



Perspectives

Explaining technological impacts without determinism: Fred Cottrell's sociology of technology and energy

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ARTICLE INFO

Keywords:

Energy and society
Human ecology
Technology studies
Degrowth

ABSTRACT

Fred Cottrell's pioneering work on the energy-society interface is built on a sociology able to explain technology's social and environmental impacts without relying on technological determinism. While technology conditions the types of possible social structures and value hierarchies that are amenable to its physical feedback and the range of ends that can be pursued through its use, societies choose whether or not to adopt technologies, and how they are used, based on preexisting social structures, values, ecological and geographical conditions, and, as stressed by Cottrell, power inequalities. Through this framework, Cottrell made substantial and still pertinent contributions, including a call for a social science that is conscious of the likelihood of future shrinking energy throughput relevant to discussions surrounding planned economic contraction ("degrowth"). To help illuminate the unique elements of his approach, Cottrell is compared to the following overlapping figures: Leslie A. White, Julian Steward, Lewis Mumford, and Howard T. Odum.

1. Introduction: the pioneering "interdisciplinary maverick" and his scattered influence

In line with projects in the environmental social sciences, energy studies, and technology studies that excavate and explicate past ideas for fresh insights (e.g., [1–10]; [11]: ch. 2), the purpose of this project is to revisit W. Fred Cottrell's pioneering work on the society-energy interface to learn how to better theorize the social and environmental impacts of technology and energy. In his *magnum opus*, *Energy and Society* ([12]: 2), Cottrell states:

[t]he thesis of the book is simple. It is that the energy available to man limits what he *can* do and influences what he *will* do. It will not be easy to establish, for the energy converters man uses are embedded in a social matrix in which it is difficult to distinguish the relationships primarily connected with technical operations from those primarily of social origins.

My goal is to integrate and systematize Cottrell's sociology of technology and energy, a framework which helps explain both the social and environmental impacts of technology and energy and how society and ecology have impacts on technology adoption and use.

After receiving his PhD from Stanford University in Political Science with a Minor in Sociology, Cottrell joined Miami University to teach courses in sociology and political science, and later served as the Chairman of the Department of Sociology and Anthropology (1959–1969), and Director (1964–1974) and Special Consultant

(1974–1979) of the Scripps Foundation [13,14]. In the autobiographical "The Saga of a Maverick" [13], Cottrell explains that his lifelong interest in the interaction of social structure, technology, ecology, values, and agency is rooted in his life history. Born in Idaho Falls, Idaho, in 1903, he grew up in Milford, Utah, which became a transcontinental railroad station in his youth. Along with his parents' devotion to community service, Cottrell [13] states that the Great Basin Desert's ecology and the railroad had an important effect on his later analyses. He started working for the Union Pacific Railroad in his early teens as a machinist apprentice, and, later, as a clerk, carpenter, and telephone line hanger, among other jobs (see also [15]: v–vi). Cottrell's underlying thesis came as a "revelation" as he observed different social groups interact in and around Milford—including the railroad and mining industries, Mormon farmers, and the Paiute—with different values and interests in how to direct energy flows (personal communication with Bob Cottrell 1/27/18; see also [13]). When reflecting on the arrival of the railroad in his hometown and the kinds of decisions the latter had to make about which infrastructural projects were worthy of immediate or extended energy (e.g., to build a school or a hospital), he states, "[i]t has never been possible for me to think of a human ecology that didn't involve choices" ([13]: 145). Attention to choice-making conditioned by social structure, power, values, and the natural and built environments sits at the heart of Cottrell's framework, allowing for explanations of technological and energetic impacts that evade both voluntarism and determinism.

Cottrell is less explicit about his intellectual influences and it is

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<https://doi.org/10.1016/j.erss.2018.03.002>

Received 19 December 2017; Received in revised form 24 February 2018; Accepted 2 March 2018
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difficult to accurately pigeonhole the self-described “interdisciplinary maverick” [13] into a school of social scientific theory. Broadly, his framework is a form of systems human ecology that attempts to account for feedback from both social and physical factors while consciously avoiding technological or environmental determinism. The discussion that follows below investigates clues about his intellectual influences and puts his ideas into conversation with overlapping figures to help illuminate the unique features of his approach. It is worth noting here that Eugene A. Rosa’s excellent reviews of “energetic theories of society” with Gary Machlis and Kenneth M. Keating [1,16] favorably evaluate Cottrell relative to other twentieth-century theories that explore the impact of energy on society.

If the intellectual influences on Cottrell are not always clear, the intellectual influence of Cottrell is dispersed. It is dispersed in the sense that Cottrell did not establish a concentrated school of thought, for at least two reasons: (1) his work was ahead of its time [17]—for example, the 1970s energy crisis brought wide attention to *Energy and Society*, a book written two decades prior [14]—and (2) his Department did not have a PhD program. Despite the latter fact, papers presented at a 1972 program on Cottrell’s social scientific contributions were published as a special supplement of an issue of *Sociological Focus* (6[4]) [18], including contributions from former Miami University students [17–20].

