, and energy justice (Independent Group of Scientists appointed by the Secretary-General, 2023; U.S. Department of Energy, 2022; White House, 2022). However, these concepts cannot be directly evaluated by researchers. Fortunately, scientific research and analysis can provide measures of outcomes related to these concepts—though the science cannot determine whether a policy is just or equitable. We therefore use the term human well-being to differentiate decision-makers' questions about equity and justice from the scientific research that can measure related outcomes, such as food, water, energy, and national security; health; ecosystem services; and economic welfare.

This workshop was motivated by three major science gaps in this field. First, human well-being as a concept can be poorly defined. In some cases, the same term may have different meanings across disciplines; in others, there may be multiple terms used to describe the same concept across research domains and policy fields. This lack of consistent definition can make it difficult to identify the key questions that decision-makers want to answer and find the appropriate metrics for measuring these concepts.

Second, we lack a framework for analyzing measures of well-being that can be used to both model potential future outcomes and to measure progress toward policy goals. The questions being asked across many sectoral, spatial, temporal, and demographic scales, with numerous and complex interactions and feedback between these. Study of a single dimension in isolation can obfuscate the tradeoffs and synergies that may exist across these outcomes.

Third, the multi-dimensional nature of this problem, along with the many uncertainties in measuring and modeling outcomes, requires improved tools for communicating these interacting outcomes. Effective policymaking requires understanding which groups will be impacted, in what dimensions, and over what time horizons. But researchers lack clear and concise methods for communicating results across multiple scenarios and outcomes for many regions, time frames, and groups in ways that are actionable and useable for decision-making.

2. Workshop Structure

The two-day workshop was hosted by Pacific Northwest National Laboratory and brought together 45 people, including researchers from many academic disciplines and policy makers across many fields, from both public and private entities. There was a broad focus on modeling approaches to well-being, but not to the exclusion of conceptual issues and qualitative approaches. It was held under the Chatham House Rule, wherein "participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed" (https://www.chathamhouse.org/about-us/chatham-house-rule), though participants are free to identify themselves. For this reason, no list of participants or the institutions they represent will be provided.

The workshop was designed to enable discussion across all these groups. Each session began with a set of 10-minute presentations and/or comments, followed by 30 minutes of open discussion. (See Appendix).

The first day of the workshop focused on one specific domain of human well-being – energy security – to enable a deeper dive into the complexities of one domain.

The second day brought this together with other dimensions of human well-being and research challenges. Sessions included presentations on food security, health, poverty and jobs, and conflict and national security. While the majority of the discussions were on these topical areas and energy security, participants raised several other aspects of well-being, including water security, environmental security (e.g., land and air), and access to/affordability of transportation and quality education. Another primary area of discussion was self-assessed human well-being. Participants had many questions about how to evaluate how people feel about their own well-being. This issue comes into several of the research themes and is discussed further below.

3. Research Themes

The workshop agenda included sessions on many topics, and common themes arose in discussions throughout both days. We have identified multiple themes coming out of the presentations and discussions, with inevitable overlap across them. They can be grouped into three broad categories: science of human well-being, applications of human well-being research, and communication of human well-being outcomes. An important overarching question that ran through the discussions and many of these themes is the need to clearly articulate what we are trying to do with this research. Different goals discussed included bringing research to communities to increase engagement in decision-making, informing decision-makers, and evaluating policies.

3.1. Science of Human Well-Being

Understanding well-being requires assembling both quantitative and qualitative data at multiple scales in time, space, and other dimensions, identifying and articulating relationships using tools and techniques drawing from multiple disciplines and applying them to both understand the past and explore the consequences of alternative decisions for the future.

3.1.1. Defining Human Well-Being

Participants recognized the importance of defining concepts to be able to talk clearly about them across groups. They noted that, without standard definitions, it is difficult to clearly define problems, evaluate solutions, and measure outcomes.

Well-being itself is defined differently across communities, as are its components, including energy security. In addition, terms that were identified as needing definitions include disadvantaged community, environmental justice, energy poverty, and energy security.

