Integrating Hybrid Artificial Intelligence Technology into Energy Policy

Dwight Ledet

University of Stavanger

27 November 2020

Socio-technical imaginaries involving smart technology limit and prioritize future outcomes. Scenario planning commonly includes ideas about technological possibilities and imagines the use of specific technologies. This framing promotes current and available technology, providing support and funding to various projects based on a bias towards the future use and value of technology, absent any consideration for changing social practice. This paper looks at socio-technological imaginaries and their role in the discourse about the future of energy policy. The analysis is informed by the Multi-Level Perspective and will discuss the impact of socio-technological imaginaries on current and future policy. Bearing in mind the simultaneous and symbiotic evolution of social practice with technology, this paper highlights the benefits of embracing a new technology based, socially oriented view of energy policy.

Considering the scope of my argument, a multi-disciplinary method is required. Using the MLP as a guide, I will navigate various schools of thought, borrowing from computer science, philosophy, economics, politics and social theory. All the while, I will remain tethered to the MLP and its ability to examine various, landscape, regime and niche levels of socio-technological transition. Since the MLP will play such a crucial role in the analysis, it is fitting that I begin with a brief assessment of its arguments, strengths and weaknesses. After the MLP assessment, I will address the current state of play in the field of climate and energy policy highlighting the failure of our human understanding of issues at landscape magnitude. I will then introduce the use of machine learning and artificial intelligence (AI) in niche level technologies and theorize the application of AI to energy and climate policy decisions. Finally, I will conclude with my remarks concerning the use of machine learning and AI in global energy policy decision making that supports the need for introducing AI into the policy mix.

The Multi-Level Perspective (MLP) is a middle range systems theoretical framework. It consists of three levels, landscape, regime and niche. The landscape is beyond human intervention. It is the catalyst, is distributed globally and, at times, necessitates significant and drastic changes at the regime level. The regime consists of actors, human and non-human participants, across the socio-technological spectrum, from technology, policy and energy systems on one side to "firms, policy-makers, politicians, consumers, civil-society, engineers and researchers" on the other (Geels 2011, p.24). Finally, at the niche level there is another set of actors similar to the regime level, but lacking agency. Niche actors and technology exist outside of the regime and gain access through structural fractures in the regime caused by inexplicable changes in the landscape.

The total workings of the MLP are best seen as a cellular non-biological mutation (Geels 2002, p. 1272). Niche actors and technology function outside and independent of regime functions and enter the regime during times of system restructuring. As an autopoietic, self-replicating, mechanism, all of the tools required for continued regime level maintenance and survival exist inside the regime. Sometimes, landscape dynamics open the allegorical, double lipid regime bilayer to the environment forcing the regime to obtain sustenance from the niche level. Niche technology and actors best suited for the regime during restructuring caused by external forces in the landscape are absorbed into the regime and become part of a newly formed, mutated regime structure. This assessment, borrowed from the field of organic biology, places the MLP somewhere between the more general systems theories of Talcott Parsons and Niklas Luhmann.

As an example, changes at the landscape level, such as global warming, that are often beyond human control, create fractures in the existing socio-technical regime and allow for the introduction and implementation of niche technologies (Geels, 2011). Regime level actors resist changes to the system, an aspect of the MLP that borrows from ideas like paradigm, Thomas Kuhn (1996) and habitus, Pierre Bourdieu (2015). The movement of niche technologies into the regime proceeds through various pathways depending on a number of variables e.g., political and economic in the system. Even in simple language the MLP's complexity provides important insight into the difficulty of socio-technological transitions and speaks directly to the impossibility of human capabilities with respect to global warming and energy policy.

It is necessary to risk a tangent here in order to correct a common flaw in current thinking regarding the landscape level in the MLP. There is a strong tendency among researchers to place politics in the landscape level. Modern vernacular allows for political and economic landscape terminology, but existence in the linguistic field is not a precursor for inclusion into the MLP landscape. While the Marxist in me feels the economic system is more suited to positioning at the landscape level, personal investments in Luhmann prevent even this allowance and situate both the political and economic systems at the regime level. The landscape level in the MLP is reserved entirely for second law thermodynamic social thinking and any repositioning of the political, economic, or any other system, can only take place between the regime and niche levels in the MLP. Mutations do not occur in the heavens. I consider the ability to flounder on this point one of the MLP's primary weaknesses.