Cottrell’s influence is also dispersed in its crossing of disciplinary boundaries. He is cited as a forerunner of, and often a pioneer in, the following areas:

- The interdisciplinary and social-scientific study of energy [1,16,21–24]
- Ecological economics/bioeconomics [25–29]
- Environmental sociology [30–33]
- Material flow analysis/industrial ecology [34]
- Industrial sociology [20]
- Gerontology [35]

Ecological economists and those in energy studies, broadly conceived, continue to approvingly cite and sometimes discuss his work, including Cleveland [28,36,37] and Martinez-Alier (e.g., [38,7,26]). Cottrell’s concept of *surplus energy*, the “energy brought under man’s control in excess of that previously under his control which was expended to secure it” ([39]: 93), is a predecessor of the energy returned on energy invested (EROI) index ([36,40]; [41]: ch. 14). Within environmental sociology, Cottrell’s ideas make relatively frequent appearances in William R. Freudenburg’s work (e.g., [42,92]), who formulated a valuable interpretation of *Energy and Society* reviewed in the beginning of Section 4.

As the impact of Cottrell’s pioneering ideas about energy, technology, and society is widely dispersed without solidifying in a coherent form, this project integrates his ideas, which, when “taken together ... fall together into a grand system” ([20]: 135), focusing on those related to technology, energy, and the environment. In what follows, I first provide a brief overview of Cottrell’s major works on technology and energy and sketch the breadth of his contributions (Section 2). Then I integrate his ideas concerning the social dimensions of technology with a special emphasis on the relations between power, social structure, and energy converter adoption (Section 3). Following, I summarize his general arguments about the social and environmental impacts of energy use, highlighting his ecological concerns (Section 4). Section 5 compares Cottrell’s views with overlapping thinkers. I conclude with a systematized summary of Cottrell’s sociology of technology and energy (Section 6).

2. An overview of Cottrell’s corpus

Cottrell’s interest in technology and energy spans his entire catalog. His first article, “Time and the Railroader” [43] examines the impact of technology and work on time consciousness (discussed in Section 3)

and *The Railroader* [15], his first book, explores how railroad occupational relations, largely organized around technology use and maintenance, shape personality, group life, and lifestyle.

In addition to his international prize-winning essay “Men Cry Peace” ([44]; see also [45]) and a chapter on urban development and nuclear power [46], Cottrell publishes his two most well-known technology- and energy-related works in the 1950s: “Death by Dieselization” in 1951 and *Energy and Society* in 1955. “Death by Dieselization” [62] details the uneven social impacts that a change from steam to diesel engines has on a railroad town (for Cottrell’s reflection and update, see [47]). Taking 15 years to write ([13]: 151), *Energy and Society* [12] forms the core of his thinking. I primarily draw from the revised version of the book [48], based on a manuscript updated throughout the years, much of it during the early 1970s, found by his son Bob Cottrell in 2008 (personal communication with Bob Cottrell, 2/1/18).¹ The environmental implications of the work are clearer in the revised version. Section 3 discusses “Death by Dieselization” and *Energy and Society* is essential to Section 4.

Throughout the 1960s and 1970s, Cottrell continues to publish works on technology and energy [49–51], often in the context of railroading [52–55], and helps establish the field of gerontology through pieces primarily concerned with the technological and energy dimensions of aging ([39,56,57]; see [35]). These works clarify *Energy and Society*’s arguments as well as spell out the ecological implications of his perspective, notably in his last reflection “Energy and Sociology” [51]. Both Section 3 on the social dimensions of technology and Section 4 on energy’s impacts on society draw from this period of work.

3. Technology in the “social matrix”: power, values, structure, and choice

Cottrell’s work charts the course between two broad categories, choice-making and the “facts of the material world” (technology, geography, and ecology), with two guiding assumptions ([19]: 111):

- (1) Technological, geographic, and ecological features and changes can alter the “order in which values are satisfied” (i.e., technology and biophysical world are not merely static-passive features) ([19]: 111).
- (2) Choice-making can follow interaction with technological artifacts and biophysical things. Along with symbolization, the active-practical use of the given material artifact is a part of social learning (see [50]; [48]: 143–145).

Technology is both “caused” by social, geographic, and ecological conditions and has “effects” on these conditions. These organizing assumptions are already present in his first article, featured in *American Sociological Review*, where Cottrell ([43]: 191, 195) explains why railroaders are “a slave to the clock” and adopt an “extreme time-consciousness” that carries over into other social relationships: (1) they are responsible for thousands of tons of steel and people and/or freight moving very quickly and (2) time is a determination of exchange value in capitalist society (for review and comparison with more recent data, see [58]: 333ff). Both theses reflect theoretical arguments developed throughout his work: (1) feedback from “the nature of things” ([43]: 191) influences social life and (2) social interests and values condition the way technology and energy are used.

While Cottrell ([54]: 8) acknowledges that to use some technologies requires “immediate, direct, and unavoidable impacts,” he rejects mechanistic thinking in all forms because determinism relies on tautological arguments ([50]: 33), cannot predict the specific impacts of newly

¹ The revised version is available for free online via *The Encyclopedia of Earth*: [https://editors.eol.org/eoearth/wiki/Energy_and_Society:_The_Relationship_Between_Energy,_Social_Change,_and_Economic_Development_\(e-book\)](https://editors.eol.org/eoearth/wiki/Energy_and_Society:_The_Relationship_Between_Energy,_Social_Change,_and_Economic_Development_(e-book)).

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