Participants noted efforts made by some of their institutions to develop definitions of well-being or its components that could be used consistently across groups. But they also noted that it was not always clear what their institutional roles should be in this process, particularly when individual institutions may be primarily concerned with only one or a few aspects of human well-being.

Some participants raised the fact that what researchers and decision-makers see as important components of human well-being may not be the same as what is seen as important by community stakeholders. Discussion focused on how to engage with communities to better understand their needs, without creating a situation in which all actors have their own definitions of human well-being, since communities are not homogenous units. But some participants also stressed that measures of human well-being should account for individual preferences, or "what people like". The question was raised as to whether there are objective measures that could constitute a decent standard of human well-being.

This tension between the recognized need to have standardized definitions and the need for communities to decide what aspects of well-being are most important for them, potentially resulting in a lack of consistent definitions, came up in multiple discussions. There was general agreement that communication with researchers, decision-makers, and community stakeholders was important in all directions to inform groups on what they see as important and educate on issues they may not be aware of.

Given the focus of the workshop on modeling approaches, many of the presentations and comments addressed some aspect of modeling challenges.

The biggest challenges that were identified included what can and should be modeled; limited modeling capabilities, particularly at fine scales; limited availability and reliability of data necessary for model development and calibration; coordination across different stakeholders' priorities, particularly when research support is siloed; overcoming researcher biases and the need for more integration across disciplines; and developing and communicating results that are actionable in a time frame relevant for decision-making.

Participants identified gaps in research abilities, noting that there is a need for more interdisciplinary conversations, both for researchers and decision-makers/sponsors. There is also a gap between decision needs and modeling capabilities. A particular need was seen to incorporate more social and behavioral science with modeling.

Understanding What Can Be Appropriately Modeled

An important consideration was identifying what can and should be modeled and the appropriate use of models. Participants noted it is important to find results that are robust across types of models and scenarios and that a common modeling framework could help to provide consistent assumptions across models. There was broad agreement that, while models can inform on human well-being considerations, they should not be used alone to make decisions.

Participants agreed that research should start with the problem and then see what tools can best address it. Models and questions need to be appropriately matched – not all models can answer all questions and using the wrong model can subtract value. This requires understanding what elements and dynamics are included in different models and where the major uncertainties lie.

There are drivers that are not currently included in models but have important implications for results, particularly behavioral drivers, such as consumer barriers to adoption (accessing funding, lack of contractors). While not all of these factors can or need to be modeled, it is important to communicate to decision-makers what is or is not included to understand how well modeling aligns with reality.

Educating consumers on what information models and modeling results can provide is important. For instance, projecting the onset of conflict is difficult, but models do a better job with the incidence of conflict. Participants felt that the lack of ability for models to forecast outcomes was seen as a flaw by decision-makers. Discussion focused on the difference between absolute and conditional forecasting. Models cannot project unconditionally, but a good model can say, "under these assumptions, we expect to see these outcomes". Models are also useful for finding the causal relationships and insights that can be drawn from model results.

More probabilistic analysis was also seen as a way to address concerns about forecasting and robustness of model results. In addition, it is important to identify what types of transient changes or discontinuities may change outcomes.

Participants also discussed the difference between analysis of current conditions – for instance, what groups of people are currently disproportionately impacted by policies and environmental stressors – and projecting changes to these conditions.

Model Design

Integral to understanding what models can inform is the design of the models themselves. There was a strong need seen for more holistic, integrated modeling that can explore feedback and interdependencies. But participants also recognized that multiple types of models will ultimately be needed for different types of questions and there is a risk to relying on a single model, as any model will have biases.

To answer decision-makers' questions around equitable distribution of benefits, several improvements to modeling capabilities were identified. Participants saw a need for improved understanding and modeling of consumer choice and demand responses, particularly how those responses vary across different groups within society. While participants noted the importance of improved modeling of the feedbacks between human well-being outcomes (e.g., conflict, education, food security) and drivers of those outcomes (e.g., economic growth, demographic changes, migration), they also recognized the difficulty in developing these capabilities and the long-term nature of the development.

Participants also raised issues of representing fundamental shifts in the economy that may be driven by movement toward renewable energy sources and a more circular economy. Questions were raised about the appropriateness of using models developed under a more linear economy based on fossil fuels and what model developments would be needed to represent these changes.

