How Algorithm-Assisted Decision Making Is Influencing Environmental Law and Climate Adaptation

Sonya Ziaja[*]

Algorithm-based decision tools in environmental law appear policy neutral but embody bias and hidden values that affect equity and democracy. In effect, algorithm-based tools are new fora for law and policymaking, distinct from legislatures and courts. In turn, these tools influence the development and implementation of environmental law and regulation. As a practical matter, there is a pressing need to understand how these automated decision-making tools interact with and influence law and policy. This Article begins this timely and critical discussion.

Though algorithmic decision making has been critiqued in other domains like policing and housing policy, climate change makes algorithms in environmental and energy policy distinct. Expectations of climatic stationarity—for example, how frequently or severely a coastal area floods or how many days of extreme heat an energy system needs to anticipate—are no longer valid. Algorithm-based tools are necessary to make sense of possible future scenarios in an unstable climate. Yet, dependence on these tools brings with it a conflict

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* JD, MSc, PhD, Assistant Professor, University of Baltimore School of Law.
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between technocracy (and the need to rapidly adapt and respond to climate change) and democratic participation, which is fundamental to equity. This Article discusses sources of that tension within algorithm-based tools and offers a pathway forward to integrate values of equity and democratic participation into these tools.

After introducing the challenge of adapting water and energy systems to climate change, this Article synthesizes prior multidisciplinary work on algorithmic decision making and modeling-informed governance—bringing together the works of early climate scientists and contemporary leaders in algorithmic decision making. From this synthesis, this Article presents a framework for analyzing how well these tools integrate principles of equity, including procedural and substantive fairness—both of which are essential to democracy. The framework evaluates how the tools handle uncertainty, transparency, and stakeholder collaboration across two attributes. The first attribute has to do with the model itself—specifically, how and whether existing law and policy are incorporated into these tools. These social parameters can be incorporated as inputs to the model or in the structure of the model, which determines its logic. The second attribute has to do with the modeling process—how and whether stakeholders and end-users collaborated in the model's development.

The Article then applies this framework and compares two algorithm-assisted decision-making tools currently in use for adapting water and energy systems to climate change. The first tool is called "INFORM." It is used to allocate water quantity and flow on the Sacramento River, while taking climate and weather into account. The second tool is called "RESOLVE." It is used by energy utility regulators in California to evaluate scenarios for energy generation. Although the development of both tools involved collaborative processes, there are meaningful distinctions in the history of their development and use. The comparisons indicate that how law and policy are incorporated into the underlying code of models influences the development and regulation of climate adaptation, while inclusiveness and collaboration during the model's development influences the model's perceived usefulness and adoption. Both conclusions have implications for equity and accessibility of environmental, natural resource, and energy planning.

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INTRODUCTION

As the reality of climate change becomes more present,[1] a quiet revolution is changing the governance of water and energy systems. Algorithmic tools that shape the regulation of these two systems are new fora for law and policymaking. Federal and state agencies responsible for water and energy systems increasingly rely on algorithm-assisted decision making to regulate these systems and shepherd them through climate adaptation.[2] Legal scholars, attorneys, and

1. *See generally* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY: WORKING GROUP II CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Christopher B. Fields et al. eds., 2014).

2. *See generally* Deniz Özkundakci et. al., *Building a Reliable Evidence Base Legal Challenges in Environmental Decision-Making Call for a More Rigorous Adoption of Best Practices in Environmental Modelling*, 88 ENV'T SCI. & POL'Y 52, 52–62 (2018). Notably, over a decade ago, the National Research Council published a report on how integral to the environmental regulatory process algorithmic tools had become, calling computational models "essential element[s] of the environmental regulatory process." COMM. ON MODELS IN THE REGUL. DECISION PROCESS, NAT'L RSCH. COUNCIL, MODELS IN ENVIRONMENTAL REGULATORY DECISION MAKING, at ix (2007), http://nap.edu/11972. A recent partnership between the United Nations Environment Programme (UNEP) and University of British Columbia makes the case for a "digital ecosystem for the planet" that would "connect individual data sets with algorithms and analysis in order to create robust and timely environmental insights and intelligence." Jillian Campbell & David E. Jensen, *The Promise and Peril of a Digital Ecosystem for the Planet*, MEDIUM (Sept. 11, 2019), https://medium.com/@davidedjensen_99356/building-a-digital-ecosystem-for-the-planet-557c41225dc2. The UNEP's enthusiasm for new tools to support environmental decision making

environmental equity advocates should care about this fundamental change in governance for three reasons. First, climate adaptation necessarily depends on these tools. They are not going away, and we need them. Second, algorithmic tools are not policy neutral; rather they embed value-laden assumptions and biases, which influence climate adaptation and law. And third, the "rules" of this new kind of forum necessarily impede equity and democratic participation, without deliberate countermeasures.

In this Article, I propose an initial step in the development of such countermeasures: a framework for evaluating how algorithm-assisted decision making, in environmental and energy regulation, influences law and what the consequences are for equity and participation. This framework is designed to bring to light embedded biases and values in algorithmic tools, open them up to deliberation, and encourage broader coproduction of tools where possible. For reasons discussed below, I believe that this framework is likely to be most useful for advocacy groups, who already work on the behalf of marginalized communities and the environment, in contexts where administrative bodies rely on algorithmic tools.

This Article proceeds by first diagnosing the problem. Part I presents an overview of how climate change disrupts existing water and energy systems, and why algorithm-assisted decision-making tools are crucial to address these disruptions. Part II examines the legal and environmental policy implications of two key attributes of environmental and natural resource models. The first attribute concerns algorithmic tools themselves—specifically, how, and whether, existing law and policy are incorporated into these tools. The second attribute has to do with the design process—how and whether stakeholders and end-users collaborated in the tool's development.

Building on these insights, in Part III this Article then presents a necessary and foundational step to ameliorating the equity issues described earlier: a framework for attorneys and advocates to evaluate equity in algorithmic-assisted decision-making tools.

To illustrate the framework, Parts IV and V rely on two examples of energy and water models: INFORM, a decision support tool used for reservoir operations on the Sacramento River, and RESOLVE, an energy dispatch optimization planning tool used by the California Public Utilities Commission

is understandable, as the world is beginning to face the cascading consequences of climate change. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2018 SUMMARY FOR POLICYMAKERS *in Global Warming of 1.5°C An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* 3–26 (Masson-Delmotte, V., P. Zhai, H.-O.Pörtner, D.Roberts, J. Skea, P.R. Shukla, A.Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X.Zhou, M.I.Gomis, E.Lonnoy, T. Maycock, M. Tignor, and T. Waterfield eds., 2018); *see also* Fiona Harvey, *IPCC Steps up Warning on Climate Tipping Points in Leaked Draft Report*, GUARDIAN (June 23, 2021, 12:34 PM), https://www.theguardian.com/environment/2021/jun/23/climate-change-dangerous-thresholds-un-report.

(CPUC).[3] The comparison of these tools and their development indicates that how law and policy are incorporated into algorithmic tools can influence the development and regulation of climate adaptation, while inclusiveness and collaboration during a tool's development influences its perceived usefulness and adoption. Both conclusions have implications for fairness and legitimacy of environmental and natural resource planning.

I. OVERVIEW OF CHALLENGES: ADAPTING WATER AND ENERGY SYSTEMS TO A NEW CLIMATE

Before unpacking the role of algorithm-assisted decision-making tools in water and energy systems, I provide some context for why regulators and managers need these tools or find them helpful in a rapidly changing climate. Freshwater systems in the United States are regulated, negotiated, and managed to meet multiple, and at times conflicting, purposes.[4] Even without considering climate impacts, river basin governance is complex.[5] Climate change exacerbates many of the existing challenges to water governance by altering the quantity, flow, and quality of available freshwater.[6]

Energy systems face a different set of challenges.[7] Burning fossil fuels to create electricity is a major source of greenhouse gas (GHG) emissions, driving climate change.[8] As jurisdictions set targets to reduce GHG emissions, energy generation systems are swapping out old fossil fuels for new renewable energy and storage (batteries).[9] The differences in how fossil fuels and renewable energy

3. The new framework in this Article builds on research from two prior studies by the author. The first is a law review article that applies an institutional economics critique to how law and policy are incorporated and represented in water resource models. Sonya F. P. Ziaja, *Rules and Values in Virtual Optimization of California Hydropower*, 57 NAT. RES. J. 329 (2017). The second is a peer-reviewed, social science publication that investigates the role of knowledge networks and boundary organizations in water model development and adoption. Sonya F. Ziaja, *Role of Knowledge Networks and Boundary Organizations in Coproduction A Short History of a Decision-Support Tool and Model for Adapting Multiuse Reservoir and Water-Energy Governance to Climate Change in California*, 11 WEATHER, CLIMATE, & SOC'Y 823 (2019).

4. *See* EDELLA SCHLAGER & WILLIAM BLOMQUIST, EMBRACING WATERSHED POLITICS 149–50 (2011); *see also* Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 826; SANDRA POSTEL & BRIAN RICHTER, RIVERS FOR LIFE: MANAGING WATER FOR PEOPLE AND NATURE (2003); Helen Ingram, *Water as a Multi-Dimensional Value Implications for Participation and Transparency*, 6 INT'L ENV'T AGREEMENTS: POL'Y, L., & ECON. 429, 429–33 (2006).

5. *See* SCHLAGER & BLOMQUIST, *supra* note 4, at 180.

6. *See*, *e.g.*, Thomas Johnson et al., *Water*, *in* 2 FOURTH NATIONAL CLIMATE ASSESSMENT: IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES 147 (David Reidmiller et al. eds., 2018), https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf.

7. *See generally* CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT: STATEWIDE SUMMARY REPORT 84 (2019), https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf; *see also* 2 FOURTH NATIONAL CLIMATE ASSESSMENT: IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES, *supra* note 6, at 76.

8. IPCC 2014, *supra* note 1, at 122.

9. *See* 100 Percent Clean Energy Act of 2018, S.B. 100, 2017-2018 Leg., Reg. Sess. (Cal. 2018); *see also* THE REG'L GREENHOUSE GAS INITIATIVE: AN INITIATIVE OF E. STATES OF THE U.S., https://www.rggi.org/ (last visited Feb. 20, 2021).

generation produce electricity means that swapping energy sources is not as simple as closing down a 150-megawatt coal plant and opening up a 150-megawatt wind farm. Most renewable energy generation sources, like wind and solar, are intermittent—the amount of energy they generate peaks and recedes throughout the day—and play different roles on the grid (for example, ancillary services, black start capability, etc.).[10] Regulators and balancing authorities are responsible for planning and managing the transition from fossil fuels to renewables in a way that maintains grid reliability.[11]

These challenges, and the solutions offered by algorithm-assisted decision making, are described in greater detail below.

A. Water Systems and Climate

The Snoqualmie River in the Pacific Northwest serves as an example of the challenges facing freshwater systems in the twenty-first century. Twenty-two miles east of Seattle, there is a manmade fork in the Snoqualmie River.[12] Water at the fork is diverted from the main river and channeled into vertical penstocks, dropping hundreds of feet below the ground to drive turbines that provide enough electricity to power about 35,000 homes.[13] Meanwhile, back on the main stem of the river, about 150 feet after the fork, water cascades down 268 feet of granite, sending mist upward.[14] That mist is sacred to the Snoqualmie Indian Tribe.[15] The river itself is the home and breeding waters of Chinook salmon,[16] a federally endangered species[17] and a key source of food for dwindling orca populations in

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10. *See*, *e.g.*, A. S. CHUANG & C. SCHWAEGERL, ANCILLARY SERVICES FOR RENEWABLE INTEGRATION 1 (2009), https://ieeexplore.ieee.org/document/5211165.

11. *See* Shelley Welton, *Rethinking Grid Governance for the Climate Change Era*, 109 CALIF. L. REV. 209, 250 (2021).

12. *See Snoqualmie Falls Hydroelectric Project*, PUGET SOUND ENERGY, https://www.pse.com/en/pages/facilities/snoqualmie-falls (last visited Oct. 27, 2021).

13. Snoqualmie Falls has a generating capacity of fifty-three MW, between two turbines. *Id.* One MW is enough to power roughly 400-900 homes. Bob Bellemare, *What is a Megawatt.*, NUCLEAR REGULATORY COMMISSION (Feb, 24, 2012), https://www.nrc.gov/docs/ML1209/ML120960701.pdf.

14. *See* Snoqualmie Indian Tribe v. Fed. Energy Regul. Comm'n, 545 F.3d 1207, 1210 (9th Cir. 2008); *see also* Jay Miller & Kenneth Tollefson, *Snoqualmie Falls The First Traditional Cultural Property in Washington State Listed in the National Register of Historic Places*, 50 J. N.W. ANTHROPOLOGY 67, 67–78 (2016).

15. *See Snoqualmie Indian Tribe*, 545 F.3d at 1211; *see also* Miller & Tollefson, *supra* note 14, at 67–78.

