

### 3 Energy and Industrial Film

#### Energo-Critical Registers

*Thomas Turnbull*

##### Abstract

Given growing interest in environmental aspects of film, this chapter proposes an energo-critical approach to industrial film, notable for depicting combustive processes, by suggesting four registers for reading such thermodynamic imagery: First the sensorial, which quantifies aspects of energy conversion. Second, energy is recognized in a physicist's sense, as a capacity to do work, pointing to the augmentation and denigration of human labour. Third, the imperative to save energy via increasing efficiency, a central characteristic of industrial film, manifest in portrayals of power transfers and transformations. Fourth the motif of friction is affirmed as various off-screen resistances impose themselves on the extractive processes of industry. Far from comprehensive, these registers offer starting points for reading energy's increasing pertinence back into film.

**Keywords:** thermodynamics; sensorium; efficiency; labour; friction

This chapter reflects upon the role of energy in industrial film. These reflections were prompted by my attendance at “Films That Work: The Circulations of Industrial Cinema,” a conference held in Frankfurt in December 2015. Many of the films screened documented the productive activities of private and publicly owned fuel companies, including Royal Dutch Shell, British Petroleum (BP), the Arabian-American Oil Company (ARAMCO), Italy's state-owned Ente Nazionale Idrocarburi (ENI), the Czech Pražská železářská společnost (PŽS), and Britain's National Coal Board (NCB), and there were two panels on “The Politics of Performance: Energy and Work.” Alongside industrial films from these fuel companies,

there were also a number of films relevant to the topic of energy in so far as the products they depicted were prominent consumers of energy both in their production and use, from American automobile firm Chevrolet to Italy's Fiat, and from the heavy industry of South Yorkshire's United Steel to the brewing processes of Dublin's Guinness. In the following discussion, drawing on films screened at this conference and others, my intention is to argue that industrial cinema can be analysed in at least four ways that are congruent with the physicist's concept of energy, understood as a capacity for work, in what I term a "thermodynamic reading" of industrial film.

In proposing these films can be addressed from the perspective of thermodynamics, I suggest the study of industrial film might benefit from considering the significance of energy as an aspect of form, content, and transmission.<sup>1</sup> What significance does the concept of energy, an assessment of a system's potential to do work, dictated by the laws of thermodynamics – laws of energy conservation and dissipation – hold for industrial film? Geographer Andrew Barry has recently argued that the concept of energy has been curiously under interrogated by social theorists, despite a growing interest in new kinds of materialist analysis and the reaffirmation of the obdurate physicality of the world as a locus of its agency. His proposed solution to this oversight is to suggest that researchers should document how energy, as it is understood by physicists and engineers, becomes folded into social life, primarily via measurements of conversion and efficiency, and manipulations in its form.<sup>2</sup> However, energy also acts upon society in more diffuse, indirect ways. Laws of energy have both shaped and been shaped by culture in significant ways, as historians of science and more recent eco-critics have demonstrated. These fields, offer a number of observations appropriate to the study of industrial film. Drawing on this scholarship, I argue here that a thermodynamic reading of industrial film can be pursued on at least four registers: those relating to the senses, the derivation of work, efficient use, and as a source of friction.

Can seemingly inviolable physical laws be considered as cultural artefacts? In their reading of Paul Theroux's novel *The Mosquito Coast* (1981), historians of science Ian Higginson and Crosbie Smith discussed the influence of the culture of New England Puritanism on the central protagonist, Allie Fox, who

1 A debt is owed to Thomas Pringle, who offered advice. His work in this same direction helped inspire and clarify my own thinking. Pringle, Thomas. "Photographed by the Earth: War and Media in Light of Nuclear Events." *NECSUS European Journal of Media Studies*, vol. 3, no. 2., 2014, pp. 131–54.

2 Barry, Andrew. "Thermodynamics, Matter, Politics." *Distinktion: Journal of Social Theory*, vol. 16, no. 1, 2015, pp. 110–25.

has committed his working life to the creation of a monstrous ice-making machine called “Fat Boy.” Rather than doomsday, this machine is a means by which Fox is able to pit himself against the universe’s tendency toward entropy, disorder and chaos. In their reading, Higginson and Smith suggest the novel rejects “an ‘essentialist’ history of thermodynamics (in which the science has some sort of independent, monolithic and timeless existence) in favour of a cultural history in which the science itself is shaped by the cultures in which it is practiced.”<sup>3</sup> As a Calvinist, Fox considers entropy as imperfection, and ice making as means of personal salvation. Their thermodynamic reading of Theroux’s book built on Smith’s contextual understanding of the science of energy in nineteenth-century Glasgow, in which a local culture of entrepreneurial engineers, Presbyterian enthusiasm for personal thrift and an eschatology of humankind’s sinfulness helped establish a particular understanding of energy and its imperative to pursue perfectibility in an imperfect world. In Smith’s account, culture lent credibility to and borrowed from the science of energy.<sup>4</sup>

A few years before Smith, historian Gillian Beer noted the dissonant cultural implications prompted by the discovery of a “progressive” evolutionary theory around the same time as the more pessimistic science of thermodynamics. In 1852 Glaswegian engineer William Thomson had written of the “universal tendency in nature to the dissipation of mechanical energy,” which led him to predict the eventual death of the Sun and, consequently, of life on Earth. Beer noted how these competing eschatologies generated a vast amount of imaginative literary work that reflected the anxieties prompted by a universe of seemingly depleting power, from George Eliot’s *Middlemarch* (1871) to H.G. Wells’ *The Time Machine* (1895).<sup>5</sup> Beer’s work emerged independently around the same time as a form of cultural studies referred to as “ecocriticism.” Prompted by environmental concerns, since the 1990s ecocriticism has undertaken the interdisciplinary task of “ecologizing” cultural artefacts, reaffirming the environmental composition and significance of literature, art, film, *inter alia*, whilst also identifying the presence of “the environment” in areas where it is less obviously present.<sup>6</sup>

3 Higginson, Ian, and Crosbie Smith. “A Magnified Piece of Thermodynamics’: The Promethean Iconography of the Refrigerator in Paul Theroux’s *The Mosquito Coast*.” *British Journal for the History of Science*, vol. 32, no. 3, 1999, pp. 325–42.