Discussions identified questions related to model development, including how we can move models from current capabilities toward what is implementable? How can decision-makers in developing countries use these studies? What level of data are needed? And how can this research be funded?

Validation

Participants recognized that, in addition to enhancing model capabilities, more work needs to be done on validating models. Decision-makers need to know how accurate models are. Part of the validation needs to include understanding what level of detail and complexity are sufficient for providing answers to different questions. Managing the complexity of models was also seen as a way to provide quicker and lower cost analyses.

Modelers noted that validation should not necessarily require models to reproduce historical trends, but should test whether the models can reproduce reactions to specific shocks. They agreed that model outputs should be regularly tested against real-world outcomes, though they also noted that research funding is often inadequate for validation.

This is particularly important because non-stationarity in climate and other systems has created a moving target for validation. Drivers are highly time variant and may be contingent on socio-political factors that cannot be predicted. It was also noted that some models can hindcast well but do very poorly in projecting the onset of new conflicts.

Scale

Multiple presentations and discussion topics focused on the issue of scale, particularly spatial and demographic scales. The topic of environmental justice was seen as a very local issue, particularly in U.S. contexts. However, many aspects of human well-being can be appropriately viewed from more aggregate scales. The ability to translate aggregate outcomes to impacts on people or groups of individuals was seen as important.

Frequently, decision-makers expressed the need for finer resolution data and outcomes. In some cases, this is not possible with current modeling capabilities. For instance, requests for "climate" data, including where droughts or floods might occur 1-5 years in the future are really requests for weather data. More communication between decision-makers and researchers is needed to help reframe questions and expectations to be consistent with existing knowledge and model capabilities, such as thinking about the probability of droughts in specific areas or understanding the impacts if a drought were to occur.

In addition, researchers emphasized that higher resolution does not necessarily mean better or more appropriate results for answering specific questions. There is a need to match scale with the question being asked, which requires on-going dialog between researchers and decision-makers.

Informing on the appropriate scale of modeling will require understanding how outcomes differ when models are run with different resolutions – for instance, modeling multiple socioeconomic groups or climate impacts at sub-annual, annual, or decadal scales. This is important because groups will be

impacted in many different ways depending on their characteristics, timeframe, and the specific aspects of well-being. However, this process needs to be studied within individual models, so as not to conflate issues of scale with the effects of model design. Regarding temporal scale, participants discussed that models are generally good at looking at gradual changes but need to improve on extreme and short-term events. It was recognized, though, that uncertainty increases as modeling gets down to finer resolutions, whether spatial, demographic, or temporal.

Participants saw value in new approaches to analyzing outcomes across multiple scales. The "telescoping" approach presented in Session 1 on the first day (https://godeeep.pnnl.gov/resources/#webinars), wherein models that cross different metrics and scales are run within a consistent framework, was seen as a good approach to understanding local changes within the context of regional, national, and global dynamics. This approach allows both local and global drivers to impact local and more aggregate outcomes.

3.1.3. Data

Issues around data availability and reliability were raised multiple times. Participants recognized that data limitations, particularly standardized, granular data, add another source of uncertainty to model outputs and, in some cases, lack of data can prevent modeling all together. Data are particularly scarce in lower-income regions that may potentially be heavily impacted by global change. The importance of improved data collection, standardization, and availability was stressed, but also the need to prioritize data that will be most impactful for decision-making. In some cases, data are collected, but there are accessibility challenges, such as national security concerns, or researchers and other decision-makers may not be aware that a data source exists.

There was also discussion on how to work around these challenges in the near-term. Ideas included identifying new sources of data and making better use of existing data sources. Potential new sources of data identified for research included satellite imagery, private data sources (e.g., household-level data from utilities), and the use of artificial intelligence to create new data. Improved methods for using existing data included efforts to harmonize multiple existing data sources, microsimulation, synthetic data sets, and machine learning to utilize data from one region or group to inform models in regions with scarce data. In addition, the need for improving sharing of data across institutions was identified.