16. *See* ETHAN SEAY & MATTHEW POULEY, TULALIP TRIBES NAT. RES. DEP'T, SNOQUALMIE RIVER JUVENILE SALMON OUT-MIGRATION STUDY PROGRESS REPORT 3 (2019), https://nr.tulaliptribes.com/Base/File/SNOQUALMIE-RIVER-JUVENILE-SALMON-OUT-MIGRATION=-STUDY-PROGRESS-REPORT-2019; *see also* JOSH KUBO ET AL., TULALIP TRIBES NAT. RES. DEP'T, 2000-2012 SKYKOMISH AND SNOQUALMIE RIVERS CHINOOK AND COHO SALMON OUT-MIGRATION STUDY 1–13 (2013), https://nr.tulaliptribes.com/Content/documents/Tulalip-Skykomish-Snoqualmie-Outmigrant-Study-2013.pdf.

17. *Chinook Salmon (Protected)*, NOAA FISHERIES, https://www.fisheries.noaa.gov/species/chinook-salmon-protected (last visited Feb. 21, 2021).

Puget Sound.[18] These uses of the river—power, religion, habitat, and conservation—are in addition to drinking water, agricultural, and recreational uses, all of which are subject to state and federal agency regulation.[19]

Climate change alters water quantity and quality, limiting the water available for multiple uses, from headwaters to delta.[20] For example, increased ambient temperatures associated with climate change lead to warmer streams, decreased snowpack, and more prominent atmospheric rivers.[21] Warmer in-stream temperatures in turn decrease the amount of dissolved oxygen available to support healthy fish and amphibians.[22] More prominent atmospheric rivers in the sky combined with decreased snowpack in the mountains lead to changes in turbidity and increased risk of floods, while changing the seasonal availability of water for hydropower generation.[23] And, at the delta, sea level rise threatens riparian habitat with salt water intrusion.[24]

For some uses, water conflicts are zero-sum. More water diverted to hydroelectric power, for example, means less mist at the falls for religious purposes. Climate impacts on river systems exacerbate the inherent tensions in these tradeoffs. Resolving conflicts among these uses falls to litigation, as it did in the case of Snoqualmie Falls.[25] Litigation and the courts, however, are not the sole mechanisms for addressing water conflicts. Negotiation and agency regulation can prevent, or minimize, future conflicts among uses, which in turn, rely heavily on software assistance to create an array of scenarios to guide decision making.[26]

18. Samuel K. Wasser et al*., Population Growth is Limited by Nutritional Impacts on Pregnancy Success in Endangered Southern Resident Killer Whales* (Orcinus Orca), PLOS ONE, June 2017, at 1–2.

19. *See* Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 824.

20. *See*, *e.g.*, Johnson et al., *supra* note 6, at 152–54.

21. N. Goldenson et al., *Influence of Atmospheric Rivers on Mountain Snowpack in the Western United States*, 31 J. CLIMATE, 9921 (2018); Ashley E. Payne et al., *Responses and Impacts of Atmospheric Rivers to Climate Change*, 1 NAT. REVS.: EARTH & ENV'T 143, 149 (2020).

22. Sarah E. Null et al., *Dissolved Oxygen, Stream Temperature, and Fish Habitat Response to Environmental Water Purchases*, 197 J. ENV'T MGMT. 559, 568 (2017); *see generally* Darren L. Ficklin et al., *Effects of Climate Change on Stream Temperature, Dissolved Oxygen, and Sediment Concentration in the Sierra Nevada in California*, 49 WATER RES. RSCH. 2765 (2013).

23. Julie A. Vano et al., *Climate Change Impacts on Water Management in the Puget Sound Region, Washington State, USA*, 102 CLIMATIC CHANGE 261 (2010).

24. Paul Stanton Kibel, *Sea Level Rise, Saltwater Intrusion and Endangered Fisheries – Shifting Baselines for the Bay Delta Conservation Plan*, 38 ENVIRONS: ENV'T L. & POL'Y J. 259 (2015).

25. *See* Snoqualmie Indian Tribe v. Fed. Energy Regul. Comm'n, 545 F.3d 1207, 1211 (9th Cir. 2008); *see also* Ziaja, *Rules and Values*, *supra* note 3, at 329–36.

26. *See*, *e.g.*, COMM. ON MODELS IN THE REGUL. DECISION PROCESS, *supra* note 3, at ix ("The use of computational models is an essential element of the environmental regulatory process."); Ziaja, *supra* note 9, at 833 tbl.2; Özkundakci et al., *supra* note 2; Ziaja, *Rules and Values*, *supra* note 3; Wendy Wagner et al., *Misunderstanding Models in Environmental and Public Health Regulation*, 18 N.Y.U. ENV'T L.J. 293 (2010); Marcela Brugnach et al., *Uncertainty Matters Computer Models at the Science-Policy Interface*, 21 WATER RES. MGMT. 1075 (2007).

B. Energy Systems and Climate

For most people, energy systems function in the background. People worry about paying their energy bills, and maybe they consider what kind of power plant generates the electricity they consume. Otherwise, as long as the lights turn on, how energy systems function is generally not a matter of day-to-day concern to the public. Behind the scenes, making certain that there is sufficient, but not too much, electricity produced to meet demand is a major concern for utilities, regulators, and balancing authorities.[27] A fundamental maxim of electricity service is that energy supply must always meet demand.[28] This is the heart of keeping the lights on. Having sufficient energy resources to meet projected demand is called "resource adequacy."[29] The grid must also have sufficient flexibility (part of "ancillary services" to the grid) to ramp up production if demand peaks and to ramp down if demand suddenly drops.[30] As discussed above, different energy generation sources have varying attributes that make them more or less able to provide that flexibility to the grid.

Multiple organizations and institutions are responsible for making sure there is sufficient generation of the right mix to provide flexibility and resource adequacy on long- and short-term bases. Federally-regulated balancing authorities are responsible for ensuring overall resource adequacy for the nation's grids, with the exception of Texas's grid, which is operated by its own regional balancing authority.[31] Individual utilities and energy providers participate in energy markets to buy and sell energy generation and to meet demand or shed load.[32] And state commissions, which oversee investor-owned utilities, can mandate specific resource adequacy requirements for regulated utilities.[33]

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27. For an accessible overview of the electricity grid, see generally U.S. DEP'T OF ENERGY, MAINTAINING RELIABILITY IN THE MODERN POWER SYSTEM (2016), https://www.hsdl.org/?abstract&did=806857, and *How the Electricity Grid Works,* UNION OF CONCERNED SCIENTISTS (Feb. 17, 2015), https://www.ucsusa.org/resources/how-electricity-grid-works. For a more in depth, but still accessible, overview, see generally GRETCHEN BAKKE, THE GRID: THE FRAYING WIRES BETWEEN AMERICANS AND OUR ENERGY FUTURE (2016).

28. U.S. DEP'T OF ENERGY, *supra* note 27, at 1, 6.

29. *See* Welton, *supra* note 11, at 231; U.S. DEP'T OF ENERGY, *supra* note 27, at 6.

30. Giulia De Zotti et al., *Ancillary Services 4.0 A Top-to-Bottom Control-Based Approach for Solving Ancillary Services Problems in Smart Grids*, 6 IEEE ACCESS 11,694, 11,695 (2018), https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8290690. For a discussion of ancillary service markets in the United States, see generally Helen Aki, Note, *Better than Net Benefits Rethinking the* FERC v. EPSA *Test to Maximize Value in Grid-Edge Electricity Markets*, 44 ECOLOGY L. Q. 419 (2020).

31. Sara Hoff, *U.S. Electric System is Made Up of Interconnections and Balancing Authorities*, U.S. ENERGY INFO. ADMIN., (July 20, 2016), https://www.eia.gov/todayinenergy/detail.php?id=27152. For a detailed assessment of RTOs, see Welton, *supra* note 11, at 225.

32. *See*, *e.g.*, Sarah M. Main, *Dual Environmentalism Demand Response Mechanisms in Wholesale and Retail Energy Markets*, 34 PACE ENV'T L. REV. 165, 187 (2016).

33. *See* Danny Cullenward & Shelley Welton, *The Quiet Undoing How Regional Electricity Market Reforms Threaten State Clean Energy Goals*, 36 YALE J. ON REGUL. BULL. 106 (2018).

Weather and climate influence the grid characteristics needed to fulfill resource adequacy.[34] Demand for heating, for example, is quantified in "heating degree days"—the amount of energy needed to heat a building when the outside temperature drops below a certain point, usually about forty degrees Fahrenheit.[35] Similarly, demand for cooling is quantified as "cooling degree days"—the amount of energy needed to cool a building when the outside temperature is above a certain point.[36]

Typically, popular writing and scholarship characterizes the energy system's relation to climate change as a source of GHGs (such as from fossil fuel energy generation) or a solution to curbing emissions (such as through switching to renewable energy generation).[37] But, the energy system itself is also vulnerable to climate impacts.[38] Increases in temperature boost total demand for energy, while reducing the efficiency of energy generation and transmission—raising the costs of electricity production.[39] Decreased snow accumulation in the mountainous regions of the world limits the availability of hydropower—one of the few generation sources that provides robust ancillary services to the electrical grid.[40] And, the spread of massive wildfires throughout the western United States threatens the availability of electricity, as utilities limit their liability by curtailing services.[41]

C. What Do Algorithms and Modeling Have to Do with This All?

First, a few definitions. How we talk about the analytic software tools that inform policy has changed over time. Algorithms and "algorithmic decision-making"[42] (ADM) are discussed and debated far more now than even a decade ago, especially regarding the application of ADM to policing and surveillance.[43] In layman's terms, an algorithm is a sequential process of calculations—or more

34. Craig D. Zamuda et al., *Energy Supply, Delivery, and Demand*, *in* 2 FOURTH NATIONAL CLIMATE ASSESSMENT: IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES, *supra* note 6, at 196.

35. For more information about heating degree days and cooling degree days, see *Units and Calculators Explained Degree Days*, U.S. ENERGY INFO. ADMIN. (June 23, 2021), https://www.eia.gov/energyexplained/units-and-calculators/degree-days.php.

36. *Id.*

37. Zamuda et al., *supra* note 34.

38. *See id.* at 175.

39. *Id.* at 176.

40. *Id.*

41. *Id.*

42. *See*, *e.g.*, Mike Ananny & Kate Crawford, *Seeing Without Knowing Limitations of the Transparency Ideal and Its Application to Algorithmic Accountability*, 20 NEW MEDIA & SOC'Y 973 (2016).

43. *See*, *e.g.*, Bruno Lepri et al., *Fair, Transparent, and Accountable Algorithmic Decision-Making Processes*, 31 PHIL. & TECH. 611 (2018); *see also* Katharina A. Zweig et al., *On Chances and Risks of Security Related Algorithmic Decision Making Systems*, 3 EUR. J. FOR SEC. RSCH. 181, 181–203 (2018); Robert Brauneis & Ellen P. Goodman, *Algorithmic Transparency for the Smart City*, 20 YALE J.L. & TECH. 103, 146–50 (2018). *See generally* David Freeman Engstrom & Daniel E. Ho, *Algorithmic Accountability in the Administrative State*, 37 YALE J. ON REGUL. 800 (2020); Aziz Z. Huq, *Racial Equity in Algorithmic Criminal Justice*, 68 DUKE L. J. 1043 (2019).

simply, what the programmer instructs a computer to do with data.[44] The term "algorithm" is frequently mistakenly conflated with "machine-learning."[45] Not all algorithms lead to machine learning or artificial intelligence, though machine learning necessarily requires algorithms.[46] Computer models of climate systems, social-economic-environmental systems, and energy grid expansion also require algorithms to function. These software products and models may represent existing conditions (simulation models),[47] or solve for least-cost policy options (optimization models),[48] among others.

To refocus our attention on broader policy processes, this Article uses the term algorithm-*assisted* decision making, which includes, but is not exclusive to, ADM. The important distinction here is the presumed role of humans in decision making. ADM is frequently discussed as though the program makes decisions apart from human intervention or systems,[49] whereas algorithm-assisted decision making recognizes the place of technology within human systems and does not focus solely on machine learning. Thus, this Article's examination of algorithm-assisted decision making includes computational models and decision support software.

What these analytic tools have in common is a process of collecting and organizing data, representing relationships among the data, and analyzing those relationships to answer a question. This process relies on quantification to represent the reality of complex environmental systems.[50] For example, a model used for river basin planning might assign numerical values for species protection, to be weighed against numerical values for hydroelectric generation.[51]

Energy regulators and utilities already rely heavily on algorithm-assisted decision making. At the national level, the recently passed Infrastructure Investment and Jobs Act of 2021 directs the Energy Information Administration to make revisions and upgrades to the National Energy Modeling System, including "greater flexibility in the modeling of environmental impacts"

44. *See generally* Harry Surden, *Machine Learning and Law*, 89 WASH. L. REV. 87 (2014); Harry Surden, *Artificial Intelligence and Law An Overview*, 35 GA. STATE U. L. REV. 1319 (2019).

