Introduction
Limited environments, fictions of escape

In a recent advertising campaign, the oil company Chevron raised concerns about mounting worldwide energy consumption and population growth. The problem we face, a narrator says in the opening of one of the ads, is that "there are six and a half billion people on this planet … and every one of us will need energy to live. Where will it come from?" Shots of highways, city skylines, and oil derricks suggest impending crisis: population growing, consumption spiraling, and energy production struggling to keep pace with demand. But there is a solution to this crisis, the narrator says, and an answer to the question "Where will it come from?" There are vast reserves just waiting to be tapped from "the greatest source of energy in the world – ourselves." And with that, the ad's images of a teeming, overpopulated globe are transformed from a source of concern to a source of optimism: "this," the ad says, "is the power of human energy."[1]

Such a formulation is misleading in many ways, and one of the most striking is its inconsistent use of the word "energy." In the opening of the ad, energy is defined as a resource, the fuel needed to keep the world's cars, airplanes, ships, stoves, light bulbs, televisions, computers, offices, hospitals, farms, factories, and cities running. But when the discussion shifts to "human energy," the word takes on an almost entirely different meaning. Energy in the second sense, "human energy," suggests something like creativity, initiative, intelligence, and cooperation. Technological innovation, it seems, brought about by the "power" of the human mind (and spearheaded by Chevron), will allow us to engineer our way out of whatever crisis we face. The ad plays upon a common understanding of the word energy as a disembodied power, a force of will or spirit that humans seemingly summon from within, which allows them to overcome whatever limits brute matter would impose. Indeed, this sense of the word is emphasized by the ad's visual rhetoric, which provides us with footage of a wide array of natural and human-made formations: glaciers, oceans, refineries, transportation networks, sprawling conurbations; the camera ranges fluidly, seemingly at will, over the globe. Swept up in this panorama and sense of complete visual command, we may not remember – we are perhaps encouraged to forget – the helicopters needed to capture many of those shots, or the fuel those helicopters used in order to do so, or, indeed, any of the resources involved in producing the two-minute fantasy of mastery designed to inspire belief in the power of human energy. Energy the resource becomes energy the metaphor, and the very problem the ad claims to address – "the population needs resources" – is transformed into its own solution – "the population *is* a resource." In this space of verbal and visual fantasy, the thermodynamic problem of the irreversible transformation of energy is solved by means of the linguistic and visual transformation of "energy."

The energy problem our world faces is both material and representational. It is material in the sense that many vital resources exist in finite quantities, and in the sense that energy-intensive practices have profound, measurable, and perhaps irreversible environmental consequences. It is representational in the sense that these issues are commonly distorted in our cultural imaginary, and through our inconsistent use of the word itself. In a recent book about sustainable energy practices, the physicist David Goodstein argues:

> We don't have to conserve energy, because nature does it for us. For the same reason, there can never be an energy crisis. That doesn't mean we don't have a problem; it just means we haven't been describing the problem in the correct terms. There is something that we are using up and that we need to learn to conserve. It's called fuel.[2]

Here, Goodstein focuses on a particular tension in the word, between energy defined as a usable resource, and energy defined as ambient agency circulating endlessly through the world. It is the latter definition that lies behind Chevron's claims about "human energy": the ad's imagery of ceaseless activity and motion at first seems like a problem ("look how much energy we're using"), but soon comes to seem like the solution ("look at all this marvelous energy").