4 Smith, Crosbie. *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain*. Athlone Press, 1998.

5 Beer, Gillian. “The Death of the Sun’: Victorian Solar Physics and Solar Theory.” *Open Fields: Science in Cultural Encounter*. Oxford University Press, 1996.

6 Garrard, Greg, editor. *The Oxford Handbook of Ecocriticism*. Oxford University Press, 2014.

A sub-field of ecocriticism soon emerged that could be termed energo-criticism, in that its proponents sought to discern how the science of energy both expressed and informed the cultural milieu from which it emerged. For example, literary critic Barri Gold suggested Alfred Tennyson's *In Memoriam* (1851), a romantic elegy for his recently deceased friend, Arthur Hallam, could be interpreted as a "brilliant work of thermodynamics," which drew on the science of energy to mourn his loss whilst also celebrating the conservation of his friend's spirit in the form of a "diffusive power."<sup>7</sup> Gold's work joined a growing body of thermodynamic interpretations of literature, which sought to discern the cultural significance of energy in the work of a range of authors, from Joseph Conrad to Thomas Pynchon.<sup>8</sup>

Film studies also entered a period of ecological reflection, with the editor of a recent collection of essays calling for the adoption of an "ecocritically informed standpoint toward all forms of cinematic productions, not just those that overtly focus on environmental issues."<sup>9</sup> Adrian J. Ivakhiv's *Ecologies of the Moving Image* (2013) has called for an "ecophilosophy of the cinema," an engagement with the ecological implications of film, and a reconsideration of it as media that does not just document environments, but is an agent of environmental change in and of itself. An ecology of film, in Ivakhiv's approach, should not only involve the "material ecologies" of film production and broadcasting; it should also consider "perceptual ecologies," moving images that have the capacity to alter our perception of, or relation to, the world.<sup>10</sup> Amid this ecocritical turn, there has been an increasing emphasis on the role of energy in film, as both a subject and means of understanding the physicality of film production, its materiality, projection, and the reception of filmic images.

Of direct relevance to industrial film, Nadia Bozak has argued that "[c]inema has always demonstrated an awareness of its industrial self and therefore a connection to the environment, the realm from which it derives its power, raw materials and, often enough, subject matter." What is often considered an ephemeral and largely immaterial medium is, Bozak argues, grounded in a material and energetic substrate. She

7 Gold, Barri. *Thermopoetics: Energy in Victorian Literature and Science*. MIT Press, 2010, p. 56.

8 MacDuffie, Allen. "Joseph Conrad's Geographies of Energy." *English Literary History*, vol. 76, no. 1, 2009, pp. 75–98; Seed, David. "Order in Thomas Pynchon's 'Entropy'." *Journal of Narrative Technique*, vol. 11, no. 1, 1981, pp. 135–53.

9 Willoquet-Maricondi, Paula, editor. *Framing the World: Explorations in Ecocriticism and Film*. University of Virginia Press, 2010.

10 Ivakhiv, Adrian. *Ecologies of the Moving Image: Cinema, Affect, Nature*. Wilfrid Laurier University Press, 2013.

points out that we can rightly consider the cinematic image as “fossilized light, thus practically and metaphorically equating cinema with the geological dimensions of the naturally derived fuels (fossilized sunlight) that continue to enable industrial society and culture.”<sup>11</sup> At least one reviewer of Bozak’s work has suggested she marks the prelude to a coming “energy era in film studies.”<sup>12</sup>

Bozak suggests the material and energetic embeddedness of film often remains overlooked in its popular forms, aside from overtly “environmental” films such as Al Gore’s *Inconvenient Truth* (2006), owing to presumed disinterest of consumers and the diktats of commercialism. In industrial film, in which often the extraction and transformation of raw materials is the primary subject, we find many exceptions to this oversight. In support of this argument, we can also point to Bozak’s notion of the “resource image,” the idea that cinematic depiction does not merely turn material things into ephemeral moving forms – film becomes a resource in and of itself. Resource images render “visible the subordination of nature as the root of industrial culture.”<sup>13</sup> This subordination occurs in the resource making of cinema: the manipulation of the photochemical process, light and the mechanisms of recording and projection allow the storage and conveyance of moving images over space and time.

Nature’s subordination to industry is, of course, readily apparent in industrial film, as raw materials – through manual and mechanical exertion – are rendered into useable products. In industrial film we directly encounter what Bozak terms the “image of a resource,” the documentation of the material and energetic basis of productive processes that “displays rather than disguises the energy economy’s less than sublime origins.”<sup>14</sup> If post-war industrial film was intended to celebrate industry’s artful manipulation of matter and pursuit of material progress, the eschatological implications of contemporary environmental concerns has considerably altered the reception of such images. Industrial film can now be considered as testament to society’s misplaced faith in energy-driven perpetual growth.<sup>15</sup>

11 Bozak, Nadia. *The Cinematic Footprint: Lights, Camera, Natural Resources*. Rutgers University Press, 2012.

12 Banita, Georgiana. “Prelude to the Energy Era in Film Studies” [review of *The Cinematic Footprint: Lights, Camera, Natural Resources* by Nadia Bozak]. *Imaginations*, vol. 3, no. 2, 2012, pp. 208–09.

13 Bozak. *The Cinematic Footprint*, p. 54.

14 *Ibid.*, p. 127.

15 Mitchell, Timothy. “Economentality: How the Future Entered Government.” *Critical Inquiry*, vol. 40, no. 4, 2014, pp. 479–507.