45. *See generally* Surden, *Machine Learning and Law*, *supra* note 44; Surden, *Artificial Intelligence and Law An Overview*, *supra* note 44, at 1316; *see also* Leo Hickman, *How Algorithms Rule the World*, GUARDIAN (July 1, 2013, 1:32 PM), https://www.theguardian.com/science/2013/jul/01/how-algorithms-rule-world-nsa.

46. For a quick and accessible overview of algorithms and artificial intelligence, see Stephen F. Deangelis, *Artificial Intelligence How Algorithms Make Systems Smart*, WIRED, https://www.wired.com/insights/2014/09/artificial-intelligence-algorithms-2/ (last visited Dec. 22, 2021). For a thorough cultural history of algorithms, see generally PAOLO ZELLINI, THE MATHEMATICS OF THE GODS AND THE ALGORITHMS OF MEN: A CULTURAL HISTORY (2020).

47. *See* Dave Owen, *Mapping, Modeling, and the Fragmentation of Environmental Law*, 45 UTAH L. REV. 219, 245 (2013).

48. Ziaja, *Rules and Values*, *supra* note 3, at 331.

49. *See*, *e.g.*, Surden, *Artificial Intelligence and Law An Overview*, *supra* note 44.

50. *See generally* Linda Pilkey-Jarvis & Orrin H. Pilkey, *Useless Arithmetic Ten Points to Ponder When Using Mathematical Models in Environmental Decision Making*, 68 PUB. ADMIN. REV. 470 (2008).

51. *See* Ziaja, *Rules and Values*, *supra* note 3, at 332–33, 353–55.

including GHG emissions and "the use of land and water resources" along with "the ability to support climate modeling."[52] And, these kinds of tools are becoming increasingly common in water governance and environmental planning. Climate change has increased the complexity of making decisions for water and energy planning, leading regulators to rely more heavily on algorithmic tools. Climate change has also raised the stakes of decision making in these domains—which makes it all the more critical to better understand how algorithmic tools operate, their role in governance, and their implications for equity and democratic participation.

II. MULTIDISCIPLINARY LITERATURE REVIEW OF THE DEVELOPMENT AND USE OF ALGORITHM-ASSISTED DECISION MAKING IN GOVERNANCE

The discussion above describes how algorithmic tools can be useful, if not critical, to climate adaptation. But how do such tools interact with law and policy? Scholarship on the role of algorithm-assisted decision making in law and public policy generally falls into two camps. Let's call these the *rational enlightenment camp*[53] and the *realist camp*.[54]

The rational enlightenment camp says something like, *the problem with models is that policymakers aren't using them enough*, or *the models are misunderstood as irrelevant*.[55] This literature argues that the ability of mathematical modeling to simplify complex, complicated, or otherwise

52. Infrastructure Investment and Jobs Act of 2021§ 40417 (11)(A), (B).

53. Stephen H. Schneider, *Integrated Assessment Modeling of Global Climate Change Transparent Rational Tool for Policy Making or Opaque Screen Hiding Value-Laden Assumptions?*, 2 ENV'T MODELING & ASSESSMENT 229, 229 (1997) (examining the "analytic tools that analysts often turn to in search for rational enlightenment in the bewilderingly complex global climate change policy debate: integrated assessment models (IAMs)").

54. For the sake of simplicity, I describe the literature in terms of separate camps, rather than a spectrum. Of course, the reality is more nuanced and variable. Individual scholars can and do write from multiple perspectives. *Compare* James D. Fine & Dave Owen, *Technocracy and Democracy Conflicts between Models and Participation in Environmental Law and Planning*, 56 HASTINGS L.J. 901 (2005) *with* Owen, *supra* note 47.

55. *See* Amy L. Stein, *Artificial Intelligence and Climate Change*, 37 YALE J. ON REGUL. 890, 890–939 (2020); *see* Owen, *supra* note 47, at 278–79 (arguing for environmental law to engage with simulation models, especially spatial analysis models, to become less fragmented across subject matter and territorial jurisdiction.); *see generally* Brugnach et al., *Uncertainty Matters*, *supra* note 26, at 1075–90; *see also* Lorène Prost et al., *Lack of Consideration for End-Users During the Design of Agronomic Models. A Review*, 32 AGRONOMY FOR SUSTAINABLE DEV. 581, 581–94 (2012); *see also* Steve Rayner et al., *Weather Forecasts Are for Wimps Why Water Resource Managers Do Not Use Climate Forecasts*, 69 CLIMATIC CHANGE 197, 197–227 (2005).

"wicked"[56] problems (such as electricity grid planning,[57] allocating water for multiple uses,[58] or fisheries management[59]) and provide a suite of scenarios for different management options[60] gives decision makers an edge in adjusting governance to climate impacts.[61] Scholarship here has investigated the models themselves,[62] the failure to consider end-users in the modeling process,[63] and the culture of potential end-users[64] as the cause of the disconnect.

The realist camp says something like, *the problem with models is that policymakers believe them too much*. In other words, the models are misleading or misinterpreted.[65] This literature argues that policymakers ask too much from models, considering them to be "truth machines,"[66] "answer machines,"[67] and maintain "ingrained myths that models can yield 'objective evidence' or 'straightforward policy solutions' . . . ."[68] Scholarship in this camp also raises the concern that policymakers may use models as a fig leaf[69] to obscure[70] or avoid making[71] politically difficult choices.

56. Cynthia H. Stahl, *Out of the Land of Oz the importance of tackling wicked environmental problems without taming them*, 34 ENV'T SYS. & DECISIONS 473, 474 (2014); Heather J. Aslin & Kirsty L. Blackstock, *Now I'm Not an Expert in Anything' Challenges in Undertaking Transdisciplinary Inquiries Across the Social and Biophysical Sciences*, *in* TACKLING WICKED PROBLEMS: THROUGH THE TRANSDISCIPLINARY IMAGINATION 117 (Valerie A. Brown et al. eds., 2010).

57. *See generally* Rodrigo Moreno et al., *Planning Low-Carbon Electricity Systems Under Uncertainty Considering Operational Flexibility and Smart Grid Technologies*, 375 PHIL. TRANSACTIONS ROYAL SOC'Y 1 (2017).

58. *See*, *e.g.*, JAY R. LUND ET AL., WATER MANAGEMENT LESSONS FOR CALIFORNIA FROM STATEWIDE HYDRO-ECONOMIC MODELING USING THE CALVIN MODEL (2009), https://watershed.ucdavis.edu/shed/lund/CALVIN/ProjectHandoutNew.pdf.

59. *See id.*

60. *See* DAVID ROLAND-HOLST ET AL., CAL. ENERGY COMM'N, CEC-500-2018-013, EXPLORING ECONOMIC IMPACTS IN LONG-TERM CALIFORNIA ENERGY SCENARIOS (2018); Anthony L. Westerling et al., *Climate Change and Growth Scenarios for California Wildfire*, 109 CLIMATIC CHANGE 445, 451–44 (2011); *see also* MAX WEI ET AL., SCENARIOS FOR MEETING CALIFORNIA'S 2050 CLIMATE GOALS: CALIFORNIA'S CARBON CHALLENGE PHASE II VOLUME I: NON-ELECTRICITY SECTORS AND OVERALL SCENARIO RESULTS, at iv (2014).

61. Ziaja, *Rules and Values*, *supra* note 3. UNEP's argument for a planetary "digital ecosystem" falls solidly in this camp. Campbell & Jensen, *supra* note 2.

62. *See generally* Ziaja, *Role of Knowledge Networks*, *supra* note 3.

63. *See generally* Prost et al., *supra* note 51; Ziaja, *Rules and Values*, *supra* note 3; *see also* Brugnach et al., *supra* note 26, at 1078; Ingram, *supra* note 4, at 429–33.

64. Rayner et al., *supra* note 55.

65. *See generally* Wagner et al., *supra* note 26; *see also* Pilkey-Jarvis & Pilkey, *supra* note 50, at 472.

66. Brian Wynne & Simon Shackley, *Environmental Models Truth Machines of Social Heuristics?*, 21 GLOBE: REVUE INTERNATIONALE D'ETUDES QUEBECOISES 6, 6–8 (1994).

67. Wagner et al., *supra* note 26, at 293, 295.

68. Anne van Bruggen et al., *Modeling with Stakeholders for Transformative Change*, SUSTAINABILITY, Feb. 2019, at 6.

69. *See* Pilkey-Jarvis & Pilkey, *Decision Making*, *supra* note 50, at 475–76.

70. *See* Brauneis & Goodman, *supra* note 43, at 119 ("The idea that algorithms are a science without politics can obscure the stakes of their private control that are clearer in other areas of privatization, such as schools and prisons.").

71. *See* Wagner et al., *supra* note 26; *but cf.* Rayner et al., *supra* note 55, at 222.

The rational enlightenment camp and realist camp have much in common. They both point to a disconnect between what policymakers think about models and what models are. They also both argue that addressing either problem requires confronting uncertainty inherent in models, stakeholder participation, and transparency.

The use of algorithm-assisted decision making in security, policing, and finance dominates current scholarship on machine-assisted decision making.[72] But, it was environmental scholarship, especially on Integrated Assessment Modeling (IAM)—commonly used, for example, in global or national climate assessments—which was among the first to point out the disconnect between policymaking and modeling, and to posit solutions for bridging that gap.[73] Stephen Schneider, a founding father of modern climate science and climate communication, summarized the modeling-policy problem in a 1997 paper.[74] He

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72. *See* Jon Kleinberg et al., *Algorithmic Fairness*, 108 AM. ECON. ASS'N PAPERS & PROC. 22, 22 (2018); Huq, *supra* note 43.

73. *See generally* Edward A. Parson, *Integrated Assessment and Environmental Policy Making In Pursuit of Usefulness*, 23 ENERGY POL'Y 463 (1995); *see also* Edward A. Parson, *Three Dilemmas in the Integrated Assessment of Climatic Change An Editorial Comment*, 34 CLIMATIC CHANGE 315, 321–24 (1996); Diana M. Liverman, *Forecasting the Impact of Climate on Food Systems Model Testing and Model Linkage*, 11 CLIMATIC CHANGE 267 (1987); Wynne & Shackley, *supra* note 66, at 6–8; Marjolein B. A. van Asselt & Jan Rotmans, *Uncertainty in Integrated Assessment Modelling From Positivism to Pluralism*, 54 CLIMATIC CHANGE 75 (2002). Wendy Wagner has published numerous articles on the complicated relationship between policymaking and scientific information (especially modeling). *See*, *e.g.*, Wendy E. Wagner, *The Science Charade in Toxic Risk Regulation*, 95 COLUM. L. REV. 1613, 1614 (1995) (writing, even then, that "[r]educed public participation, excessive regulatory delays, and the incomplete and inaccurate incorporation of science have plagued science-based environmental regulation for nearly three decades"); Wagner et al., *supra* note 26 (arguing that policymakers need to go beyond viewing computational models as "answer machines" or "truth machines"); Wendy E. Wagner & Martin Murillo, *Is the Administrative State Ready for Big Data? Exploring the Accountability Challenges in Environmental and Public Health Regulation*, Knight First Amendment Inst. at Colum. Univ. (Apr. 30, 2021), https://knightcolumbia.org/content/is-the-administrative-state-ready-for-big-data. There is also a rich literature on the related topic of the legitimacy of cost-benefit analysis ("CBA") in environmental law policymaking. An intrinsic attribute of both CBAs and algorithm-assisted decision making is that both rely on simplifications. The choices of how to simplify necessarily influence outcomes and obscure political choices. They differ, however, in complexity and legibility even among technocrats. Unraveling the connection between CBAs and algorithm-assisted decision making is deserving of its own article, and beyond the scope of this one. But, for those interested in the topic, see generally MICHAEL A. LIVERMORE & RICHARD L. REVESZ, REVIVING RATIONALITY: SAVING COST-BENEFIT ANALYSIS FOR THE SAKE OF THE ENVIRONMENT AND OUR HEALTH (2021); Amy Sinden, *Formality and Informality in Cost-Benefit Analysis*, 2015.1 UTAH L. REV. 93 (2015); Giulia Wegner & Unai Pascual, *Cost-Benefit Analysis in the Context of Ecosystem Services for Human Well-Being A Multidisciplinary Critique*, 21 GLOB. ENV'T CHANGE 492 (2011); Cass R. Sunstein, *Cost-Benefit Analysis and Arbitrariness Review*, 41 HARV. ENV'T L. REV. 1 (2017). For a very short case study of the steep challenges of creating defensible CBAs for endangered species, see Norman K. Whittlesey & Phillip R. Wandshneider, *Salmon Recovery As Viewed by Two Economists*, 7 CHOICES: MAG. FOOD, FARM, & RES. ISSUES 3, 5 (1992) ("[I]n our society, issues such as endangered species are often decided with valuations inconsistent with the calculus of tradeoffs that economists employ. Fair treatment and moral obligation cannot be incorporated into the economic analyses.").