The failure to differentiate these two different uses of the word is an ongoing source of misprision and fuzzy thinking about resource consumption, but the conflict has its roots in the nineteenth century, and it is those roots this book is interested in investigating. Although, as Christopher Herbert notes, intellectual history requires "abandoning the fantasy of originary moments," we can locate a few pivotal junctures in the formation of these issues, and in the history of the representation of energy resources.[3] One is Thomas Robert Malthus's *Essay on the Principle of Population*, together with the work that, in part, prompted him to write it, William Godwin's essay "Of Avarice and Profusion." Although Malthus was not concerned with fossil fuels, he was focused, at heart, on the availability of energy, and the material limits to human growth. For him, those limits centered upon a point of equilibration between food supply and human energy demands: when the population exceeded available resources, famine and disease would cut it back down to a sustainable size, after which it would begin growing again. The problem for Malthus is that utopian texts like Godwin's represent energy as something derived from within the human mind or spirit, rather than something that needs to be harvested from the environment. Thus he critiques Godwin's arguments about the "power of the mind over the body," because they imply that energetic limits can be surpassed through will, attitude, or motivation. He quotes Godwin's comment: "I walk twenty miles in an indolent and half determined temper and am extremely fatigued. I walk twenty miles full of ardour, and with a motive that engrosses my soul, and I come in as fresh and alert as when I began my journey." Malthus concedes there is a "mysterious connection of mind and body,"[4] but argues that a stimulus like this represents only a temporary means of forgetting fatigue, not a material supply of fuel: "if the energy of my mind had really counteracted the fatigue of my body, why should I feel tired the next morning?"[5] For Malthus, there is no "effort of reason" that can engineer its way out of the energy problem – because any increase in productive power or efficiency will only cause a corresponding surge in population – but there are also no mysterious springs of energy intrinsic to, or generated by, the human spirit.[6]

Malthus was wrong about quite a lot, and his arguments about scarcity were inflected by his commitment to a ruinous *laissez-faire* economic doctrine. In his work, the burden and the moral responsibility fall upon the backs of the poor and almost nowhere else. The argument for the scarcity of resources, as Marx and Engels saw, served to disguise the problem of the *distribution* of resources, exploitative social relations, and the question of the ownership of the means of production. Moreover, the astonishing expansion of industry and the development of agricultural chemistry soon increased human productive power to levels Malthus could not have imagined in 1798. As Kathleen Tobin argues, it was common for Malthus's Victorian critics to reference "technological advances in agriculture as evidence that [his] claims could no longer be substantiated."[7] Lewis Henry Morgan, for example, argues that "mankind are the only beings who may be said to have gained an absolute control over the production of food,"[8] echoing Godwin's claim that "Man is to a considerable degree the artificer of his own fortune."[9] And Engels argued that "science increases at least as fast as population; the latter increases in proportion to the body of knowledge passed down to it by the previous generation, and science advances in proportion to the size of the previous generation, that is, in the most normal conditions it also grows in geometrical progression – and what is impossible for science?"[10] If Malthus imagined an entrapping world of struggle and want, new energy technologies seemed the key to emancipation: the natural world was nowhere near as tight-fisted as he would have us believe. As we shall see, the doctrine of the conservation of energy suggested to many Victorians a universe of almost infinite energetic plentitude just waiting to be tapped by human industry.

And yet, one can see behind Engels's comment an almost faith-based argument about the course of scientific development and the unstoppable upward march of technology. This was a common refrain about energy resources in the Victorian period (as it is in ours): science will always figure out a way to stay one step ahead of scarcity. In a sense, it is a version of Godwin's argument, a belief in technological advance and humanity's potential finally to master its environment. But as Malthus pointed out, there is an "essential difference … between an unlimited improvement and an improvement the limit of which cannot be ascertained."[11] The enormous development of industrial and agricultural energy, the sudden (in historical terms) access to immense reserves of stored motive power in the form of fossil fuels made it easy to mistake the former for the latter. Malthus's predictions seemed misguided not because his basic principles were necessarily wrong, but because he could not have predicted that the amount of energy available for human purposes would spike in such dramatic fashion, or that human civilization would begin running through it so quickly.[12]

Malthus left a decidedly mixed legacy for Victorian thinking about energy. On the one hand, his theory provided a powerful means of conceptualizing crucial questions about environmental limits and resource scarcity. On the other hand, the ideologically offensive elements of his theory, the way it seemed to naturalize an unfettered, weak-to-the-wall brand of free-market economics, made it (understandably) toxic to left-wing and radical Tory critics of capitalism alike. Economist Michael Perelman argues this was a pivotal problem for Marx, who wanted to critique capitalist production as environmentally reckless and unsustainable, but did not want to cede an inch of ground to Malthus or to the notion that scarcity was a natural, rather than a social, phenomenon. Thus for Marx "shortages reflected the inability of capital to master the environment": a problem that would be rectified in the future Communist state.[13]