## Energy as Sensorium

In its close documentation of the transformation of raw materials into secondary goods, industrial film provides accounts of physical changes in state achieved via the exertions of human and mechanical means for directing energy. As sociologist and business historian James Beniger has noted, manufacturing, at its most abstract, is simply “the synthesis of matter and energy into more organized forms.”<sup>16</sup> For film and media scholar Florian Hoof, beside their promotional role, industrial films can be seen as repositories of evolving managerial knowledge regarding these organizational processes. Management consultants adopted film as a means of governing “processes of labour” and, we can suggest, flows of energy.<sup>17</sup> In the film *Master Hands* (1936) we see the stages of manufacture by which a Chevrolet was assembled in the Flint, Michigan, automobile plant.<sup>18</sup> We see a worker, off-screen, apply a matchstick to ignite a taper, and then a blowtorch bursts into flame and is inserted into a furnace. We see torrents of molten metal, and the eventual casting of the automobile’s engine. All this productive power results from the thermic energy of a single matchstick. As Beniger explains, in manufacturing a “system can only sustain work if its internal energy is purposively organized in a heat gradient.”<sup>19</sup> Production requires the transfer of energy from one system to another, according to differences in chemical potential or temperature. We see energy in the consequences of these transfers, the result of its successful conversion or wasteful diffusion.<sup>20</sup> In a volume documenting the first “Films That Work” conference, Vinzenz Hediger suggested a crisis in visibility had occurred in industrial film at the cusp of the information age, as manufacturing became directed at the manipulation of symbols rather than forms. In discussing computerized control in German industry, specifically Krupp, he pointed

16 Beniger, James. *The Control Revolution: Technological and Economic Origins of the Information Society*. Harvard University Press, 1986.

17 Hoof, Florian. *Angels of Efficiency: A Media History of Consulting*. Oxford University Press, 2020, p. 15.

18 The film was the work of the Detroit-based Jam Handy Organization, which specialized in making “soft sell” educational films on behalf of industry that contained an underlying commercial imperative. Prelinger, Rick. “Smoothing the Contours of Didacticism: Jam Handy and His Organization.” *Learning with the Lights Off: Educational Film in the United States*, edited by Devin Orgeron et al. Oxford University Press, 2011.

19 Beniger. *The Control Revolution*, p. 46.

20 Shove, Elizabeth. “Revealing the Invisible: Sociology, Energy, and the Environment.” *International Handbook of Environmental Sociology*, edited by Michael Redclift and Graham Woodgate. Edward Elgar, 1997.

out that the physics of production were no longer readily apparent, so film required animated annotation to explain how computerized industry worked. Computers were animated as if they were heat engines, in an attempt at instructive communication he terms “thermodynamic kitsch.” By contrast, he notes, in “the thermodynamic age work, and the control of work, were essentially tied to visibility.”<sup>21</sup> Production required acts of combustion or mechanical manipulation. Whilst the central protagonist, energy, remains invisible, via acts of transduction, there is no crisis of visibility in more physical productive processes.

In industrial film, the sensorial aspects of energy conversion come to the fore. In *Substance and Function* (1910), a systematic account of the role of concepts in scientific reasoning, philosopher of science Ernst Cassirer suggested the emergence of the modern concept of energy meant energy now superseded matter as the fundament of objective reality. In fact, it could even explain human perception. Quoting chemist Wilhelm Ostwald, Cassirer noted that: “What we see is nothing but radiating energy, which effects chemical changes in the retina of our eye that are felt as light.”<sup>22</sup> Cassirer’s use of Ostwald was intended to remind the reader that alongside conversion efficiencies energy is a bearer of “sensuous properties” which are perceived in qualitative terms. Sound, movement, heat and light are the primary ways that energy is experienced sensorially. Beginning from this observation, it can be argued that certain examples of industrial film can be thought of as the resensualisation of things normally relegated to quantitative processes of conversion in industrial production.

Energy is not a single definable entity, as geographer Vaclav Smil has sought to affirm, it is “rather an abstract collective concept, adopted by nineteenth-century physicists to cover a variety of natural and anthropogenic phenomena.”<sup>23</sup> In industrial film we see these diverse phenomena in action. In *Master Hands* we are shown the searing heat of molten metal,

21 Hediger, Vinzenz. “Thermodynamic Kitsch: Computing in German Industrial Films, 1928/1963.” *Films That Work: Industrial Film and the Productivity of Media*, edited by Vinzenz Hediger and Patrick Vonderau. Amsterdam University Press, 2009.

22 I thank Daniela Russ for drawing my attention to this aspect of Cassirer’s work, and for her ongoing friendship and collaboration. Ostwald, Wilhelm. *Vorlesungen über Naturphilosophie*. 1901, pp. 159–60; Cassirer, Ernst. *Substance and Function and Einstein’s Theory of Relativity*. Translated by William and Marie Swabey. Open Court, 1923. [Translation of *Substanzbegriff und Funktionsbegriff: Untersuchungen über die Grundfragen der Erkenntniskritik*. Verlag Bruno Cassirer, 1910.]

23 Smil, Vaclav. *Energy: A Beginners Guide*. Oneworld Publications, 2006.

the relentless motion of assembly lines, the clanging of mechanical casts, the glow of diffusing sparks as air is blown through molten metal. In British Petroleum's playful *Divertimento* (1968) we see the microscopic chemical refinement of hydrocarbons, the delicate geometrical and fractal like forms they assume at this scale. In Michelangelo Antonioni's *Sette canne, un vestito* (1949) we witness the transubstantiations of industrial chemistry, as reeds are first heated in vast steaming crucibles, then cleaned in bubbling tanks of chemically infused water. This solution is then manipulated in a continual process of refinement to extract fibres to create rayon, a cutting-edge fabric of post-war modernity.

In industrial film we see energy being converted into qualitatively different states with an arrestingly sensorial aspect. To paraphrase historian Anson Rabinbach, in documenting processes of transduction, we are reminded that modernity is primarily an achievement powered by the combustion of carbon.<sup>24</sup> Jean-François Lyotard, in one of his few pronouncements on film, compared the medium of film to the energetic but extravagant combustion of fireworks. Under capitalism such pyrotechnics could assume a function, which sprang "from the effort to eliminate aberrant movements, useless expenditures, differences of pure consumption. This film is composed like a unified and propagating body, a fecund and assembled whole transmitting instead of losing what it carries."<sup>25</sup> Following Lyotard, we might consider industrial film as a form of utilitarian pyrotechnics, a series of edited images intended to reveal productive conversions, via motion and light, in a sequence intended to both instruct and enchant with regard to the miracles of production.