74. *See generally* Schneider, *supra* note 53. Notably, Dave Owen and James Fine trace the tension between modeling and participation even further in caselaw. *See* Fine & Owen, *supra* note 54, at 914–15 (citing to Sierra Club v. Costle, 657 F.2d 298 (D.C. Cir. 1981)).

argued that IAM was intended to be, and should be, a useful tool for policymakers to govern the environment.[75] For Schneider, IAM would make decision making "more rational," even if not completely so.[76] But, Schneider argues, because environmental models are necessarily complex and contain "value-laden assumptions," they can "obscure values or make implicit cultural assumptions about how nature or society works (or the modelers' beliefs about how they 'should' work)" and "diminish the openness of the decision-making process," making it "less rational."[77] Schneider proposed a means to express uncertainty in modeling results, arguing that modelers had a "special obligation to make . . . tools transparent as possible,"[78] and "[m]ost critical . . . to engage in a vigorous outreach program to entrain decision-makers and citizens at all levels into the process of helping to design, test, and use IAMs for real policy questions."[79] In Schneider's view, failing to address sources that allow unchecked value-laden assumptions to persist would "make IAMs at best irrelevant to policy-makers, and at worst, misleading."[80]

From Schneider's work, we can then derive three diagnostic categories to address the concerns of both the rational enlightenment and realist camps: uncertainty, transparency, and stakeholder collaboration. A discussion of each follows.

A. Uncertainty

Uncertainty is a key feature of most environmental models, but may not be readily apparent in the model outputs or its code. Wilson explains that many environmental systems, like watersheds or fisheries, are complex adaptive systems[81]—where underlying cause-and-effect relationships may not be known or even knowable. This is called system uncertainty or "model uncertainty."[82] Using a "reductionist approach" simplifies the system structure, which conceals the underlying system uncertainty.[83] Schlager and Blomquist build on Wilson's observations, arguing that "[i]n the effort to manage and protect complex adaptive systems, failure to recognize and acknowledge uncertainty can magnify

75. Schneider, *supra* note 53.

76. *Id.* at 230.

77. *Id.*

78. *Id.*

79. *Id.*

80. *Id.* at 246.

81. *See* Bobbi Low et al., *Redundancy and Diversity Do They Influence Optimal Management?*, *in* NAVIGATING SOCIAL-ECOLOGICAL SYSTEMS: BUILDING RESILIENCE FOR COMPLEXITY AND CHANGE 83, 103 (Fikret Berkes et al. eds., 2002) (describing complex adaptive systems as being "composed of a large number of active elements whose rich patterns of interactions produce emergent properties–which are not easy to predict by analyzing the separate system components").

82. James Wilson, *Scientific Uncertainty, Complex Systems, and the Design of Common-Pool Institutions*, *in* THE DRAMA OF THE COMMONS 327, 333 (Elinor Ostrom et al. eds., 2002); *see also* Fine & Owen, *supra* note 54, at 922–26 (discussing sources of uncertainty in simulation models).

83. Wilson, *supra* note 82, at 328.

the error proneness of management effects."[84] Brauneis and Goodman put an even finer point on the problem of uncertainty in modeling, albeit in a different context,[85] stating:

> [t]he risk is that the opacity of the algorithm enables [. . .] capture of public power. When a government agent implements an algorithmic recommendation that she does not understand and cannot explain, the government has lost democratic accountability, the public cannot assess the efficacy and fairness of the governmental process, and the government agent has lost competence to do the public's work in any kind of critical fashion.[86]

Uncertainty then is not just a matter of needing further scientific study—it is a matter of communication and the capacity to understand.

Scholarship on environmental modeling in decision making has consistently argued that modelers should be explicit about model uncertainty.[87] Solutions for resolving or clarifying uncertainty tend to rely on increased stakeholder involvement in the modeling process,[88] or greater forthrightness about uncertainty on the part of modelers.[89] Brugnach and others argue that by doing both, projects are able to build capacity among decision makers to understand the model and build trust between modelers and stakeholders.[90]

B. Transparency

Legal approaches to the problems of algorithm-assisted decision making have focused on transparency as a solution.[91] The European Union's General Data Protection Regulation (GDPR), for example, famously includes a "right to an explanation" regarding algorithmic decision making.[92] Legal scholarship closer to home likewise stresses transparency in algorithm-assisted decision making.[93] A recent examination of predictive algorithms used in local

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84. SCHLAGER & BLOMQUIST, EMBRACING WATERSHED POLITICS, *supra* note 4, at 149–50.

85. Brauneis & Goodman, *supra* note 43, at 109 (examining the use of ADM in policing).

86. *Id.*

87. van Asselt & Rotmans, *supra* note 73, at 108; *see generally* Schneider, *supra* note 53; *see also* Brugnach et al., *supra* note 26, at 1082.

88. *See*, *e.g.*, Brugnach et al., *supra* note 26.

89. Wagner et al., *supra* note 26, at 7 (both participation and transparency); *see also* Özkundakci et al., *supra* note 2, at 61 ("[I]f models are to be of substantial help in environmental and resource management decision-making, then modellers and decision-makers will need to ensure that there is a clear understanding of the purpose of a model, the modelling process is transparent, and that best practice guidelines are followed."). *See generally*, John Bistline et al., *Deepening Transparency About Value-Laden Assumptions in Energy and Environmental Modelling Improving Best Practices for Both Modellers and Non-Modellers*, 21 CLIMATE POL'Y 1 (2020) (arguing that interdisciplinary collaboration is needed to unearth and openly discuss hidden "value-laden" assumptions in environmental and energy models).

90. *See* Brugnach et al., *supra* note 26, at 1082.

91. *See* Sandra Wachter, *The GDPR and the Internet of Things A Three-Step Transparency Model*, 10 L., INNOVATION & TECH. 266, 280 (2018).

92. *See* Lilian Edwards & Michael Veale, *Slave to the Algorithm? Why a Right to an Explanation' Is Probably Not the Remedy You Are Looking For*, 16 DUKE L. & TECH. REV. 18, 20 (2017).

93. *See* Brauneis & Goodman, *supra* note 43, at 109; *see also* Engstrom & Ho, *supra* note 43, at 15.

governance to allocate resources concludes that "[p]ublic entity contracts should require vendors to create and deliver records that explain key policy decisions and validation efforts, without necessarily disclosing precise formulas or algorithms."[94]

However, there are significant doubts as to whether transparency alone is sufficient to overcome obfuscation, especially algorithm-assisted decision making's obfuscation of uncertainty and associated "value-laden" assumptions. Many, if not most, environmental models and software include a descriptive model process manual, which describes the model's structure, calibration, and data, and generally how the model works. But, this does not necessarily make the model accessible to non-engineering audiences.[95]

Mike Ananny and Kate Crawford in particular interrogate whether transparency is sufficient to have accountability of algorithmic-assisted decision making in government, concluding that "transparency is an inadequate way to understand—much less govern—algorithms."[96] Similarly, in a critique of the GDPR's reliance on transparency as an oversight mechanism, Lilian Edwards and Michael Veale note that in complex and complicated systems, transparency is unlikely to lead to understanding or oversight.[97] This is because "the explanation itself may not be meaningful enough to confer much autonomy even on the most empowered data subject" and "[i]ndividuals are mostly too time-poor, resource-poor, and lacking in the necessary expertise to meaningfully make use of these individual rights."[98] To put this another way, transparency tends to provide detail, not clarity.

C. Stakeholder Collaboration

It is said in political science that "[p]olitics is not only 'who gets what, when, and how' . . . [i]t is also *who decides* who gets what, when, and how, and *how we decide* such things."[99] With this definition in mind, algorithmic tools are political machines—allocating resources according to internal rules (who gets what, when, and how). That is only half of the story, though; it is necessary to look beyond what the outputs of a particular model are to who developed the model, and how decisions were made in its development. Ananny and Crawford note that:

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94. *See* Brauneis & Goodman, *supra* note 43, at 176.

95. For example, see U.S. EPA's model documentation for the SAGE model of the U.S. economy for environmental planning. A. Marten, A. A. Schreiber, & A. Wolverton, *SAGE Model Documentation (2.0.1)*, EPA, https://www.epa.gov/environmental-economics/cge-modeling-regulatory-analysis (last visited Jan. 4, 2022).

96. Ananny & Crawford, *supra* note 42, at 983.

97. *See* Edwards & Veale, *supra* note 92, at 67.

98. *Id*.

99. SCHLAGER & BLOMQUIST, EMBRACING WATERSHED POLITICS, *supra* note 4, at 149–50. (quoting HAROLD LESSWELL, POLITICS: WHO GETS WHAT, WHEN, HOW (New York: McGraw-Hill, 1936)).

> [a]n algorithmic system is not just code and data but an assemblage of human and non-human actors—of 'institutionally situated code, practices, and norms with the power to create, sustain, and signify relationships among people and data through minimally observable, semiautonomous action.' This requires going beyond 'algorithms as fetishized objects' to take better account of the human scenes where algorithms, code, and platforms intersect.[100]

In other words, for algorithm-assisted decision making, the *process* of development is part of the system.

Schneider proposed stakeholder collaboration as important to the future of environmental modeling.[101] He called for the "increased involvement of diverse policy actors in the development and use of assessments and assessment tools . . . ."[102] He also noted that while calling for stakeholder involvement was obvious, how to do it was less so.[103]

Bistline and colleagues argue that interdisciplinary collaboration is needed to unearth and openly discuss hidden value-laden assumptions in environmental and energy models; for example, which discount rate is used in cost-benefit analyses has implications for intergenerational equity.[104] Similarly, Wagner and colleagues point out that environmental decision makers fail to understand, or investigate, underlying assumptions and uncertainties in the models.[105] They recommend changing administrative rules to encourage stakeholder participation in model oversight and for modelers to be explicit about assumptions and uncertainty.[106]

Existing literature does not agree on the appropriate timing and extent of stakeholder collaboration for model development. Much of the literature maintains that stakeholder collaboration should occur throughout the modeling process.[107] Uncertainty in models should be assessed throughout the model

100. Ananny & Crawford, *supra* note 42, at 983 (first quoting Mike Ananny, *Toward an Ethics of Algorithms Convening, Observation, Probability, and Timeliness*, 41 SCI., TECH., & HUM. VALUES 93, 93 (2016), then quoting Kate Crawford, *Can an Algorithm Be Agonistic? Ten Scenes from Life in Calculated Publics*, 41 SCI., TECH., & HUM. VALUES 77, 89 (2016)).

101. Schneider, *supra* note 53, at 235.

102. *Id.* (quoting Edward A. Parson, *Three Dilemmas in the Integrated Assessment of Climate Change An Editorial Comment*, 34 CLIMATIC CHANGE 315, 324 (1996)).

103. *Id.* ("[H]ow do we cajole such a diverse set of policy actors and social agents to set aside their agendas, prejudices and fears to even look at complex analytical tools like IAM? Moreover, how can we help them to overcome the initial effort barrier to their getting started in discovering – and using – IAMs?").

104. *See* Bistline et al., *supra* note 89, at 1.

105. *See generally* Wagner et al., *supra* note 26.

106. *See id.*

107. *See*, *e.g.*, Katharine J. Mach et al., *Actionable Knowledge and the Art of Engagement*, 42 CURRENT OP. ENV'T SUSTAINABILITY 30, 32–33 (2020); Jens Christian Refsgaard et al., *Uncertainty in the Environmental Modelling Process – A Framework and Guidance*, 22 ENV'T MODELLING & SOFTWARE 1543, 1544–45 (2007); Susanne C. Moser, *Can Science on Transformation Transform Science? Lessons from Co-Design*, 20 CURRENT OP. ENV'T SUSTAINABILITY 106, 111–12 (2016).

development process "from the very beginning,"[108] in collaboration with end users and stakeholders. The argument, generally, is that by including stakeholders from the start—codesigning[109] decision support tools—the end product will have improved legitimacy, credibility, and salience.[110] However, a recent longitudinal study of water governance modeling illustrates that even successful collaborative environmental, algorithm-assisted decision making can have extended periods of time where no collaboration took place, and that those periods may be critical to the success of the project.[111]

D. Implications for Substantive and Procedural Equity across Uncertainty, Transparency, and Stakeholder Collaboration

Value-laden assumptions in decision making are inextricably tied to questions of substantive and procedural equity. Before digging into this point, however, it is important to clarify what I mean by equity and how it relates to democratic participation in this Article.[112]

Equity is becoming prominent in contemporary climate and environmental scholarship.[113] There is broad agreement across environmental and energy studies that "equity" denotes fairness or justice.[114] But, systematic reviews of conservation literature, for example, demonstrate there is not a consistent definition of equity, such that it is not possible to compare across studies of equity in conservation.[115] There is no broadly agreed upon framework for "knowing equity when we see it."[116] Absent an agreed upon definition of equity in environmental and energy scholarship, I draw on definitions from the fields of public affairs and public policy.

In these fields, equity is a distribution problem.[117] What a *fair* or *just* distribution of rights, duties, or resources is may not always mean equal

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108. *See* Refsgaard et al., *supra* note 107, at 1543.

109. *See* Moser, *supra* note 107, at 113.