At the landscape level the MLP operates like the Braudelian longue durée popularized by the Annales School (Geels, 2011, p. 28). This aspect of the MLP is useful for examining the symbiotic relationship between humans and technology - a relationship that often clouds the waters of objective analysis. As explained above, the desire to place specific forms of human intervention at the landscape level provides sustenance to the idea that humans are capable of predetermining and shaping events in the landscape. The realization of the lack of knowledge, prior to scientific discoveries, of the human impact on the climate is not corrected by an overzealous assessment of the power of human scientific understanding. Borrowing from Neil deGrasse Tyson (2017), the universe is not obligated to make sense to us. As Braudel (2008) explains in his work on Mediterranean societies, in order to gain a deeper level of understanding it is necessary to view events in a locality from a much larger field of vision. While the human mind is capable of understanding politics and economics in the macro, it is insufficient for a realistic comprehension of the landscape as it is defined in the MLP. The distinction drawn, here ends the tangent.

The IPCC (2018) published a special report with the stated goal of assessing the impact of global warming for the specific purpose of advising policy makers on the threat of climate change, "sustainable development, and efforts to eradicate poverty" (p.4). The report includes language referring to policy instruments, policy design, policy tools and policy mixes that all point to the role of human intervention in current policy regarding global warming and sustainable development. It warns that public acceptability will be based on "the individual's evaluation of expected policy consequences" and how this distribution is perceived based on the distribution of consequences and the "fairness of decision procedures" (IPCC, 2018, p.22). I claim, the time for concern over policy consequences has drawn to a close and without swift, meaningful action we are doomed to sympathize ourselves into extinction.

Attempts to determine the role of imaginaries on current policies are possible, but we must recognize that the dynamic nature of socio-technological evolution renders it useless in the long term. As Bataille (2012) states, "to subordinate is not only to alter the subordinated element but to be altered oneself" (p. 41). This struggle means, as technological advances present themselves to an ever-changing social system, their sustained existence is nearly impossible to predict. In this way, while actors may be physically planted in the regime level of the MLP, psychologically they are forever part of the landscape.

The inability to predict social responses to changing technology makes it difficult to determine the best course of action in current energy policy. As Kojève (1980) suggests, "the human brick changes during the construction, just as the human mason and the human architect do" (p. 32). As a result, smart energy systems must find a workaround for human reactions. The most sensible and equitable solution to the variability of social systems is deep machine learning and Artificial Intelligence (AI).

A number of academics have addressed issues of policy in regard to energy transitions. Kern and Rogge review the state of current policy frameworks and reflect on "their usefulness in the context of sustainability transitions" (Kern & Rogge 2018, p. 103). A survey of political theory makes for excellent armchair reading but does little or nothing to motivate requisite action. James Meadowcroft (2009) looks at the role of governance and politics in shaping the long-term trajectory of policy in advanced industrial nations. He cautious us against dramatic changes that overturn large systems that impact "consumers and reaches down into the patterns of their everyday lives" (Meadowcroft, 2009, p. 337). While I agree with Meadowcroft in theory, the time constraint forced upon us by a rapidly changing climate demands immediate action. Further, the unknowable social response to changes in energy technology render useless any "kid gloves" decision making process. The human incapacity to make truly binary decisions based solely on data and absent any concern for impacted social systems necessitates a transition to AI based policy making technology.

AI is a branch of machine learning that uses computational systems to mimic neurological process in the human brain. These artificial neural networks can be trained using vast amounts of data to perform functions beyond the capacity of previous computer technology and in many ways far superior to human intelligence. The caveat here is, while humans remain superior to computers in their ability to process complex data, they will always be inferior to computers in their ability to do so absent emotion or bias. In other words, while the human mind is still the most powerful computer on the market, culture has rendered it incapable of making rational choices on a global scale. In terms of climate and energy policy, rational, pure, logical and ruthless decision making is necessary, and AI based neural networks exceed our human capacity in this arena. As they are capable of making decisions in an emotional vacuum, neural networks are also the go to mechanism for insuring a “just transition” to renewable energy and “climate justice” as set out in the Paris Agreement (UNFCCC, 2015. P. 21).

Neural networks have been proposed as a solution for various renewable energy technologies. In their comparison of neural networks for wind speed forecasting Gong Li and Jing Shi (2010) highlight the benefits and limitations of three models - adaptive linear element, back propagation, and radial basis function - based on performance. Although Li and Shi only used one year’s worth of data in their modeling, they provide valuable insight into the technological advances in computational machine learning.