## Energy as Work

As stated, energy is an assessment of a system's ability to "do work." This curiously anthropocentric definition is why American physicist Percy Bridgman suggested of all nature's laws, thermodynamics "smells more of its human origin."<sup>26</sup> This conflation of meaning began in the nineteenth century, as engineers and natural philosophers sought to quantify the

24 Rabinbach, Anson. *The Human Motor: Energy, Fatigue, and the Origins of Modernity*. University of California Press, 1990.

25 With thanks to Dawid Kasproicz for directing me to this reference. Lyotard, Jean. "Acinema." *Narrative, Apparatus, Ideology: A Film Theory Reader*, edited by Philip Rosen. Columbia University Press, 1986, pp. 349–59.

26 Bridgman, Percy. *The Nature of Thermodynamics*. Harper and Row, 1941.



power of steam engines in terms of labour. As Norton Wise stated, “steam engines, like all other engines, produced work by energy conversion. Engines therefore embedded both the natural philosopher’s ‘energy’ and the political economist’s ‘labour value’ as work.”<sup>27</sup> In a strange conflation of engineering and cosmology, the growing credibility of thermodynamics meant the human principles of “work” and “waste” assumed universal import, becoming laws of “conservation” and “dissipation.”<sup>28</sup> It was this realization, as Rabinbach documented, that led to the emergence of a “science of work” in late nineteenth-century society, a discipline aimed at optimizing the “human motor.”<sup>29</sup>

Drawing on energy’s conceptual origins, we can address the idea that energy is not only a prosthesis to human labour but its replacement. Rabinbach believes Marx most clearly affirmed a belief in an equivalence between labour and machines. By the time he wrote *Capital* (1867), Rabinbach argues, Marx considered efficient machinery, if in the right hands, as the means by which labour would be emancipated from perpetual servitude.<sup>30</sup> The expenditure of energy on film must surely be considered in its relation to labour. Chevrolet’s *Master Hands* (1936), like many other industrial films, shows human labour augmented by combustion; at one point a boiler’s dial shows fluctuations in the physiologically grounded units of “horsepower” (fig. 3.1). Each unit of expended energy is in some way equivalent to, and therefore possibly a replacement for, animal or human labour. Whether such machinic energy leads to labour’s emancipation is, of course, a question of politics.

What *Master Hands* ignored, for obvious reasons, was an ongoing conflict between labour and industry at the plant it depicted. That same year, workers at Chevrolet joined others in a violently opposed general automotive workers’ strike. Its Flint Michigan factory was considered a “slave plant” by trade unionists, while General Motors, Chevrolet’s holding company, was known for its poor working conditions. Smoke, gasses, bubbling pots of cyanide solution, and static electricity assailed workers. On the assembly line, they carried out repetitious tasks at an unforgiving rate, driven by a bonus system considered a “racket” and “predicated on getting every bit

27 Wise, Norton. “Mediating Machines.” *Science in Context*, vol. 2, no. 1, 1988, pp. 77–113.

28 Smith, Crosbie, and Norton Wise. “Work and Waste: Political Economy and Natural Philosophy in Nineteenth Century Britain.” *History of Science*, vol. 27, no. 3, 1989, pp. 263–301.

29 Rabinbach. *The Human Motor*; see also Curtis, Scott. *The Shape of Spectatorship: Art, Science, and Early Cinema in Germany*. Columbia University Press, 2015.

30 Rabinbach. *The Human Motor*, p. 73.



Fig. 3.1. Boiler horse power gauge. Still frame from *Master Hands* (1936). © Handy (Jam) Organization, archival footage supplied by Internet Archive (archive.org) in association with Prelinger Archives.

of work out of a person [...] that he could stand.”<sup>31</sup> As Marx had predicted, without political resistance, industrial work “confiscates every atom of freedom, both in bodily and intellectual activity.”<sup>32</sup> Human labour would be subsumed by the pursuit of capital. As energy and mechanization allowed the increasing automation of industrial processes, humans’ role on the factory floor was increasingly limited to those activities that could not be automated.<sup>33</sup> In pursuit of efficiency and profit, workers found themselves “deskilled” by machines, which in turn, justified their lower wages.<sup>34</sup> Far from the harmonious energetic augmentation of human labour depicted in *Master Hands*, increasingly efficient industrial conversions were almost invariably at the expense of the worker.

### Energy as Efficiency

The nineteenth-century discovery that energy dissipated as it was converted made its efficient use an imperative. Hence, as the science of work evolved,

31 West, Kenneth. “On the Line”: Rank and File Reminisces of Working Conditions and the General Motors Sit-down Strike of 1936–1937.” *Michigan Historical Review*, vol. 12, no. 1, 1986, pp. 57–82.

32 Rabinbach. *The Human Motor*, p. 74.

33 Ford engineering executive Del Harder first applied the term “automation” to manufacturing in 1947. He did not mean automated servo-mechanical or computational control, but rather an increase in electro-mechanical, hydraulic, and pneumatic means of production. See Noble, David. *America by Design: Science, Technology and the Rise of Corporate Capitalism*. Oxford University Press, 1979.

34 Idem. *Forces of Production: A Social History of Industrial Automation*. Transaction, 2011.

its adherents emphasized the need for conservation. First proposed by American mechanical engineer Frederick W. Taylor in 1911, the principles of scientific management were encapsulated by his dictum:

Science, not rule of thumb.

Harmony, not discord.

Cooperation, not individualism.

Maximum output, in place of restricted output.

The development of each man to his greatest efficiency and prosperity.