110. David W. Cash et al., *Knowledge Systems for Sustainable Development*, 100 PROC. NAT'L ACAD. SCIS. 8086, 8086 (2003).

111. Ziaja, *Role of Knowledge Networks*, *supra* note 3.

112. For an assessment of what scholars mean by "equity" in subfields of environmental policy, see generally Rachel S. Friedman et al., *How Just and Just How? A Systematic Review of Social Equity in Conservation Research*, ENV'T RSCH. LETTERS, Apr. 2018.

113. *See* Frank Biermann & Agni Kalfagianni, *Planetary Justice A Research Framework*, EARTH SYS. GOVERNANCE, Dec. 2020, at 1.

114. *See*, *e.g.*, *id.* at 2–3; Friedman et al., *supra* note 112, at 3.

115. *See generally* Biermann & Kalfagianni, *supra* note 113; Friedman et al., *supra* note 112. For a summary of what justice and equity mean in the energy context, see generally Sanya Carley & David M. Konisky, *The Justice and Equity Implications of the Clean Energy Transition*, 5 NATURE ENERGY 569 (2020).

116. Margaret Wilder & Helen Ingram, *Knowing Equity When We See It Water Equity in Contemporary Global Contexts*, *in* THE OXFORD HANDBOOK OF WATER POLITICS AND POLICY 49 (Ken Conca & Erika Weinthal eds., 2016).

117. *See* DEBORAH STONE, POLICY PARADOX: THE ART OF POLITICAL DECISION-MAKING 39–60 (1997); H. GEORGE FREDERICKSON, SOCIAL EQUITY AND PUBLIC ADMINISTRATION: ORIGINS,

proportions across recipients.[118] For example, giving equal slices of cake to a class may be unfair or inequitable, if only a portion of the class contributed to making the cake and the other portion tried to sabotage the oven.[119] As one might imagine from even this simplistic example, there are earnest differences in opinion about what should constitute equitable distribution.[120]

In a democracy, choices among competing visions of equity are political dilemmas,[121] subject to deliberation.[122] Deliberation depends on participation (who is part of the conversation)[123] and accessibility (whether interested groups and individuals have access to the deliberative forum and subject matter).[124] For law in a modern democracy to be legitimate, and for deliberation to be meaningful, people need to see themselves in the law and the process behind it; or as Habermas put it, they need to perceive themselves as "authors."[125] As I argue in this article, the nature of algorithmic tools and the typical design process of such tools frustrates participation in and accessibility of deliberation—obscuring questions of equity.

Value-laden assumptions inherent in algorithm-assisted decision making can act as a barrier to equity. For example, consider Wilder and Ingram's concept of equity, developed in their 2016 synthesis of principles of equity in water governance.[126] They note that "[equity requires] engaging in a process of critical inquiry that delves into the value bias of existing institutions and processes, the openness and accessibility of political arenas, an appraisal of what and who is being served by water related decisions, and what and who may be left out."[127] In traditional governance institutions—for example, courts, legislatures, and collaboratives—what Wilder and Ingram propose is challenging, but not

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DEVELOPMENTS, AND APPLICATIONS 12–13 (2010); Mary E. Guy & Sean A. McCandless, *Social Equity Its Legacy, Its Promise*, 72 PUB. ADMIN. REV. s5, s5 (2012).

118. *See* STONE, *supra* note 117, at Chapter 3.

119. Deborah Stone lays out eight challenges to equality ("same size share for everybody") using a brilliant chocolate cake analogy to unpack the dimensions of equity, Nozick, and Rawls. *Id.*

120. *Id.*

121. *Id.* at 39; DANIEL BROMLEY, SUFFICIENT REASON: VOLITIONAL PRAGMATISM AND THE MEANING OF ECONOMIC INSTITUTIONS 16 (2010) ("In democratic states, these declarations of what must (or ought to) be done emanate from the judicial and parliamentary branches of government. That is, after all, the reason why these branches of government exist. It is in the discourses of parliaments—and the considerations of the courts—that debates about the relative merits of Y and ~Y take place. Although Paretian economists may feel uncomfortable at the prospect of making choices without prices (and thus without monetary estimates of $\sum \$V_Y$), this is a misplaced concern. Democratic structures and processes exist for precisely those purposes." (internal citations omitted)).

122. *See* BROMLEY, *supra* note 121, at 31–42.

123. *See* Sherry R. Arnstein, *A Ladder of Citizen Participation*, 35 J. AM. INST. PLAN. 216, 220 (1969).

124. Jonathon Skinner Thompson, *Procedural Environmental Justice*, 96 WASH. L. REV.__ (forthcoming 2022).

125. JURGEN HABERMAS, BETWEEN FACTS AND NORMS, CONTRIBUTIONS TO A DISCOURSE THEORY OF LAW AND DEMOCRACY 33 (1992) ("[M]odern law lives off a solidarity concentrated in the value orientations of citizens and ultimately issuing from communicative action deliberation.").

126. *See* Wilder & Ingram, *supra* note 116.

127. *Id.* at 11.

impossible.[128] Advocates and activists may readily perceive and counter deliberately hurtful assumptions, or dog whistles, and inadvertent assumptions in natural language. By contrast, with few exceptions,[129] uncovering, understanding, and addressing similar assumptions in algorithm-assisted decision making is more difficult.

A careful reader may be asking themselves, "Isn't equity in algorithm-assisted decision making just a question of getting the inputs right?" Dear reader, you are not alone. For some kinds of algorithm-assisted decision making—like screening decisions—models are particularly sensitive to inputs and training data.[130] Even in energy and environmental models, the choice of inputs drive outcomes. In one blatant example, an energy utility in the Pacific Northwest regularly argued that its resource adequacy model demonstrated that it could not retire old coal plants without sacrificing grid reliability.[131] In reality, the utility had set the parameters of the model to never consider reliability without existing plants.[132] Once the utility changed that parameter and allowed the model to consider whether it could have sufficient energy generation without old coal plants, the model output suggested that it could, in fact, retire plants without sacrificing reliability.[133] Garbage in, garbage out.

What focusing solely on inputs and parameters misses, though, are opportunities to foster procedural equity (who decides and how, of Lasswell[134]). As noted previously, the process of development is part of the algorithmic system. The network of individuals and organizations involved in the development of the model control what the inputs and parameters of the product are.[135] Beyond that, who is involved in the development of the model can also influence the process of development itself—expanding or constraining the world of stakeholders who could participate and influence the model.[136] Put another way, the rules and norms determining who is included in the development process and how their contributions are incorporated (or not) into the model influence access, and are therefore necessarily important for procedural equity.

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128. *Id*.

129. *See generally* Jon Kleinberg et al., *Discrimination in the Age of Algorithms*, 10 J. LEGAL ANALYSIS 114 (2019) (discussing how for screening algorithms, discrimination in algorithm-assisted decision making may be more apparent and fixable than discrimination among humans, without a machine intermediary).

130. *See* Kleinberg et al., *supra* note 72, at 22; Kleinberg et al., *supra* note 129, at 118.

131. Interview with CPUC Staffer (2020).

132. *See id.*

133. *See id.*

134. LASSWELL, *supra* note 99.

135. Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 824–31 fig.1.

136. *Id.*

III. Framework for Evaluating Value-Laden Assumptions in Algorithm-Assisted Decision Making

Drawing from the above literature review, I suggest the following six-part framework for evaluating value-laden assumptions in algorithm-assisted decision making (see Table 1). This framework is not intended to produce a straight yes or no answer to whether any particular decision support program is equitable or fully considers value-laden assumptions. It is intended, though, to provide a structure to answer some of the concerns posed by Schneider. It is also meant to serve as a guide for attorneys and policymakers for approaching algorithm-assisted decision-making tools, and to focus attention on attributes that may influence substantive and procedural equity in algorithm-assisted decision making.

There are two important caveats to this framework. First, the framework is primarily concerned with procedural equity. This is deliberate. Whether and to what extent algorithm-assisted decision making creates hidden inequitable impacts in energy or environmental processes, akin to say racial and gender bias in future earnings calculations[137] or biases in housing decisions,[138] is not currently known and is beyond the scope of this article to estimate. The tools discussed here are different from those in security or financial decision making in that natural resources and energy tools tend not to incorporate inputs from data that have direct ties to race or gender of individuals. So, in the environmental, energy, and natural resources context, following the inputs alone is not sufficient to begin investigating potential disparate impacts linked to algorithmic tools. Rather, opening up the design process and logic of the tools to inquiry, in other words, focusing on procedural justice, is a necessary first step to identify potential substantive equity issues.

Second, I am not suggesting in this Article that agencies should or should not increase public participation efforts in the creation, choice, or implementation of algorithmic tools. Broad inclusion efforts can backfire, exacerbating power differences and mistrust and should therefore be done with care and rigor.[139] Meaningful participation takes time, can be costly, and frequently requires technical capacity building or translation.[140] What I am suggesting is modest and pragmatic. Intermediate advocacy groups—for

137. Ronen Avraham & Kimberly Yuracko, *Opinion The use of race- and sex-based data to calculate damages is a stain on our legal system*, WASH. POST (Apr. 29, 2021, 1:41 PM), https://www.washingtonpost.com/opinions/2021/04/29/race-sex-based-data-legal-damages/.

138. Michele E. Gilman, *Poverty Lawgorithms A Poverty Lawyer's Guide to Fighting Automated Decision-Making Harms on Low-Income Communities*, DATA & SOCIETY (Sept. 15, 2020) (University of Baltimore School of Law Legal Studies Research Paper Forthcoming), https://ssrn.com/abstract=3699650.

139. Thompson, *supra* note 124.

140. *See id.*; Sonya Ziaja, *Lessons on Race and Place-Based Participation from Environmental Justice and Geography*, YALE J. ON REGUL.: NOTICE & COMMENT (Aug. 16, 2020), https://www.yalejreg.com/nc/lessons-on-race-and-place-based-participation-from-environmental-justice-and-geography-by-sonya-ziaja/.

example organizations like the Natural Resources Defense Council, which already participate in environmental and energy policy processes, and have some in-house expertise in energy and environmental issues—can use this framework to assess value-laden assumptions in algorithmic tools, and meaningfully open up this new policymaking fora to questions regarding equity in the world of normal human communication and dialogue. To put this another way, algorithms embed legal and policy assumptions without input from lawyers or policymakers. This framework provides a way for those groups to engage in the new fora.

Table 1

	Model Itself	**Design Process**
Uncertainty	How is governance and conflict represented? To what extent do the model's mechanisms for assigning weighted values and choosing optimal solutions reflect existing governance? What are the kinds of uncertainty in the system being modeled that simplification may obscure?	How is uncertainty communicated and to whom? Who is involved in determining sources of uncertainty?
Transparency	Is the logic of the model explicable? What aspects, if any, of the model are "black box" and unknowable? Are the inputs and parameters open to verification from outside sources?	Are participants in the design and implementation known?
Stakeholder Collaboration	Is stakeholder collaboration advisory or determinative? Is stakeholder knowledge incorporated into the model?	Who determines which stakeholders are relevant? With what parameters? Can stakeholders themselves expand who participates? To what extent do stakeholders

		determine processes for collaboration? How are disagreements among stakeholders and designers resolved?

IV. Cross Case Comparison and Application of Framework

How would this framework function in practice? Depending on the algorithms, some questions from the framework become more salient than others. This is best seen through comparison across models. Below I present and compare two models: one for water regulation and the other for energy planning. The comparison reveals that while both models influence law and regulation of these resources, they raise different issues of equity due to divergences in the models' design processes and logics.

A. Water Governance and Algorithm-Assisted Decision Making on the Sacramento River

The water of the Sacramento River, from its snowy headwaters at Mt. Shasta to its marshy delta, is the lifeblood of four competing uses: hydroelectric power production, aquatic habitat, urban use, and agriculture.[141] Although allocation across these uses is not necessarily zero-sum, the timing, amount, and quality for each of these uses can have negative implications for the others.[142] For example, hydropower generation can negatively impact aquatic habitat, but not total availability of water for urban or agricultural use.

Two systems regulate the flow and allocation of the Sacramento. There is the physical system of reservoirs which stores, diverts, and releases water.[143] Reservoirs also serve a role in flood control, releasing water before it topples over the dam.[144] And there is the social system of regulation, which depends on laws, litigation, and the administrative state to determine how those reservoirs

141. Cal. Dep't of Water Res., California Water Plan: Update 2018: Managing Water Resources for Sustainability 1-8 tbl.1-3 (2019), https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2018/Final/California-Water-Plan-Update-2018.pdf.

142. *See* Ziaja, *Rules and Values*, *supra* note 3; *see also* Carl J. Bauer, *The Long View of the Water/Energy Nexus Hydropower's First Century in the U.S.A.*, 60 Nat. Res. J. 173 (2020); Postel & Richter, *supra* note 4; Philip R. Wandschneider, *Neoclassical and Institutionalist Explanations of Changes in Northwest Water Institutions*, 20 J. Econ. Issues 87, 97–99 (1986).