3.1.4. Incorporating Qualitative Information

Participants recognized the importance of qualitative information, which cannot be readily modeled or measured. Discussions around qualitative information had two main sub-themes: human well-being definitions and moving from qualitative to quantitative information.

Participants felt it was necessary to acknowledge what cannot be easily measured and incorporated into models, such as agency, emotions, and procedural justice, but could potentially be described. For instance, losing access to specific food sources may have strong cultural implications for some groups. While the negative cultural outcome cannot be directly measured or modeled, research can inform on potential future changes to the availability of that food source.

Questions around the ability to connect quantitative and qualitative information come up repeatedly. Participants questioned whether there were ways to bring qualitative aspects into models, translate qualitative to quantitative research, or develop metrics that account for feelings related to self-assessed well-being.

3.1.5. Metrics

Participants discussed what types of metrics were important, how to define and evaluate metrics, and challenges with modeling these metrics with existing model capabilities.

Multiple types of metrics were discussed, including ones that can be connected with other goals like the sustainable development goals (Independent Group of Scientists appointed by the Secretary-General, 2023). Some participants raised the question of whether an aggregate metric of human well-being would

be informative. In general, though, participants felt that multiple metrics would better communicate the tradeoffs and synergies that might exist across different aspects of human well-being. Participants raised many ideas for new metrics, including the need to move beyond measures of availability for food, water, and energy security to outcomes that include measures of affordability, accessibility, and acceptability, and those that measure actual human outcomes, such as malnourishment. Participants also saw the need to develop metrics for more aspects of human well-being, particularly around conflict, water, health, livelihoods, infrastructure, and mobility, and to further develop models to incorporate hidden changes, such as labor productivity increases that will come with electrification.

Several questions were raised about developing and defining metrics, particularly on whether current metrics are the "correct" ones and whether metrics should be community-defined or defined by modelers, decision-makers, or other stakeholders, such as utilities. Many participants noted that research questions will help identify appropriate metrics, requiring co-development of questions between modelers and decision-makers.

There was also discussion about modeling and measurement of metrics. On the former, participants discussed what metrics can be modeled to ensure that metrics are developed with appropriate models. They also recognized that most current metrics have been "opportunistic," making use of the capabilities of current models, which tend to focus on outcomes such as production and prices. Participants stressed the need for more funding for research to develop the capabilities both to identify which aspects of consumer heterogeneity are important to model and to move beyond these metrics to ones that are more directly relatable to human well-being, such as malnutrition, mortality, and education. Issues around measurement included evaluating metrics with real-world data and comparing outcomes across scales and types of models.

3.1.6. Scenarios

Participants discussed whether current standard scenario designs, such as the Shared Socioeconomic Pathways, were appropriate for understanding human well-being or meaningful to stakeholders (O'Neill et al., 2014). Many participants saw value in designing scenarios around outcome metrics to identify goals and find different pathways to achieving those goals (van Ruijven et al., 2023). Participants also noted that developing large ensembles of scenarios will help identify what conditions and drivers result in specific outcomes for different measures of human well-being.

The importance of capturing both positive and negative impacts of climate change and decarbonization policies in scenarios was also discussed. Participants noted that the "baseline" scenario should include climate change and other impacts because the costs of not taking actions are not included in current baseline scenarios.

Participants also discussed the need to be able to model more fine resolution policies. More research and development are also needed to understand what drivers will influence outcomes like conflict and how to include those in models.

3.2. Applications of Human Well-Being Research

The goal of developing a scientific understanding of well-being is to have tools that can inform decisions. Applying the tools of well-being science has two distinct benefits. First, the multi-dimensional, multi-disciplinary tools and data enable better decisions. In addition, the use of well-being science to inform decisions can improve the direction of research and its quality.

3.2.1. Policy Design and Implementation

Participants discussed many requirements to develop policies that incorporate considerations of human well-being. They noted that policy makers need to understand what groups of people will be impacted and in what ways, what barriers to technological adoption might exist and how these could differ across groups and relate to well-being outcomes, and how multiple outcomes of well-being are connected. This requires the identification of metrics of well-being that are correlated with the policy goals that are also modellable and measurable.