Taylorism was a science of work, intended not only to optimize worker efficiency through measurement, but also to dampen potential labour disputes in a period of growing industrial unrest. Harmony, Taylor claimed, could be achieved by increasing productivity for the manager and increasing prosperity for the worker, primarily through the analysis of the worker's output over time, and the development of new working practices or systems of incentive that could increase individual effort and overall productivity.<sup>35</sup> For Taylor, the measurement of energy provided a uniform unit to analyse the operations of a given worker's movements in the course of a work shift. Both mechanical and human action could be quantified in "foot-pounds of energy exerted for each man each day," allowing clear cut comparison between the efficacy of different workers and different configurations of labour.<sup>36</sup>

As Hoof details, the principles of Taylorism were integrated with filmic technologies by industrial engineer and consultant Frank B. Gilbreth, who used film to capture worker's movements as a sequence of images. Melding graphical depictions of labourers in motion with Taylor's promise of increasing labour's output via its measurement, Gilbreth sold a purportedly scientific approach to optimizing industrial productivity based on analysing film.<sup>37</sup> Again, energy was at the fore, as Gilbreth and his wife Lillian would pitch their motion film method as a means of achieving something called a "fatigue study" in which pictorial analysis of movement over time could be used to minimize the "unnecessary waste of human energy" that dissipated

35 Maier, Charles. "Between Taylorism and Technocracy: European Ideologies and the Vision of Industrial Productivity in the 1920s." *Journal of Contemporary History*, vol. 5, 1970, pp. 27–61.

36 Taylor, Frederick W. *The Principles of Scientific Management*. Harper and Brothers, 1911, pp. 55–57.

37 Hoof. *Angels of Efficiency*. As Hoof notes, Gilbreth's children would gently satirize their parent's work in the novel *Cheaper by the Dozen* (1948), which was made into a feature film in 1950.

in every misdirected effort, exaggerated movement, and even improperly spent period of leisure time.<sup>38</sup>

Whilst such forms of management had been intended to quell class tensions, disruptions in industrial flow often resulted from breakdowns in labour relations. In such situations, as we saw at Chevrolet's Michigan plant, rather than a salve, the physiological and psychological implications of the finely tuned rationalization of workers' embodied dispositions were often resented and bitterly opposed on occasion. Such scientism could be seen as part of the dehumanizing processes of alienation that capital inflicted on labour.<sup>39</sup> If efficient energy use was central to this managerial ethos, one way of manifesting opposition, proposed institutionalist economist Thorstein Veblen, was the "conscientious withdrawal of efficiency."<sup>40</sup> For Veblen, withdrawal did not have to involve full-scale strikes, of the kind that later occurred at Chevrolet, but could mean an array of sabotaging micro-aggressions, from "surreptitious manoeuvres of delay, obstruction, friction and defeat."<sup>41</sup> But he also argued managerial interventions could be considered acts of sabotage if wrongly motivated by the pursuit of pecuniary advantage rather than the "conservation of economic energy."<sup>42</sup>

Returning to the manifestation of such concerns in film, in Fiat's *Sotto i tuoi occhi* (1931) we see not only the rationalization of automobile manufacturing, but how the factory itself, a monumental hippodrome designed by Mattè Trucco, was a concrete manifestation of scientific management. Trucco had studied Taylor's work on the advice of Giovanni Agnelli, Fiat's founder. The Lingotti plant realized Taylorist principles of flow: raw materials entered at the bottom of the building, and assembly continued up each floor of the building, until the cars reached the roof, where the climax of the film shows a number of recently made Fiat 522s being dramatically test-run in formation on a steeply banked track overlooking Turin, their six-cylinder internal combustion engines producing the equivalent motive energy of

38 Ibid., ch. 3; see also Gilbreth, Frank, and Lillian Gilbreth. *Fatigue Study: The Elimination of Humanity's Greatest Unnecessary Waste: A First Step in Motion Study*. Sturgis & Walton Company, 1916.

39 Karns Alexander, Jennifer. *The Mantra of Efficiency: From Waterwheel to Social Control*. Johns Hopkins University Press, 2008.

40 Knoedler, Janet. "Veblen and Technical Efficiency." *Journal of Economic Issues*, vol. 31, no. 4, 1997, pp. 1011–26.

41 Veblen, Thorstein. *The Engineers and the Price System*. Viking, 1921.

42 White, Ron D. "Growth versus Conservation: A Veblenian Perspective." *Journal of Economic Issues*, vol. 12, no. 2, pp. 427–33; Veblen. 1900. Qtd. in Mirowski, Philip. *Against Mechanism: Protecting Economics from Science*. Rowman & Littlefield, 1988, p. 1.

fifty or sixty horses.<sup>43</sup> Clearly the pursuit of efficiency documented in this industrial film not only employed the visual rhetoric of productive transductions in energy, but also showed how such processes could be housed in elegant architectural forms that were themselves intended to maximize the efficiency with which energy was converted in processes of production.

In his study of the depiction of electrical appliances in the promotional films of *Électricité de France* (EDF), historian Yves Bouvier suggests the ways in which energy suppliers chose to present themselves offers a means to “deconstruct the cultural representations associated with energy and to analyse how these representations emerged within the scope of business strategies.”<sup>44</sup> In many industrial films industry represented itself via elegant, smooth productive flows and the unbroken conveyance of a companies’ products. In so doing, industrial film conveyed the seamless logic of managerial rationality, and the corporation could present itself as a benevolent guardian against inefficiency. The resolution of disruption was the theme of *La pattuglia del Passo San Giacomo* (1954), in which Ermanno Olmi, filming for Edison-Volta, Italy’s national power company, presented a romanticized depiction of power line repair in the Italian Alps. The film documents a patrol team of engineers, whose work and good humour are in harmony with a pristine snow-covered landscape and its rural people, grateful for but unchanged by electrification.

The reinstatement of energy supply resonated with Italy’s post-war reconstruction. Film historian Paulo Bonifazio explains that Edison-Volta had its own film unit, Sezione Cinema Edison-Volta (SCE), and that the majority of Olmi’s films for SCE portrayed a beneficent managerial paternalism that it was hoped would diffuse through the nation. Such paternal benevolence was evident to Olmi, whose father and mother had worked for Edison-Volta, and who joined the company at fifteen – they even gave him his first camera. Bonifazio suggests Edison-Volta’s aim was not to sell their product, as they were Italy’s sole electricity supplier at the time. Rather, their aim was to sell the benefits of hydropower technology to rural Italians, hence the film depicts technology in harmony with nature, against a quiet, unobtrusive soundtrack filled with running water and crisp snow.<sup>45</sup> Olmi’s film reiterated an older

43 Kirk, Terry. *The Architecture of Modern Italy, Volume 2: Visions of Utopia, 1900–Present*. Princeton Architectural Press, 2005.