143. *See* Cal. Dep't of Water Res., *supra* note 141.

144. *See* Ann D. Willis et al., *Climate Change and Flood Operations in the Sacramento Basin, California*, 9 S.F. Estuary & Watershed Sci. 1, 1 (2011).

operate.[145] The two systems together determine who gets what quantity and flow of water and when.[146]

From an engineering perspective, the main mechanism for managing water for flood control, distributing water to cities and farms, and protecting stream flow for aquatic habitat, is a single decision: when to release water from reservoirs. That decision is predetermined by the U.S. Army Corps of Engineers for the large dams along the Sacramento River.[147] When a reservoir is created, the Army Corps of Engineers sets the maximum fill line for that reservoir, for each month of the year. In water management jargon, this is called the "rule curve."[148] Of course, the rule curve does not prevent rain from falling or snow from melting; so, as "new" water enters the system behind the dam, the dam operator must release existing water to keep the maximum fill line at the Corps' specified limit.

Climate change challenges the prevailing operating rules and regulations for dams.[149] For most federal and federally funded dams, rule curves were set in the mid-twentieth century and were based on a limited historical sample of weather.[150] Those fundamental assumptions about seasonal precipitation, temperature, and evaporation rates no longer hold true.[151] Changing them to fit the emerging reality of climate change for any given reservoir is more politically difficult than one might expect. The rule curves for many large dams were created before the National Environmental Protection Act; changing the rules would require National Environmental Protection Act compliance, with associated costs and, at times, difficult reflections.[152] So, absent an act of Congress to either create an exemption or increase funding to the Corps, the old rules largely remain.

The network of state and federal law governing the physical regulation of the Sacramento River requires close coordination between state and federal agencies[153]—so close, in fact, that the federal agencies (National Oceanic and Atmospheric Administration and the Bureau of Reclamation) and the California

145. *See* Ziaja, *Rules and Values*, *supra* note 3; *see generally* Bauer, *supra* note 142.

146. *See* J.B. Ruhl & Robin Craig, *4°C*, 106 MINN. L. REV. 191, 255 (2021).

147. *See* U.S. ARMY CORPS ENG'RS, NEW BULLARDS BAR DAM AND RESERVOIR, NORTH YUBA RIVER, CALIFORNIA: WATER CONTROL MANUAL (2004).

148. Willis et al., *supra* note 144, at 1.

149. *See* Ziaja, *Rules and Values*, *supra* note 3; *see also* Willis et al., *supra* note 144, at 2.

150. *See* Ziaja, *Rules and Values*, *supra* note 3, at 343–44.

151. *Id.*

152. *See id.* at 343–44; Willis et al., *supra* note 144, at 3.

153. *See* Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 833 tbl.2 (on the energy side, the California Independent Systems Operator and the California Public Utilities Commission oversees energy procurement, the Federal Energy Regulatory Commission licenses hydropower operations; on the water side, the U.S. Bureau of Reclamation operates large multipurpose hydropower projects, the U.S. Army Corps of Engineers sets operating rules for maximum fill level of reservoirs, the State Water Resources Control Board oversees water quality licensing, the California Department of Water operates the state's large water conveyance system; the National Oceanic and Atmospheric Administration , the U.S. Fish and Wildlife Service, and the California Department of Fish and Wildlife all oversee aspects of aquatic habitat and species protection); Ziaja, *Rules and Values*, *supra* note 3, at 335–43.

Department of Water Resources share offices at the Joint Operations Center in Sacramento.[154] And while federal and state civil servants at the Joint Operations Center do communicate, the operating rules for the dams along the Sacramento River are largely uncommunicative to each other. Among the myriad agency rules for regulating stream flow from hydropower projects, few were designed with the other rules in mind.[155] And barely any of the operating rules consider the impact of the other dams along the same river.[156] On a systemwide level, it never made much sense for purposes of energy production, irrigation, or habitat protection, that operating rules are developed or implemented in isolation.[157] Climate change simply makes that more apparent by narrowing the margins for error.[158]

Algorithm-assisted decision making has proven to be a useful workaround to these limitations of existing law. After a decade of testing and modifications to water management algorithms, the California Department of Water Resources installed software at the Joint Operations Center.[159] The software, a program called INFORM, works alongside human water managers to regulate the flow of the Sacramento River.[160] What INFORM does, that the law does not, is coordinate reservoir operations across multiple spatial and temporal scales, while including short- and long-term weather and climate forecasts.[161] Here's what that means in practice.

Existing law and regulation are represented in INFORM through operational rules. These rules function by assigning numerical values to competing reservoir operations objectives—for instance, the highest values for flood control and the lowest values for hydroelectric power.[162] These are fed through a model that allocates water by optimizing for irrigation, habitat, energy, and other uses, while meeting minimum flow requirements across multiple reservoirs along the Sacramento River—represented as "nodes" in the INFORM

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154. *See* BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, JOINT OPERATIONS CENTER (2021), https://www.usbr.gov/mp/mpr-news/docs/factsheets/joc.pdf. For a livelier read about what the facility is like, see JOAN DIDION, *Holy Water*, *in* THE WHITE ALBUM 59 (1979).

155. *See* Joshua H. Viers, *Hydropower Relicensing and Climate Change*, 47 J. AM. WATER RES. ASS'N 655, 657–58 (2011); Willis et al., *supra* note 144, at 8 (A notable exception to this is the New Bullards Bar dam, whose operating manual mandates coordination with the St. Mary's dam, which was never built).

156. *See* Viers, *supra* note 155, at 658–59; *see also* Willis et al., *supra* note 144, at 4 (explaining that a notable exception to this is the New Bullards Bar dam, whose operating manual mandates coordination with the St. Mary's dam, which was never built).

157. *See* Viers, *supra* note 155, at 657–59.

158. *See* Huaming Yao & Aris Georgakakos, *Assessment of Folsom Lake Response to Historical and Potential Future Climate Scenarios 2. Reservoir Management*, 249 J. HYDROLOGY 176, 187–88 (2001) (discussing penalty parameters); *see also* Ziaja, *Rules and Values*, *supra* note 3, at 356–57.

159. *See* Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 837 fig.4.

160. *See id.* at 827.

161. *See id.*

162. *See* Yao & Georgakakos, *supra* note 158, at 187–88 (discussing penalty parameters); Ziaja, *Rules and Values*, *supra* note 3, at 356–57.

system.[163] The outputs of the optimization model are combined into model sets, which incorporate water-supply forecast over multiple time scales, incorporating short-term weather forecasts and long-term climate scenarios for the Sacramento River.[164] After a human water manager chooses the specific time horizon, INFORM then creates "runs" from the model sets and evaluates tradeoffs for water uses, before finally presenting the water manager with analyzed results for "optimal" operations management.[165] What multi-year studies confirm is that INFORM outperforms normal reservoir decision making for all objectives: hydroelectric generation, instream water use, and agricultural and urban water distribution.[166]

What is remarkable about INFORM from a legal and public policy perspective is that its representation of law and policy depends not just on law on the books, but also informal law as practiced and interpreted by water managers.[167] The development of INFORM depended on interviews and collaborations with a group of informed stakeholders and end-users from state and federal agencies.[168] Those collaborations influenced both the process used to develop and refine INFORM, and the final product itself.[169] Specifically, through interviews with reservoir operators, the INFORM design team learned that there were instances where operators felt they could deviate, even minutely, from regulations on the books.[170] The design team incorporated these perceptions and practices into the algorithms of INFORM.[171]

B. Integrated Resource Planning for Renewable Energy Build Out and Algorithm-Assisted Decision Making

By law, the energy system in California must change to reduce emissions.[172] By necessity, the same system must adapt to a changing climate.[173] The regulatory body tasked with ensuring that private energy utilities meet

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163. *See* KONSTANTINE GEORGAKAKOS ET AL., HRC – GWI FINAL REPORT: INTEGRATED FORECAST AND RESERVOIR MANAGEMENT (INFORM): IMPLEMENTATION OF A STAND-ALONE OPERATIONAL INFORM SYSTEM FOR THE CALIFORNIA DEPARTMENT OF WATER RESOURCES (DWR) 23, 27, 104 (2018).

164. *See id.* at 27, 101.

165. *See* Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 827–28.

166. *See* GEORGAKAKOS ET AL., *supra* note 158.

167. *See generally* Ziaja, *Role of Knowledge Networks*, *supra* note 3.

168. For a detailed discussion on the history of INFORM*,* see generally *id.*

169. *Id.* at 824–31 fig.1.

170. *See* Ziaja, *Rules and Values*, *supra* note 3, at 356–57.

171. *See id.*; *see also* Telephone Interview with Konstantine Georgakakos, Hydrologic Rsch. Ctr., Scripps Inst. of Oceanography, San Diego, CA. (Dec. 6, 2016); *see also* Interview with Guido Franco, Cal. Energy Comm'n, Sacramento, CA. (Apr. 6, 2016).

172. Clean Energy and Pollution Reduction Act of 2015, S.B. 350, 2015-2016 Leg., Reg. Sess. (Cal. 2015); *see also* 100 Percent Clean Energy Act of 2018, S.B. 100, 2017-2018 Leg., Reg. Sess. §§ 1–2 (Cal. 2018).

173. *See generally* 2 FOURTH ASSESSMENT: IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES, *supra* note 6.

renewable generation, grid reliability, and emissions reduction goals relies on a mathematical model to identify gaps in energy generation buildout.[174]

California's legislature has set increasingly ambitious targets to reduce GHG emissions, beginning with the passage of the California Global Warming Solutions Act of 2006.[175] By 2015, the legislature, in SB 350, set GHG emissions and renewable energy development targets for regulated electric utilities,[176] reducing "emissions by 40 percent by 2030, including efforts to achieve at least 50 percent renewable energy procurement, doubling of energy efficiency, and promoting transportation electrification."[177] The same law requires each regulated energy utility to submit a plan for renewable energy development—an Integrated Resource Plan (IRP)—to be evaluated by the California Public Utilities Commission (the Commission).[178] In most states, the goals of the IRP process would be handled through federally-regulated balancing authorities.[179] But, California's experience with failed deregulation in the 1990s, and growing environmental concerns in the 2000s, led the state to give authority to develop energy procurement planning to the Commission, keeping renewable energy concerns under state rather than federal oversight.[180] So, in response to SB 350, the Commission established the IRP and Long Term Procurement Plan (IRP-LTPP), an "umbrella" administrative proceeding to evaluate electricity procurement policies and capacity requirements.[181]

The Commission opened a quasi-legislative rulemaking to comply with the IRP directive in SB 350, resulting in an order a year later.[182] The order broadly outlined critical IRP implementation issues and addressed the need to undertake "comprehensive resource optimization," rather than planning on a resource-

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174. *See generally RESOLVE Renewable Energy Solutions Model*, ENERGY & ENV'T ECON., INC. (E3), https://www.ethree.com/tools/resolve-renewable-energy-solutions-model/ (last visited Dec. 27, 2021).

175. *See* California Global Warming Solutions Act of 2006, A.B. 32, 2005-2006 Leg., Reg. Sess. (Cal. 2006).

176. Cal. S.B. 350.

177. *Clean Energy and Pollution Reduction Act of 2015 (SB 350)*, CAL. PUB. UTIL. COMM'N, https://www.cpuc.ca.gov/sb350/ (SB 350 "requires the CPUC to focus energy procurement decisions on reducing greenhouse gas (GHG) emissions by 40 percent by 2030, including efforts to achieve at least 50 percent renewable energy procurement, doubling of energy efficiency, and promoting transportation electrification").

178. CAL. PUB. UTIL. CODE § 454.51–52; *see also* CAL. PUB. UTIL. COMM'N, 16-02-007, ORDER INSTITUTING RULEMAKING TO DEVELOP AN ELECTRICITY INTEGRATED RESOURCE PLANNING FRAMEWORK AND TO COORDINATE AND REFINE LONG-TERM PROCUREMENT PLANNING REQUIREMENTS (2016) [hereinafter 2016 ORDER INSTITUTING RULEMAKING].

179. For an overview of federally-regulated balancing authorities, see Hoff, *supra* note 31.

180. For a brief overview of deregulation and its aftermath, see CARL PECHMAN, CALIFORNIA'S ELECTRICITY MARKET A POST-CRISIS PROGRESS REPORT 2–4 (2007), https://www.ppic.org/wp-content/uploads/content/pubs/cep/EP_107CPEP.pdf.

181. *See* 2016 ORDER INSTITUTING RULEMAKING, *supra* note 178, at 3, 25; *see also Integrated Resource Plan and Long Term Procurement Plan (IRP-LTPP)*, CAL. PUB. UTIL. COMM'N, https://www.cpuc.ca.gov/irp/ (last visited Dec. 27, 2021).