Participants identified challenges with both the design and implementation of decisions and policies. Participants noted that policy makers may desire very specific answers from researchers on the "best" policy actions and struggle with more nuanced outcomes. Some noted that without specific recommendations from researchers, there might be a tendency to take no action. Institutional organization was identified as a barrier to both effective policy design and implementation. Participants noted that organizations can be too siloed, with decision-makers having relatively narrow focus areas. Within the context of policy design, they discuss that there is frequently not enough organizational emphasis on looking at the "big picture" and cross-cutting issues, though some organizations have been making efforts to overcome this challenge.

Policy implementation, too, is often hindered by organizational structure, with federal funds for policies distributed to states or local groups which may not always implement policies in similar ways and therefore make policy evaluation more difficult. The question of why uptake of existing policies is low came up in several presentations and comments. Participants noted that it can be difficult to evaluate this question because of a lack of centralized data on policy uptake.

3.2.2. *Connecting Research to Decision-Making*

There was general agreement that the fundamental goals for modeling and measuring human well-being are to inform decision-making and evaluate progress and effectiveness of interventions, which will then inform future decisions. These decisions occur across many inter-related and overlapping domains, from energy and environmental justice and security, to health, national security, and economic welfare. Participants discussed how current outcome metrics, such as drought incidence, yields, and production and consumption changes, generally stop short of fully connecting issues such as conflict, environmental, economic, and trade shocks to actual measures of human well-being, including health outcomes, income, nutrition, conflict, and educational attainment.

Participants discussed that providing appropriate outcome metrics requires understanding the needs of decision-makers. They also noted that, in some cases, decision-makers are aware of the importance of integrating issues of justice and equity into policy making, but need better information from researchers and modelers to understand the scope of the problem and what can be modeled and is relevant to the questions being asked. Accomplishing this requires on-going dialog between researchers and decision-makers.

Several comments noted the decision-making need for models to provide insight into optimal decisions. But participants also discussed that "optimal" needs to be defined by policy makers, not researchers, as any policy will require tradeoffs across dimensions and weighing these tradeoffs is the domain of policy, not academic research.

Participants also expressed the desire for flexible modeling frameworks that can be adapted to multiple definitions of human well-being, but also to enable the exploration of potential tradeoffs across different metrics and scales.

3.3. Communication of Human Well-Being Outcomes

Well-being science needs to communicate across the full spectrum of stakeholders, decision-makers, and researchers. Successfully doing so requires engagement with stakeholders at many levels and defining terminology for improving communication across and within the science and stakeholder communities.

3.3.1. *Stakeholder Engagement*

Community stakeholder engagement was seen as a vital means of soliciting feedback on what attributes are important to groups of people. Researchers can use these attributes to develop quantitative measures of self-defined human well-being that resonate with communities. Some participants mentioned the need for more research with stakeholder engagement components, which can include workshops, fieldwork, and interviews.

Discussions about stakeholders included the need to identify whether the stakeholders are government/policy makers, industry, or communities. Community groups have different needs, concerns, and definitions of human well-being, as do different government entities. There are multiple ways of identifying stakeholder groups, including income groups, physical location, and religious or other identity. Participants noted that the definition of stakeholder can influence what information is included in data collection and modeling and it is important to ensure that multiple voices are included in discussions. Some participants commented that government agencies are actively looking for ways to engage and integrate community preferences into their analyses because understanding the needs of community stakeholders is important for designing effective policy. Participants raised questions about whether this engagement should be done by researchers, decision-makers, or both groups.

Some participants raised the option of bringing quantitative tools to communities, which would enable community stakeholders to interact with data and be better informed on issues and consequences to their communities. Other participants questioned the value of this, noting that an appropriate interpretation of the data and modeling outcomes requires significant explanation and dialog. Participants also noted that in some cases, consumers may not necessarily want to be presented with specific options, but rather want decision-makers to understand and consider what the community finds acceptable.

There was again a tension between the need for clear definitions to enable communication and decision-making and the desire for groups to be able to self-define what constitutes well-being for their group.

3.3.2. Communication

The discussion on communication involved two main sub-themes: defining terms and communication between modelers and stakeholders.