44 Bouvier, Yves. “Filming Electrical Consumption: EDF’s Promotional Films (1946–2004).” *Past and Present Energy Societies: How Energy Connects Politics, Technologies and Cultures*, edited by Nina Möllers and Karin Zachmann. Transcript Verlag, 2012.

45 Bonifazio, Paulo. *Schooling in Modernity: The Politics of Sponsored Films in Post-war Italy*. University of Toronto Press, 2014.

idea that electricity held a utopian potential in contrast to the dirty and labour-intensive direct use of coal. During the New Deal Era American critic and philosopher Lewis Mumford (1895–1990) argued that the use of electricity could lead to a “neotechnic” society in which electricity-driven prosperity would engender social and natural order. In his *Technics and Civilization* (1934), Mumford described an electrified world in which “[t]he same qualities prevail in the power station or the factory as in the kitchen or the bathroom of the individual dwelling. In any one of these places one could eat off the floor.”<sup>46</sup> This image of a pristine productive environment, in which processes flow without hindrance from an incompressible nature or labour force, in which interruptions in productive flows are skilfully and harmoniously corrected, seems a persistent narrative in the rhetoric of industrial film.

### Energy as Friction

But just as new energy technologies displaced or degraded labour rather than replacing it, the same could be said of new forms of energy supply. In post-war Italy, and for Western Europe in general, the American-led recovery, the so-called “Marshall Plan,” was largely predicated upon a shift from coal to oil as the primary feedstock for generating electrical power. Around ten per cent of the funding Europe received in Marshall Plan aid was recycled back into the coffers of American owned oil companies funnelling oil from the Middle East.<sup>47</sup> Italy had become the “refinery of Europe,” the unloading point for oil tankers arriving in the Mediterranean via the Suez Canal.<sup>48</sup> Historian Timothy Mitchell argues this shift in fuel dependency was partly intended to break the control of increasingly nationalized and often socialist coal mining industries had across much of Europe: coal depended upon miners’ labour power, whereas, once infrastructures were in place, oil could be pumped and piped from wells with relative ease.<sup>49</sup> By 1956, around 65 million tons of oil came by tanker from the Persian Gulf each year, another 35 million came via the new Trans-Arabian pipeline and the older British-owned “Iraqi Petroleum Company” pipeline.<sup>50</sup> Such

46 Carey, James, and John Quirk. “The Mythos of the Electronic Revolution.” *American Scholar*, vol. 39, no. 3, 1970, pp. 395–424.

47 Painter, David. “The Marshall Plan and Oil.” *Cold War History*, vol. 9, no. 2, 2009, pp. 159–75.

48 King, Russell. *The Industrial Geography of Italy*. Routledge, 2015.

49 Mitchell. *Carbon Democracy: Political Power in the Age of Oil*. Verso, 2013.

50 OEEC. *Europe’s Need for Oil: Implications and Lessons for the Suez Crisis*. Organisation for European Economic Co-operation, 1958.

globe-spanning infrastructure, such as pipelines, often become sites of “friction,” echoing Veblen’s notion of the withdrawal of efficiency. Borrowed from physics, anthropologist Anna Tsing suggests friction encapsulates the “awkward, unequal, unstable and creative qualities of interconnection across difference” that globalization entails.<sup>51</sup> Here it is suggested the concept of friction, often absent from the smooth processes shown in industrial film, particularly with regard to oil, provides one means of addressing energy as an aspect of industrial film.

In *Desert Venture* (1958 [1947]) the consequences of the new global geography of energy were made clear. An orientalist image of Saudi Arabia, the site of the Arabian-American Oil Company’s (ARAMCO) newly discovered reserves is shown to the viewer via a sequence of shots contrasting the physical labour of Arabs with the highly technologized work of the American oil company. Cultural frictions are absent, the two nations work harmoniously, exchanging smiles and each in awe at the peculiarities of the other. Such beneficent cooperation could be seen as a stage-managed attempt to soften ARAMCO’s control over this premodern nation. America’s first Saudi Arabian ambassador had described ARAMCO as an “octopus,” whose tentacles extended in every domain. He warned Washington that this private American company would dominate the Middle East. Alert to such accusations, ARAMCO spent millions of dollars in portraying an image of partnership rather than parasitism. *Desert Venture* failed in this respect, as Crown Prince Ibn Saud considered the film an insult, due to its presentation of ARAMCO as the Saudis’ saviour.<sup>52</sup>

Off-screen frictions are readily apparent elsewhere in “petrofilms,” as film scholar Mona Damluji terms them.<sup>53</sup> She argues petrofilms are a distinct genre of industrial film, unconcerned with selling the company’s product – oil – so much as selling the image of a civilizing, modernizing, and altruistic company that can smoothly extract a nation’s oil and leave progress in its wake. Much like *Desert Venture*, she describes how the Anglo-Iranian Oil Company (AIOC) put out *Persian Story*<sup>54</sup> (1951), a rosy take on Iran’s response to the extraction of its oil, which ignored the fact that Iranian oil workers had just begun to protest against the exploitation and their

51 Tsing, Anna. *Friction: An Ethnography of Global Connection*. Princeton University Press, 2005.

52 Vitalis, Robert. *America’s Kingdom: Mythmaking on the Saudi Oil Frontier*. Stanford University Press, 2006.

53 Damluji, Mona. “The Image World of Middle Eastern Oil.” *Subterranean Estates: Life Worlds of Oil and Gas*, edited by Hannah Appel et al. Cornell University Press, 2015.

54 Note: not screened at “Films That Work.”

unsanitary living arrangements. Their strike, a conscious withdrawal of efficiency, eventually encouraged Prime Minister Mohammad Mossadegh to nationalize Iranian oil, so beginning a move toward oil nationalism in the Middle East that precipitated the crisis of the 1970s and continues to provoke geopolitical tensions. As Damluji notes, a work of fiction, the film provided British audiences with an upbeat account of the Iranian oil industry that wholly ignored the ongoing Iranian oil crisis.