182. *See generally* 2016 ORDER INSTITUTING RULEMAKING, *supra* note 178.

specific basis.[183] The Commission contracted with an energy and environmental consulting firm, Energy and Environmental Economics Inc. (or E3), to develop a decision support tool to assess energy procurement scenarios called "RESOLVE."[184]

RESOLVE is a capacity expansion model. It solves for optimal capital allocation,[185] grid reliability (whether energy supply meets demand throughout the year), and GHG targets.[186] The model conducts capacity expansion—building out virtual energy generation—to meet forecasted load growth, while complying with exogenously set GHG emissions constraints and resource adequacy requirements in a least-cost manner.[187] RESOLVE is not intended to dictate outcomes on its own. Its results are supposed to be advisory to the Commission.[188]

Like all models, RESOLVE necessarily depends on some simplification of the physical, legal, and political world it is representing. Geography and time in RESOLVE work differently than in reality. If RESOLVE were a person, and asked to draw what it thought California looked like, it would draw eleven separate buckets—each representing a different section of the California grid, or "renewable resource and transmission development zones."[189] Inside the buckets, there would not be any local distribution lines delivering energy to homes. What there would be, though, are four key inputs: the total amount of renewable energy generation that can be built; the energy output of renewables in each zone; the availability of transmission lines to integrate new renewables;[190] and the local resource adequacy constraints.[191]

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183. *See id*.

184. *See generally RESOLVE Renewable Energy Solutions Model*, ENERGY & ENV'T ECON., INC. (E3), https://www.ethree.com/tools/resolve-renewable-energy-solutions-model/ (last visited Dec. 27, 2021).

185. The capital cost allocation mechanism is important here because unlike thermal generation, wind and solar energy generation does not require fuel; so the more renewable generation is integrated into the grid, the higher the percentage of capital costs. Interview M. Chhabra (November 2020) (on file with author).

186. ENERGY & ENV'T ECON., INC., RESOLVE CAPACITY EXPANSION MODEL: USER MANUAL 3–4 (2019), https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2019-2020-irp-events-and-materials/resolve-user-guide—-public-release-20191106.pdf.

187. Inputs & Assumptions: 2019-2020 Integrated Resource Planning, CAL. PUB. UTIL. COMM'N 4–5 (NOVEMBER 2019), https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2019-2020-irp-events-and-materials/inputs--assumptions-2019-2020-cpuc-irp_20191106.pdf.

188. *See* 2016 ORDER INSTITUTING RULEMAKING, *supra* note 178, at 13–15.

189. Nick Schlag et al., *RESOLVE Model Overview IRP Modeling Advisory Group* 15 (2016). https://www.cpuc.ca.gov/-/media/cpuc-website/files/legacyfiles/i/6442451316-irp-mag-e3-resolve-2016-10-20.pdf.

190. *Id.* (Slide 16: This input dictates when the model builds more renewables without transmission, or more renewables alongside new transmission).

191. Local resource adequacy, for example, considers how much energy production capacity must exist in each bucket, considering how much each bucket could import from the others. *Id.* at Slide 16.

RESOLVE's sense of time is similarly idiosyncratic. Instead of representing sequential weather conditions that lead to changes in the number of heating degree days or cooling degree days—needed to measure resource adequacy on a day to day level—RESOLVE relies on a selection of weather data from thirty-seven, non-sequential days to represent the range of weather conditions in a year.[192] Despite its oddities, or perhaps because of them, RESOLVE has been used to great effect by other jurisdictions like Hawai'i[193] and the Pacific Northwest's Public Generating Pool.[194] RESOLVE's core simplification (geography in buckets, and time as non-sequential samples) makes quickly running different scenarios feasible. Problems arise, though, when RESOLVE's outputs are taken to be prescriptive.

C. Comparison of Value-Laden Assumptions in INFORM and RESOLVE across Uncertainty, Transparency, and Stakeholder Participation

The framework divides algorithm-assisted decision-making tools into two components: the model itself and the design process behind the model. Under each, questions target how uncertainty, transparency, and stakeholder collaboration lead to or resolve value-laden assumptions. The answers to these questions uncover how the values of the network designing the model are embedded in the algorithms.

1. Uncertainty

The bulk of the framework's investigation into uncertainty is on the model side. The framework first considers how governance and conflict are represented. Governance here means the mechanisms by which choices between objectives are determined. In both INFORM and RESOLVE, the mechanism of governance is literally mechanical, a quantified optimization problem. The choice of which course of action, whether reservoir operation or building renewable energy, is determined by assigning values and solving for least-cost solutions. In essence, they function much like market mechanisms—given no externalities.

The framework then asks about the extent to which the model's mechanisms for assigning weighted values and choosing optimal solutions reflect existing governance. INFORM and RESOLVE both diverge significantly from existing real-world governance. In the real world, governance of multi-objective reservoirs is determined through law, negotiated agreements between state and

192. Interview with M. Chhabra, *supra* note 185.

193. *See Case Study Cost Effective Pathways to Hawaii's 100 Percent RPS Goal*, ENERGY & ENV'T ECON., INC. (E3), https://www.ethree.com/projects/cost-effective-pathways-hawaiis-100-percent-rps-goal/ (last visited Feb. 26, 2021).

194. *See Case Study Study of Policies to Decarbonize Electric Sector in the Northwest I Public Generating Pool, 2017 – Present*, ENERGY & ENV'T ECON., INC. (E3), https://www.ethree.com/projects/study-policies-decarbonize-electric-sector-northwest-public-generating-pool-2017-present/ (last visited Mar. 14, 2021).

federal governments, and litigation.[195] The "value" of choices and their consequences are not determined by numerical value or exchange value, but through deliberation.[196] Governance of renewable energy build out and planning for energy resource adequacy is a bit different from water resources governance because it includes real world market mechanisms,[197] in addition to law and local utility regulation. So, RESOLVE determines numerical values for future renewable build out to meet GHG reduction, future energy needs, and resource adequacy goals. As one stakeholder put it, "[t]he trouble is that these values are determined by key inputs and assumptions of how the market would work and how regulations would be enforced; i.e., these are most likely outcomes given perfect knowledge of future market forces, regulation, and politics. But things don't always play out as planned."[198] For example, economic pressures external to those considered in RESOLVE could force existing gas-powered plants to suddenly retire, as several in California did.[199] Such retirements change the type and amount of renewable generation actually needed for resource adequacy. In short, there are numerical values associated with energy build out and resource adequacy that drive RESOLVE. The trouble for RESOLVE is that it is the modelers who choose what those values are, rather than arriving at those values as the result of a true market.

Building from these two initial questions, the framework then inquires about the kind of social-ecological-technical system being represented, whether there are sources of inherent uncertainty in such a system, and whether simplification preserves or obscures those sources. INFORM, for example, can only model and represent a few of aspects of the Sacramento River.[200] It does not consider how habitat or population changes may develop with climate change or how changes to reservoir operations influences instream temperature for various threatened species.[201]

As one member of a technical advisory committee to RESOLVE put it, "[the model] is deterministic and doesn't model uncertainty."[202] The simplified governance mechanism in RESOLVE may obscure uncertainty surrounding a key input. For energy modeling, it is difficult to tell what the price of energy will be because prices are influenced by exogenous factors to the market. For

195. *See*, *e.g.*, CAL. PUB. UTIL. COMM'N, FACT SHEET: DECISION ON 2019-20 ELECTRIC RESOURCE PORTFOLIOS TO INFORM INTEGRATED RESOURCE PLANS AND TRANSMISSION PLANNING (2020), https://www.cpuc.ca.gov/-/media/cpuc-website/files/legacyfiles/i/6442464699-irp-2019-rsp-fact-sheet-v3.pdf.

196. Inputs & Assumptions, *supra* note 187, at 4-5.

197. *Id*. (California did experiment with relying solely on market mechanisms during deregulation, which resulted in part in massive rolling brown outs and inflated consumer costs).

198. Interview with M. Chhabra, *supra* note 185.

199. *See* Mark Specht, *Natural Gas Power Plant Retirements in California*, UNION CONCERNED SCIENTISTS: EQUATION (Feb. 25, 2019), https://blog.ucsusa.org/mark-specht/gas-retirements-california/.

200. *See* Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 837.

201. *Id*.

202. Interview with M. Chhabra, *supra* note 185.

example, regional balancing authorities, under federal guidance, can require utilities to enter into energy procurement contracts with specific generation sources, in order to ensure resource adequacy.[203] Balancing authorities also can set the price for those contracts.[204] The existence of those contracts can shift the market price for other energy procurement.[205] The influence of these contracts is not modeled in RESOLVE.[206] Yet, energy price inputs in RESOLVE are outcome determinative.[207]

Turning to uncertainty in the design process, the framework asks about the social processes surrounding communication of uncertainty: How is uncertainty communicated and to whom? Who is involved in determining sources of uncertainty? The INFORM research team communicated uncertainty in the model to the working group at semiannual working group meetings.[208] The working group similarly discussed system uncertainty with the researchers at the same meetings.[209] For RESOLVE, model uncertainty is discussed openly by the modelers to the working group.[210]

2. Transparency

Transparency is closely related to uncertainty. The more uncertainty exists (both known and unknown) in a model, the less transparent it is likely to be. But, as the framework questions and literature review above illustrate, there are other influences on transparency. The framework begins by asking whether the logic of a model is explicable. This question is not concerned with sources of uncertainty from inputs, parameters, or the system being represented. It simply asks whether it can be explained how an algorithmic tool arrives at its conclusion.

There are degrees of transparency and opacity here. An algorithmic tool could be a black box, such that even its designers are not clear on how the program learns and produces outcomes.[211] There are models that are relatively simple, like RESOLVE. And then there are models whose logic is nominally explicable, but difficult for even experts to understand. INFORM falls into this latter category. The math behind INFORM is not unknowable, but it is especially

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203. Severin Borenstein & James Bushnell, *The U.S. Electricity Industry After 20 Years of Restructuring* (Nat'l Bureau of Econ. Rsch., Working Paper No. 21113, 2015), https://www.nber.org/system/files/working_papers/w21113/w21113.pdf; Severin Borenstein et al., *Expecting the Unexpected Emissions Uncertainty and Environmental Market Design* 24 (Nat'l Bureau of Econ. Rsch., Working Paper No. 20999, 2018), https://www.nber.org/system/files/working_papers/w20999/w20999.pdf.

204. *See* Borenstein & Bushnell, *supra* note 203; Borenstein et al., *supra* note at 4.

205. *See generally* Borenstein & Bushnell, *supra* note 203; Borenstein et al., *supra* note 203.

206. *See* ENERGY & ENV'T ECON., INC., *supra* note 186, at 3–4.

207. *See id.;* Interview with M. Chhabra, *supra* note 185.

208. Ziaja, *Role of Knowledge Networks*, *supra* note 3.

209. *See id.*

210. Interview with E3 staff (February 4, 2021) (on file with author); Interview with CPUC Staffer, *supra* note 131; Interview with M. Chhabra, *supra* note 185.

211. Note, this is a significant problem for many kinds of machine-learning. Ananny & Crawford, *supra* note 42.

complicated. There is a story from the history of INFORM, prior to its adoption, in which the Department of Water Resources was approached to potentially fund the development of INFORM. As the story goes, the Department refused, stating that the math was "too complex."[212] In response, the researchers brought in a trusted third-party water expert, winner of a MacArthur "Genius" Fellowship, to give the Department his take.[213] He blessed the project, but noted that he did not understand the math either.[214] Answers to this question, therefore, will vary based on who is trying to understand the model, and are likely to be subjective in most cases.

The framework also asks a more objective question regarding transparency in the model: whether the inputs and parameters are open to verification from outside sources. The Commission requires that RESOLVE be transparent.[215] It operates under a public license and the data sources are likewise open to the public.[216] Because INFORM is operated by the Department of Water Resources, its inputs are subject to the state's public records act.[217] However, some parameters are opaquer. From prior interviews it is evident that when developing the model, the researchers consulted reservoir operators and included parameters to represent circumstances under which operators felt they could deviate from law on the books.[218] But none of the researchers interviewed could recall what those parameters were.[219] The result is that there are elements of the model that are obscured and may no longer be knowable.

Regarding the design process, the framework posits another objective question: are the participants in the design and implementation known? In the case of the two models discussed here, both RESOLVE and INFORM are state funded and the development and implementation process are matters of public record. In both cases, the participants are known or discoverable.

3. Stakeholder Collaboration

Both INFORM and RESOLVE have had technical advisory groups, where outside interested parties can ask questions about the model and collaborate in its design. How those groups came to be, their operating rules, and their roles diverge. INFORM's technical advisory group developed as a result of contract requirements between California and the researchers developing the model, in

212. Ziaja, *Role of Knowledge Networks*, *supra* note 3 at 838.
213. *See id.*
214. *See id.*
215. CAL. PUB. UTIL. COMM'N, *supra* note 195.
216. *See RESOLVE Model Inputs and Results Used for 2019 IRP Reference System Plan Decision*, CAL. PUB. UTILS. COMM'N (Mar. 23, 2020), https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2019-20-irp-events-and-materials/resolve-model-inputs-and-results-used-for-2019-irp-reference-system-plan-decision.
217. *See* California Public Records Act, CAL. GOV'T CODE §§ 6250–6270.7.
218. Ziaja, *Role of Knowledge Networks*, *supra* note 3 at 827–28.
219. *Id.*

addition to the researchers' own interest in collaborative design.[220] The technical advisory group started relatively small and later expanded as group members suggested bringing in other technical experts.[221] Participants in the collaboration were therefore all part of the same network of highly technical experts who knew one another.