There was a heavy emphasis on the importance of defining terms. As discussed above, clear definitions will help improve communication across groups, including researchers in different domains, decision-makers, and stakeholders, and will help researchers and decision-makers to identify research questions and understand community concerns. The importance of asking questions about other groups' terminology to avoid confusion was emphasized. Clarifying definitions will also improve researchers' abilities to inform stakeholders about results, including tradeoffs that may be expected, and discuss connections between qualitative and quantitative metrics.

Issues related to communication between modelers and stakeholders involved articulating model input assumptions, identifying exogenous vs. endogenous factors, and when to apply various data and models. There was also discussion around communicating model results to decision-makers and community stakeholders, particularly on how best to communicate tradeoffs, how to communicate quantitative outcomes in the context of qualitative concerns, and limitations of model results. At the same time, there was a tension between the need and desire to have all modeling details fully explained so decision-makers can fully understand the nuances of the results and assumptions, and the desire for higher-level takeaways that can be readily implemented.

4. Recommendations

The final session of the workshop was a discussion of recommendations and next steps. The recommendations fell into three main categories, establishing a new field of human well-being science and research, developing and communicating human well-being applications for decision-making, and developing long-term, sustainable funding to support this multi-disciplinary, multi-scale research.

Establish a new field of human well-being science and research: Participants recognized that the research and modeling of human well-being is in its infancy and significant model development is needed to be able to fully address decision-makers' questions and evaluate existing policies. They also noted that because models will produce different results, research is needed to identify outcomes that are robust across models and scenarios.

Opportunities for improving communication include taking a research-to-operations-to-research (R2O2R) approach to connect scientific modeling with the needs of stakeholders in applied fields. Suggestions included:

(1) Developing a Community of Practice on human well-being for researchers and policy makers from different academic and policy domains,

(2) Holding additional workshops to connect researchers and end users, specifically:

- Connecting researchers and end users to develop a common lexicon and better understand the needs and questions of end users
- Facilitating/enhancing coordination across decision-making institutions
- Enhancing connections between quantitative and qualitative researchers
- Community stakeholder engagement
- Deeper dives into specific aspects of well-being.

(3) Bringing together the attendees from this workshop to write a commentary describing the need for this type of research.

Develop and communicate human well-being applications for decision-making: A primary need identified is for significant model developments, as there is currently a mismatch between the types of questions being asked by decision-makers and the ability to model those outcomes. Participants also saw a need to conduct validation and model intercomparison exercises to understand what outcomes are well measured and modeled and are robust across different models.

Develop long-term, sustainable funding to support this multi-disciplinary, multi-scale research: The most important recommendation was to increase funding for research and model development. Without this funding, researchers will not be able to provide the analyses and results that decision-makers need to account for aspects of equity and justice in their decisions. All communication and modeling recommendations require financial support. Many decision-making organizations have limited funds to support scientific research, though, and participants suggested that end users should look for opportunities to coordinate and leverage funding across organizations and to encourage organizations that support basic scientific research to increase and target funding toward this field of study.

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Appendix – Workshop Agenda
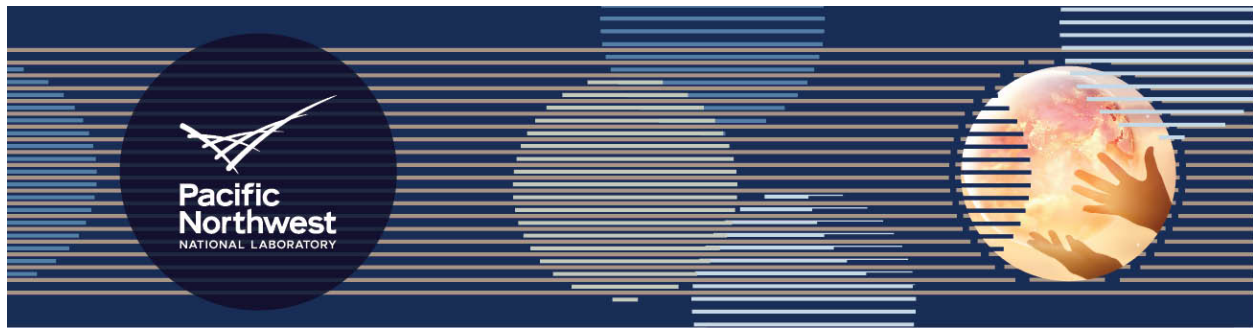
Workshop on Human Well-Being
September 27–28, 2023 | College Park Maryland