Similarly ameliorant, scholar Georgiana Banita argues that Bernardo Bertolucci's *La via del petrolio* (1967), in its artfully detached portrayal of oil's conveyance from Iran to Europe, demonstrates "blissful immunity from the political critique that has shaped the late twentieth century's energy conscience."<sup>55</sup> Funded by Italy's Ente Nazionale Idrocarburi (ENI), *La via del petrolio* depicts the monolithic infrastructures of oil transport, its extraction, pumping, and shipping through the Suez Canal to the refineries of Genoa, and on to Switzerland and Bavaria. Though frictions are alluded to, particularly the Suez Crisis of 1956, during which the Suez Canal was blockaded by Egyptian president Abdel Nasser, which forced tankers to take a 9,600-mile detour while delivering Europe's oil, they were presented as assailable. In Bertolucci's film, once more, the rhetoric of petrofilms suggest a harmonious geopolitics. This is the legitimating function of such films, attempts to render extractive relations free from political critique. However, from our contemporary perspective, in which the oil-rich Middle East has been riven with conflict, and into which human energy use has transformed the climate and other aspects of the Earth system, these past attempts to evade critique appear naïve if not malevolent. To return to Ivakhiv, in light of our current energetic condition, we can reaffirm his statement that films "make a cut in time (and in space), but this cut is artificial and ultimately unsustainable; the real will always return in one form or another."<sup>56</sup>

In the novelist W.G. Sebald's *Die Ringe des Saturn*, during a hallucinatory journey through Suffolk, England, the unnamed protagonist observes that "[c]ombustion is the hidden principle behind every artefact we create."<sup>57</sup> This chapter has argued that the combustive origins of our contemporary condition were graphically affirmed in industrial film. Combustion, the energetic feedstock of industrial production, imposed obligations on the

55 Banita, Georgiana. "From Isfahan to Ingolstadt: Bertolucci's *La via del petrolio* and the Global Culture of Neorealism." *Oil Culture*, edited by Ross Barrett and Daniel Worden. University of Minnesota Press, 2014.

56 Ivakhiv. *Ecologies of the Moving Image*, p. 305.

57 Sebald, W.G. *The Rings of Saturn*. Translated by Michael Hulse. Harvill, 1998. [Translation of *Die Ringe des Saturn. Eine englische Wallfahrt*. 1995.]



managerial class that found expression in industrial film. In proposing a tentative thermodynamic reading of industrial film, it is suggested the laws of energy can be read in at least four registers. First, industrial film re-evokes the sensorial qualities of productive transductions in energy. Combustion is not hidden, as Sebald observed, but affirmed, reminding the viewer of the miraculous plasticity that humankind's control over heat transfer is able to achieve, and the visual spectacle such productive pyrotechnics entail. Second, the augmentation of human labour with power derived from energy resources are readily apparent. The controlled use of energy extends the human capacity for labour to a superhuman extent. These films emphasize the harmonious nature of this co-production. No more so than in the third register, in which the visual rhetoric of efficient energy transfer is foregrounded, with imagery of industry engaging in unbroken transductions, with energy applied purposively through the heat gradient. But fourth, and finally, a thermodynamic reading of such demonstrative efficiency ignores the second law of thermodynamics. Entropy, or friction, is apparent in what lies off camera, be it conscious withdrawal of efficiency, organized labour, waste, finitude or the transformation of the atmosphere.

## Works Cited

- Banita, Georgiana. "From Isfahan to Ingolstadt: Bertolucci's *La via del petrolio* and the Global Culture of Neorealism." *Oil Culture*, edited by Ross Barrett and Daniel Worden, University of Minnesota Press, 2014.
- Banita, Georgiana. "Prelude to the Energy Era in Film Studies" [review of *The Cinematic Footprint: Lights, Camera, Natural Resources* by Nadia Bozak]. *Imaginations*, vol. 3, no. 2, 2012, pp. 208–09.
- Barry, Andrew. "Thermodynamics, Matter, Politics." *Distinktion: Journal of Social Theory*, vol. 16, no. 1, 2015, pp. 110–25.
- Beer, Gillian. "'The Death of the Sun': Victorian Solar Physics and Solar Theory." *Open Fields: Science in Cultural Encounter*. Oxford University Press, 1996.
- Beniger, James. *The Control Revolution: Technological and Economic Origins of the Information Society*. Harvard University Press, 1986.
- Bonifazio, Paulo. *Schooling in Modernity: The Politics of Sponsored Films in Post-war Italy*. University of Toronto Press, 2014.
- Bouvier, Yves. "Filming Electrical Consumption: EDF's Promotional Films (1946–2004)." *Past and Present Energy Societies: How Energy Connects Politics, Technologies and Cultures*, edited by Nina Möllers and Karin Zachmann. Transcript Verlag, 2012.