For RESOLVE, the Commission required a technical advisory group and held working group meetings to facilitate collaboration.[222] The meetings are open to the public;[223] in theory, anyone could attend and add their input. But the Commission proceedings are highly specialized and technical. Meetings are also held during normal working hours,[224] making it very difficult for a person or group to contribute unless doing so is already tied to their profession. The result, in practice, is that all members of the working group are industry insiders.

The framework begins by asking two questions about stakeholder collaboration and the functioning of the model itself. First, is stakeholder collaboration advisory or determinative? For INFORM's process, stakeholder collaboration was determinative. It also depended on consensus decision making. No one voice controlled.[225] For RESOLVE, the working group is purely advisory. It is ultimately up to the modelers and the Commission to decide what inputs and design parameters to use. Second, and related, is stakeholder knowledge incorporated into the model? For both RESOLVE and INFORM, knowledge from the working groups changed inputs to the model.[226]

The framework then turns to three sets of questions regarding the design process. First, who determines which stakeholders are relevant and included in the process? Those who determined the stakeholders relevant to the development of INFORM changed over time.[227] At the beginning, the researchers took an interest in developing connections with specific federal and state agencies that could end up using their product.[228] From there, once the product development was funded by government agencies, those agencies determined which additional stakeholders should be on the technical advisory committee for the project.[229] However, once the advisory committee began to meet, the participants could, and did, suggest additional stakeholders who would be interested in the outcome or

220. *See id.* at 838.

221. *See id* at 839.

222. CAL. PUB. UTILS. COMM'N, IRP MODELING ADVISORY GROUP CHARTER (2019), https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpucwebsite/content/utilitiesindustries/energy/energyprograms/electpowerprocurementgeneration/irp/2018/irp-modeling-advisory-group-charter-v7.pdf.

223. *Id.*

224. Interview with E3 staff, *supra* note 210; Interview with CPUC Staffer, *supra* note 131.

225. Interview with working group participants (on file with author).

226. For detailed INFORM results from the working group, see Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 824–31 Fig.1.

227. *Id.* at 836–39.

228. *Id.* at 836–38.

229. *Id.*

who could provide specific input to shape the model.[230] Thus, stakeholders could expand who participated in the design process of INFORM. The process was different for RESOLVE. On paper, it was the administrative law judge, with advice from a staffer within the analysis division of the Commission, who weighed the input and advice of stakeholders before determining which comments influence the development of RESOLVE.[231] In practice, the opinions of the regulated utilities, the expertise of the modelers, and the political pressures of the moment can add a thumb to the scale.

Second, to what extent do stakeholders determine processes for collaboration? For RESOLVE, stakeholders do not formally drive the collaboration, but rather the process is determined by the Commission.[232] However, since several of the participants are from organizations with few staff, some will informally work together, strategize, and jointly submit comments to divide up the work.[233] For INFORM, the minimum standards for collaboration were set by the funding agencies.[234] Once initial advisory group meetings took place, stakeholders and researchers jointly determined the process for collaboration.[235]

And third, how are disagreements among stakeholders and designers resolved? This question gets at the power dynamics between stakeholders and designers. The answers determine whose vision, and at times associated assumptions, are embedded in the algorithmic tools. For INFORM, disagreement was resolved through discussion of working group members and researchers.[236] For RESOLVE, disagreements are synthesized by the assigned administrative law judge, who then makes a recommendation to the Commission.[237]

V. EQUITY CONSIDERATIONS

Drawing from Wilder and Ingram's concept of equity,[238] we can now "engag[e] in a process of critical inquiry that delves into . . . the openness and

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230. *Id.* at 839.

231. *See*, *e.g.*, ADMINISTRATIVE LAW JUDGE'S RULING SEEKING COMMENTS ON PROPOSED PREFERRED SYSTEM PLAN, ORDER INSTITUTING RULEMAKING TO CONTINUE ELECTRIC INTEGRATED RESOURCE PLANNING AND RELATED PROCUREMENT PROCESSES (Aug. 17, 2021) https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M399/K450/399450008.PDF.

232. Interview with working group participants, *supra* note 225.

233. Interview with M. Chhabra, *supra* note 185.

234. *See* Ziaja, *Role of Knowledge Networks*, *supra* note 3, at 843.

235. *Id.* at 839.

236. Interviews with working group participants, *supra* note 225.

237. *Id*. For an example of comments, see Comments of the Natural Resources Defense Council (NRDC) on 2019-2020 Electric Resource Portfolios to Inform Integrated Resource Plans and Transmission Planning, in Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long Term Procurement Planning Requirements (Mar. 12, 2020), https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M329/K437/329437858.PDF.

238. *See* Wilder & Ingram, *supra* note 116.

accessibility of political arenas, an appraisal of what and who is being served by . . . decisions, and what and who may be left out."[239]

On its face, a straight comparison of the two models, without considering the design process, would suggest that RESOLVE is more transparent than INFORM. While the internal logics of INFORM and RESOLVE are largely similar in that they solve for least-cost solutions to given parameters, they differ in their complexity. A core attribute of RESOLVE that makes it appealing to multiple jurisdictions is the relative simplicity of its design and how easily it is explained to decision makers. INFORM, on the other hand, is tailored to a single jurisdiction, significantly more complicated, and difficult to explain.

Transparency, however, is not the same as accessibility.[240] Even though RESOLVE is relatively simple, its limitations are routinely misunderstood, even by informed members of the technical advisory group.[241] In interviews with modelers, members of the technical advisory committee, and end users, there was no similar evidence that INFORM was misunderstood.[242] This is notable since both RESOLVE and INFORM had educational components and opportunities for collaboration built into their design processes. Both had technical advisory committees that met regularly with the modelers.

But there are key differences between these two advisory committees. RESOLVE's committee is nominally more open. Parties to the quasi-legislative proceeding vary in the kind of expertise they bring, their organizational missions, and their technical capacity. Within the Commission itself, a high turnover rate among staff results in lack of institutional memory from meeting to meeting.[243] Membership on INFORM's committee, on the other hand, was essentially by invitation only. Even though the network that comprised INFORM's committee expanded over time, the characteristics of the members remained stable.[244] Everyone was an expert in the field and had a background as a researcher or as a worker in state or federal civil service.[245]

It seems from these two cases that for stakeholders to understand the models and therefore be able to meaningfully contribute to their development, those stakeholders need an extraordinarily high level of technical expertise, and the available time (or economic interest) to commit to providing input. For both INFORM and RESOLVE, the network of active and expert stakeholders influences the inputs and parameters for the two tools—driving the development and implementation of water and energy regulation, and those systems' adaptation to climate change. Ultimately, these networks are embodied in the decision support systems they create.

239. *Id.*
240. *See*, *e.g.*, Ananny & Crawford, *supra* note 42.
241. Interview with E3 staff, *supra* note 210; Interview with M. Chhabra, *supra* note 185.
242. Ziaja, *Role of Knowledge Networks*, *supra* note 3.
243. Interviews with working group participants, *supra* note 225.
244. *See* Ziaja, *Role of Knowledge Networks*, *supra* note 3.
245. *Id.*

Here, we run straight into the main tension between the need to rely on these tools and the need for participation. If (1) the focus on equity is who is being left out and whether the political arena is open and accessible; (2) the ability to influence algorithm-assisted decision-making tools depends on high technical capacity along with an economic or mission interest; and (3) the network of people and organizations who do participate in the development of the model influence inputs and parameters which embed value-laden assumptions and biases; then are algorithmic tools destined to be inequitable in environmental governance? And because of our dependence on these tools, are environmental, natural resource, and energy planning doomed to be increasingly inaccessible and inequitable with greater complexity? Possibly.

But the two cases and the framework provide some hope. Even though not all stakeholders in the RESOLVE process completely understood the model, they nonetheless are able to comment and raise their concerns to decision makers and modelers alike. At a minimum, this means that decision makers are at least aware of the concerns and can act accordingly. The open process of development still serves a governance function. The history of INFORM, meanwhile, demonstrates that close collaboration between modelers and stakeholders is possible. In short, there are degrees of accessibility. Both INFORM and RESOLVE could have had far more closed processes.

In the end, the framework presented in this Article can be boiled down to a single question: is equity (substantive and procedural) included in the network for producing algorithmic tools? By assessing how uncertainty is created and communicated, the extent to which a model and its process of development are transparent, and the role of stakeholders in the production of the model, the framework provides a way for legal practitioners and advocates to approach the question of equity in algorithm-assisted decision making. It also allows them to become involved in making these tools more equitable.

CONCLUSION

What is at issue when considering algorithm-assisted decision making in environmental law is not programming, the rise of machines, or any such prelude to sci-fi fantasy. What we are talking about is a new kind of augmented governance.[246] In essence, these algorithmic tools are new fora for decision making and the development of law to take place. This kind of forum has different rules than a legislative body, court, or city council; the rules in the new forum require abstraction, simplification, and quantification to function. The process by which values are defined, debated, and weighed in democratic institutions is fundamentally different from how values are determined in algorithm-assisted decision making. The players in the forum are different as

246. Notably, computer models in American environmental law have been around for over 40 years. *See*, *e.g.*, Fine & Owen, *supra* note 54. However, compared to other governance fora in democracies, for example, legislatures, courts, or even administrative agencies, these are still quite new.

well. Instead of lawyers, judges, commissioners, or legislators, the new forum relies on engineers, programmers, and a variety of technical experts. It is still governance, though, subject to the same concerns and deserving of the same level of scrutiny as more longstanding institutions. Concerns about existing power imbalances in decision making across race, class, or geography[247] are relevant to how decisions are made within mathematical models.

For climate adaptation and complex water and energy system planning, this is an indispensable form of governance. Although it is not, and should not be expected to be, a crystal ball into the future, algorithm-assisted decision making provides decision makers and stakeholders with multiple possible scenarios, which can account for potential changes to short- and long-term climate. As seen in INFORM, these tools also offer a quick workaround to some of the inherited shortcomings of existing water and energy law. As seen in RESOLVE, these tools also influence how regulators conceptualize existing energy issues and plan for the future. In short, algorithm-assisted decision-making tools influence what environmental law is and how regulation is implemented.

The trade-off for all of us is that access and accountability are sacrificed in this new forum.[248] Few decisions have such a direct impact on the health and wellbeing of communities and ecosystems as choices in water and energy regulation. Even absent climate change, decisions about energy and water are highly technical, jargon-laden, and nuanced. Nonetheless, organizations, scholars, and litigators invest time and expertise to communicate potential inequities in water and energy decision making to the public and hold decision makers accountable. In the new forum of algorithm-assisted decision making, uncertainty and lack of transparency can make doing so near impossible.

The framework I propose in this Article offers a practical means for attorneys, watchdog organizations, and responsible decision makers to examine and assess algorithmic tools in a holistic manner. By considering sources of value-laden assumptions across uncertainty, transparency, and stakeholder collaboration, this framework indicates inflection points for substantive equity. By also considering the process of development, this framework incorporates lessons from the past two decades of social science on the importance of networks for the legitimacy and acceptability of scientific products.

It is an old trope that law was the last profession to give up the feather quill.[249] We do not have the luxury of time, in this case, to ignore that algorithmic

247. *See* Ziaja, *supra* note 140.

248. This is not to say that older fora are necessarily open and transparent or do not create issues of subordination. *See* Michael B. Gerrard, *Presidential Progress on Climate Change Will the Courts Interfere With What Needs to Be Done to Save Our Planet?*, AM. CONST. SOC'Y at 2 (2021) (discussing the Supreme Court's shadow docket and unsigned order staying the Clean Power Plan), https://scholarship.law.columbia.edu/faculty_scholarship/2740; Matthew B. Lawrence, *Subordination and Separation of Powers*, 131 YALE L.J. 78 (2021). But at least they are in language we can criticize and discuss.

249. In more contemporary terms, it is among the last to give up Word Perfect.

tools are becoming part of the fabric of environmental law. These tools are not going away. And, because they are by nature technical, necessarily rely on simplifications, and embed the value-laden assumptions and biases of the networks that create them, these tools threaten to deepen the divide between technocracy and democratic participation in environmental decision making, while eroding equity. Without more active participation in their development and implementation from a broader range of stakeholders (let alone lawyers and policymakers), the rules by which these tools operate and the rules they begin to impose on social and ecological systems will be driven by the value-laden assumptions of a remarkably small group of people. It is imperative to understand these tools on their own terms, while finding ways to bring them more in line with ideals of democratic participation and processes; to compare their understanding of governance to what we want governance to be; to understand how these tools influence existing governance; and to develop assessment tools and aids to foster substantive and procedural equity in their development. I present the framework and examples here to begin this needed work and to offer them as an invitation to dialogue.