COLLEGE PARK MARRIOTT HOTEL & CONFERENCE CENTER | 3501 University Blvd E | Hyattsville, MD

Time	Energy Security and Well-being
9:00 – 10:00 am	**Meeting Opening**
0:05	Welcome
0:02	Logistics
0:15	Self-introductions
0:08	Workshop goals and preview
0:10	Defining Human Well-being
0:20	Discussion
10:00 – 11:00 am	**Modeling Aspects of Human Well-being Within the Context of Decarbonization**
0:15	Grid Operations Decarbonization, Energy and Environmental Equity Platform
0:22	Modeling decarbonization impacts across income groups and scales
0:08	Visualizing Outcomes: Energy Justice-Visualization and Impact Analysis Tool
0:15	Discussion
11:00 – 11:15 am	**Break**
11:15 – 11:30 am	**General Discussion**
11:30 – 12:30 pm	**Status of Energy Security Research and Analysis**
	Household-level energy poverty security
0:10	Energy security and well-being in the US: Insights
0:10	from a novel synthetic dataset of US households
	Robust, Sustainable, and Equitable Power System
	Planning: towards incorporating qualitative
0:10	research
	Discussion
0:30	
12:30 – 2:00 pm	**Working Lunch and Extended Discussion on Energy Security Research and Analysis**

Time	Energy Security and Well-being
2:00 – 3:00 pm	**What Can We Measure and Model? Gaps in Human Well-being Research**
0:10	Modeling dimension of human well-being
0:10	Current gaps in human well-being research
0:10	Comment
0:30	Discussion
3:00 – 3:15 pm	**Break**
3:15 – 3:30 pm	**General Discussion**
3:30 – 4:55 pm	**Stakeholder Needs for Energy Security Research**
0:10	Metrics for international analysis
0:10	Implications for national security
0:10	Power sector
0:10	Decision maker perspective
0:10	Comment
0:10	Comment
0:25	Discussion
4:55 – 5:00 pm	**Day 1 Closing**
5:30 pm	**Dinner (Optional, self-funded)**

Time	Modeling Human Well-being
9:00 – 9:20 am	**Meeting Opening**
0:02	Welcome Back
0:18	Recap of Day 1
9:20 – 10:30 am	**Other Dimensions of Human Well-being: Current State of the Research**
0:10	Health
0:10	Food security
0:10	Poverty, jobs, and livelihoods
0:10	Conflict
0:30	Discussion
10:30 – 10:45 am	**Break**
10:45 – 11:00 am	**General Discussion**
11:00 – 12:15 am	**Methods and Frameworks for Integrated Analysis of Human Well-being**
0:10	Scenarios and metrics
0:10	Integrated modeling capabilities
0:10	State of the art/shortfalls in current modeling frameworks
0:10	Crossing scales
0:35	Discussion
12:15 – 1:45 pm	**Working Lunch and Extended Discussion on Frameworks for Analysis of Human Well-being**
1:45 – 2:45 pm	**Future Research Directions to Address Gaps in Human Well-being Research**
0:10	Climate security
0:10	Analysis of Environmental Justice
0:10	Quantitative to qualitative approaches and communication to policy makers
0:10	International development analytical needs
0:20	Discussion
2:45 – 3:00 pm	**Break**

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COLLEGE PARK MARRIOTT HOTEL & CONFERENCE CENTER | 3501 University Blvd E | Hyattsville, MD

Time	Modeling Human Well-being
3:00 – 3:15 pm	**General Discussion**
3:15 – 4:35 pm	**Stakeholder Needs for Human Well-being Research**
0:10	Decision maker perspective
0:10	Decision maker perspective
0:10	Decision maker perspective
0:10	Decision maker perspective
0:40	Discussion
4:35 – 4:55 pm	**Discussion of next steps**
4:55 – 5:00 pm	**Workshop Closing**