A deep dive into the workings of neural networks is beyond the scope of this essay, but a brief explanation is necessary in order to highlight the differences between machine learning and traditional algorithms. An adaptive linear network (Adaline) is a powerful differential model, capable of providing solutions to linearly separable items – this or that in Boolean terminology. Feed forward back propagation networks use hidden layers in the neural network to feed incorrect test results back through the network. These errors are weighted through a sigmoid or rectified linear unit (ReLU) function and fed forward again through a series of epochs used to train the network. In addition to this or that decisions, they are capable of processing this and that scenarios. The radial basis network involves multi-input, single output neurons and provides a non-zero output response (Li & Shi 2010, pp. 2314-2315). Each of these networks has advantages and disadvantages for windspeed forecasting, and research on these and various other networks is ongoing.

Researchers (Yang et al., 2019) have also trained neural networks to forecast electricity pricing using three indicators relating to electricity generation, distribution and consumption. Their ability to accurately predict electricity pricing using hybrid forecasting systems shows that neural networks are capable of predicting future commodity prices with greater accuracy than human calculations. These examples show that the adaption of neural networks in renewable wind energy is a promising niche technology capable of development into the regime if energy policies are implemented.

This superficial explanation shows that, unlike traditional algorithms, machine learning and AI are not designed to follow decision trees in the conventional sense. Neural networks learn from data sets and, after they are trained, can provide solutions to complex problems beyond human comprehension. The volume of data that can be provided to a neural network is staggering and their output remains securely behind the veil of ignorance.

Although, referencing the MLP, some AI technologies have made their way into the regime, AI based smart systems primarily exist at the niche level. A common argument against AIs ability to gain traction at the regime level is the fear of human supplication to the machine. Humans lost that battle when people started feeding plants to engines. Another common argument against AI technology specifically and automation in general is the displacement of workers in the energy sector. In order to insure a just transition for energy workers, policies need to address the future educational and employment needs of the workforce. Existing and future renewable energy systems require human intervention and workers at various levels of the energy sector will find employment in industries that remain essential for the production of energy. This employment transition involves policy planning for educating and transitioning workers currently employed in the fossil fuel industry into various positions within the renewable energy sector. Humans remain capable of policy decisions regarding a latent work force. For this reason, a hybrid policy making AI technology can be implemented.

Energy efficiency is the greatest single solution to issues involving climate change. Global warming's hyperobjectivity (Morton, 2010) necessitates AI, specifically the application of AI on energy efficiency. There is little use developing smart technological systems for people who will not turn off the lights when leaving a room. The application of deep machine learning and AI on smart grid technology and the Internet of Things (IoT) supersedes humanities ontological inability to see the damage a single lightbulb can do. Implementing AI into energy policy and energy systems overrides this hyperobjectivity and its structure, unlike historic human based computational algorithms, eliminates cultural bias leading to more effective overall policy determinants.

Shifting from a centralized energy grid into a decentralized AI controlled smart grid is a first step. Allowing for direct communication from smart grids to the IoT will involve policies that set the general course of technology on various transformation pathways (Geels et al., 2016). While it is difficult to predict the particular pathway resulting from a climate policy shifting from human to AI technological systems, studies on transformations in renewable technology can provide insight into possible directions. Geels (2002) shows the MLP to be a useful tool for studying technological transitions through an examination of socio-technological configuration in transportation. Studying sustainable transitions to offshore wind in Norway, Normann (2015) acknowledges their dependance on technology-specific policies and concludes that the complexity of these policies is not fully understood. Normann's analysis shows, landscape level issues such as climate change, are not always sufficient for the exploitation of windows of opportunity for niche technology (Normann, 2015, p. 190). Issues such as "technical feasibility and cost" undermine efforts to bring offshore wind technology to Norway and political conditions influence "the development of renewable energy technologies" (Normann, 2015, pp. 190-191). This inability to forecast transformation pathways, making the framework something akin to GPS in the past tense, underscores the need to bring AI into policy decision making.

Humans are incapable of making the fundamental shift from policies that are based upon current cultural and localized economic realities towards a general economy (Bataille, 2013) that, through its application of the second law of thermodynamics, considers universal energy consumption in its entirety. The most effective next step is to implement the functions of AI in energy policy. "The possibility of pursuing growth is itself subordinated to giving" (Bataille, 2013, p. 25), and technology incapable of human traits - greed, lust, pride, fear, inter alia - is best suited to provide society with solutions that enable the equal distribution of renewable energy on a global scale.