- Bozak, Nadia. *The Cinematic Footprint: Lights, Camera, Natural Resources*. Rutgers University Press, 2012.
- Bridgman, Percy. *The Nature of Thermodynamics*. Harper and Row, 1941.
- Carey, James, and John Quirk. "The Mythos of the Electronic Revolution." *American Scholar*, vol. 39, no. 3, 1970, pp. 395–424.
- Cassirer, Ernst. *Substance and Function and Einstein's Theory of Relativity*. Translated by William and Marie Swabey, Open Court, 1923. [Translation of *Substanzbegriff und Funktionsbegriff: Untersuchungen über die Grundfragen der Erkenntniskritik*. Verlag Bruno Cassirer, 1910.]
- Curtis, Scott. *The Shape of Spectatorship: Art, Science, and Early Cinema in Germany*. Columbia University Press, 2015.
- Damluji, Mona. "The Image World of Middle Eastern Oil." *Subterranean Estates: Life Worlds of Oil and Gas*, edited by Hannah Appel, Arthur Mason, and Michael J. Watts, Cornell University Press, 2015.
- Garrard, Greg, editor. *The Oxford Handbook of Ecocriticism*. Oxford University Press, 2014.
- Gilbreth, Frank, and Lillian Gilbreth. *Fatigue Study: The Elimination of Humanity's Greatest Unnecessary Waste: A First Step in Motion Study*. Sturgis & Walton Company, 1916.
- Gold, Barri. *Thermopoetics: Energy in Victorian Literature and Science*. MIT Press, 2010.
- Hediger, Vinzenz. "Thermodynamic Kitsch: Computing in German Industrial Films, 1928/1963." *Films That Work: Industrial Film and the Productivity of Media*, edited by Vinzenz Hediger and Patrick Vonderau. Amsterdam University Press, 2009.
- Higginson, Ian, and Crosbie Smith. "A Magnified Piece of Thermodynamics': The Promethean Iconography of the Refrigerator in Paul Theroux's *The Mosquito Coast*." *British Journal for the History of Science*, vol. 32, no. 3, 1999, pp. 325–42.
- Hoof, Florian. *Angels of Efficiency: A Media History of Consulting*. Oxford University Press, 2020.
- Ivakhiv, Adrian. *Ecologies of the Moving Image: Cinema, Affect, Nature*. Wilfrid Laurier University Press, 2013.
- Karns Alexander, Jennifer. *The Mantra of Efficiency: From Waterwheel to Social Control*. Johns Hopkins University Press, 2008.
- King, Russell. *The Industrial Geography of Italy*. Routledge, 2015.
- Kirk, Terry. *The Architecture of Modern Italy, Volume 2: Visions of Utopia. 1900–Present*. Princeton Architectural Press, 2005.
- Knoedler, Janet. "Veblen and Technical Efficiency." *Journal of Economic Issues*, vol. 31, no. 4, 1997, pp. 1011–26.
- Liotard, Jean. "Acinema." *Narrative, Apparatus, Ideology: A Film Theory Reader*, edited by Philip Rosen. Columbia University Press, 1986, pp. 349–59.

- MacDuffie, Allen. "Joseph Conrad's Geographies of Energy." *English Literary History*, vol. 76, no. 1, 2009, pp. 75–98.
- Maier, Charles. "Between Taylorism and Technocracy: European Ideologies and the Vision of Industrial Productivity in the 1920s." *Journal of Contemporary History*, vol. 5, 1970, pp. 27–61.
- Mirowski, Philip. *Against Mechanism: Protecting Economics from Science*. Rowman & Littlefield, 1988.
- Mitchell, Timothy. *Carbon Democracy: Political Power in the Age of Oil*. Verso, 2013.
- Mitchell, Timothy. "Economentality: How the Future Entered Government." *Critical Inquiry*, vol. 40, no. 4, 2014, pp. 479–507.
- Noble, David. *America by Design: Science, Technology and the Rise of Corporate Capitalism*. Oxford University Press, 1979.
- Noble, David. *Forces of Production: A Social History of Industrial Automation*. Transaction, 2011.
- OEEC. *Europe's Need for Oil: Implications and Lessons for the Suez Crisis*. Organisation for European Economic Co-operation, 1958.
- Painter, David. "The Marshall Plan and Oil." *Cold War History*, vol. 9, no. 2, 2009, pp. 159–75.
- Prelinger, Rick. "Smoothing the Contours of Didacticism: Jam Handy and His Organization." *Learning with the Lights Off: Educational Film in the United States*, edited by Devin Orgeron, Marsha Orgeron, and Dan Streible. Oxford University Press, 2011, pp. 338–55.
- Pringle, Thomas. "Photographed by the Earth: War and Media in Light of Nuclear Events." *NECSUS European Journal of Media Studies*, vol. 3, no. 2., 2014, pp. 131–54.
- Rabinbach, Anson. *The Human Motor: Energy, Fatigue, and the Origins of Modernity*. University of California Press, 1990.
- Sebald, W.G. *The Rings of Saturn*. Translated by Michael Hulse. Harvill, 1998. [Translation of *Die Ringe des Saturn. Eine englische Wallfahrt*. 1995.]
- Seed, David. "Order in Thomas Pynchon's 'Entropy'." *Journal of Narrative Technique*, vol. 11, no. 1, 1981, pp. 135–53.
- Shove, Elizabeth. "Revealing the Invisible: Sociology, Energy, and the Environment." *International Handbook of Environmental Sociology*, edited by Michael Redclift and Graham Woodgate. Edward Elgar, 1997, pp. 261–73.
- Smil, Vaclav. *Energy: A Beginners Guide*. Oneworld Publications, 2006.
- Smith, Crosbie. *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain*. Athlone Press, 1998.
- Smith, Crosbie, and Norton Wise. "Work and Waste: Political Economy and Natural Philosophy in Nineteenth Century Britain." *History of Science*, vol. 27, no. 3, 1989, pp. 263–301.

- Taylor, Frederick W. *The Principles of Scientific Management*. Harper and Brothers, 1911.
- Tsing, Anna. *Friction: An Ethnography of Global Connection*. Princeton University Press, 2005.
- Veblen, Thorstein. *The Engineers and the Price System*. Viking, 1921.
- Vitalis, Robert. *America's Kingdom: Mythmaking on the Saudi Oil Frontier*. Stanford University Press, 2006.
- West, Kenneth. "‘On the Line’: Rank and File Reminisces of Working Conditions and the General Motors Sit-down Strike of 1936–1937." *Michigan Historical Review*, vol. 12, no. 1, 1986, pp. 57–82.
- White, Ron D. "Growth versus Conservation: A Veblenian Perspective." *Journal of Economic Issues*, vol. 12, no. 2, pp. 427–33.
- Willoquet-Maricondi, Paula, editor. *Framing the World: Explorations in Ecocriticism and Film*. University of Virginia Press, 2010.
- Wise, Norton. "Mediating Machines." *Science in Context*, vol. 2, no. 1, 1988, pp. 77–113.

## About the Author

**Thomas Turnbull** is a researcher at the Max Planck Institute for the History of Science in Berlin, where his focus is the history of energy in all its forms, and he works as part of a wider research group called "Anthropocene Formations." Recent publications include "Energy, History, and the Humanities: Against a New Determinism" (*History and Technology*, 2021) and "Toward Histories of Saving Energy: Erich Walter Zimmermann and the Struggle against ‘One-Sided Materialistic Determinism’" (*Journal of Energy History/Revue d'histoire de l'énergie*, 2020).