Reiterating my position that economics and politics involve human intervention, placing them firmly in the regime level, there are numerous arguments for various policy-based transition theories rooted in the maintenance of economic growth through renewable energy transitions. None of these available theories provide an explanation as to why economic growth is necessary. I argue, it is not. When economic growth is removed from the equation, energy policy becomes clear: reduce the negative human impact on the environment at any cost or face extinction. Confronted with that choice, human based political and economic systems are not unlike the alcoholic who, when faced with absolute ruin, cannot summon the will to quit drinking. It is therefore necessary to remove humans from the apparatus of decision making; to not only introduce AI systems into a decentralized energy grid complete with IoT technology, but also into the climate and energy policy making system itself.

The AI applications I have described are, individually and collectively, beyond human comprehension. The magnitude of just one implementation of AI in the technical, political or economic system is immense. And yet, we are continent to believe the human mind capable of processing all three. This is so far outside the realm of human capacity it is absurd. Social systems wrought with bias and emotion are constrained and incapable of determining the best course of action. We must resign as general managers of the universe, and hand control over climate and energy policy making to machine learning and AI.

Change has come to the environmental landscape, and it has shaken the regime to its core. Business as usual will not provide humanity with the tools needed for continued survival. It may seem that I am suggesting ecological genocide. Verily, that holy terror has already arrived, and the limiting factor preventing its full acceptance stems from equal parts hubris and hyperobjectivity. The time to wrest control of energy transitions from those who seek to profit from them has passed; and, lacking any other reasonable arbiter, we must relinquish partial policy determinants over to the unhuman.

References

Bataille, G., & Hurley, R. (2012). *Theory of religion*. New York: Zone Books.

Bataille, G. & Hurley, R. (2013). *The accursed share. essays on general economy*. New York: Zone Books.

Bourdieu, P. (2015). *Distinction: A social critique of the judgement of taste*. London: Routledge, Taylor & Francis Group.

Braudel, F. (2008). *The Mediterranean and the Mediterranean world in the age of Philip II*. Berkeley: Calif. Univ. Press.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, *31*(8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002

Geels, F. W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., Neukirch, M., & Wassermann, S. (2016). The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014). *Research Policy*, *45*(4), 896–913. https://doi.org/10.1016/j.respol.2016.01.015

IEA (2019), World Energy Outlook 2019, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2019

IPCC, 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* [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.)].

Kern, F., & Rogge, K. S. (2018). Harnessing theories of the policy process for analysing the politics of sustainability transitions: A critical survey. *Environmental innovation and societal transitions*, *27*, 102-117.

Kojève, A. (1980). *Introduction to the reading of Hegel*. Ithaca, NY: Cornell University Press.

Kuhn, T. S. (1996). *The structure of scientific revolutions*. Chicago: The University of Chicago Press.

Lahn, B. (2020). A history of the global carbon budget. *WIREs Climate Change*, *11*(3). https://doi.org/10.1002/wcc.636

Li, G., & Shi, J. (2010). On comparing three artificial neural networks for wind speed forecasting. *Applied Energy*, *87*(7), 2313–2320. https://doi.org/10.1016/j.apenergy.2009.12.013

Meadowcroft, J. (2009). What about the politics? Sustainable development, transition management, and long term energy transitions. *Policy sciences*, *42*(4), 323.

Normann, H. E. (2015). The role of politics in sustainable transitions: The rise and decline of offshore wind in Norway. *Environmental Innovation and Societal Transitions*, *15*, 180–193. https://doi.org/10.1016/j.eist.2014.11.002

Sovacool, B. K., Hess, D. J., Amir, S., Geels, F. W., Hirsh, R., Rodriguez Medina, L., Miller, C., Alvial Palavicino, C., Phadke, R., Ryghaug, M., Schot, J., Silvast, A., Stephens, J., Stirling, A., Turnheim, B., van der Vleuten, E., van Lente, H., & Yearley, S. (2020). Sociotechnical agendas: Reviewing future directions for energy and climate research. *Energy Research & Social Science*, *70*, 101617. https://doi.org/10.1016/j.erss.2020.101617

Tyson, N. D. (2017). *Astrophysics for people in a hurry*. New York: W. W. Norton & Company.

UNFCCC. *Adoption of the Paris Agreement*. Report No. FCCC/CP/2015/L.9/Rev.1, http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf (UNFCCC, 2015)

Yang, W., Wang, J., Niu, T., & Du, P. (2019). A hybrid forecasting system based on a dual decomposition strategy and multi-objective optimization for electricity price forecasting. *Applied Energy*, *235*, 1205–1225. https://doi.org/10.1016/j.apenergy.2018.11.034