Open and closed systems

Not only does Malthus insist that the "power" of the human mind is not an avenue of escape from resource scarcity, he paints a bleak vision of the earth as a single enclosed system, where there are no fuel supplies or geographical spaces that can relieve the conflict between population growth and environmental limits.[14] Introducing one of his thought experiments, he writes: "To make the argument more general and less interrupted by the partial views of emigration, let us take the whole earth, instead of one spot."[15] His argument actually requires a vision of the earth as a single totality; otherwise, the processes of emigration and the cultivation of other lands suggest there are "elsewheres" – vents for excess population, sources of additional energy – that can mitigate or disguise the basic problem of overpopulation and resource depletion. But when imagined as a totality, the earth clearly has only limited space for people (or any species), and only so much arable land. Thus what appears to be development is merely a very long process – punctuated by periods of starvation and misery for the poor – of discovering how much human consumption the earth can sustain. Malthus fills his pages with the vocabulary and imagery of entrapment, enclosure, and thwarted escape: "Necessity, that imperious all-pervading law of nature, restrains them within the prescribed bounds. The race of plants, and the race of animals shrink under this great restrictive law. And the race of man cannot, by any efforts of reason, escape from it."[16] Possible routes out of this dilemma are ruthlessly foreclosed, especially in the *Essay*'s first edition. This image of a single, inescapable world-environment would become a significant component of twentieth- and twenty-first-century discourse on ecological destruction and sustainable development. It appears perhaps most famously in the English-American economist Kenneth Boulding's metaphor of "spaceship earth." Popularized in the 1960s, the idea of the earth as a spaceship conjures a small, tightly bounded world that must subsist on its stored resources and carefully manage its waste products. For Boulding, an ecological vision that can meet the challenges of modernity requires coming to terms with new kinds of imaginative models for human life on the planet. It means recognizing that there are no "elsewheres," no unspoiled zones to move to if we ruin the one we're living in. He writes:

> We are now in the middle of a long process of transition in the nature of the image which man has of himself and his environment. Primitive men, and to a large extent also men of the early civilizations, imagined themselves to be living on a virtually illimitable plane. There was almost always somewhere beyond the known limits of human habitation, and over a very large part of the time that man has been on earth, there has been something like a frontier. That is, there was always some place else to go when things got too difficult, either by reason of the deterioration of the natural environment or a deterioration of the social structure in places where people happened to live. The image of a frontier is probably one of the oldest images of mankind, and it is not surprising that we find it hard to get rid of.[17]

Malthus may be living at the dawn of empire, but he is already beginning to imagine the end of new frontiers.

As both writers suggest through their imagery – and as Boulding was well aware – one of the key conceptual models for the discourse of energy resources, waste, and the environment is the *closed system*. As we will see, the idea of the closed system is at the very heart of Victorian thermodynamic discourse, and its formulation of the entropy concept. Although modern physics uses the term somewhat differently, we will follow the Victorians and define a closed system as one that does not receive any inputs of energy from outside itself. As Daniel Hall puts it in a Victorian physics primer: "in any closed system the energy present is a constant quantity."[18] But "constant," paradoxically, does not mean "unchanging" – and here we run into Goodstein's distinction between energy and fuel. The second law of thermodynamics states that, in a closed system, energy always moves from an available to an unavailable state. So the total amount of energy remains constant, but the amount of fuel, or usable energy, decreases. The cosmos itself was often imagined in these terms: as T. E. Young puts it, "the Solar Universe is a closed system receiving no supplies of energy from external sources."[19] Such a bounded cosmic model gave rise, in the middle decades of the nineteenth century, to fears of the ultimate "heat death" of the sun, which we will discuss in more detail in Chapter 2. An open system, in contrast, is defined by an incoming flow of energy that counteracts whatever dissipation occurs. Eric Schneider and Dorion Sagan call this "metastability" and liken it to the way a ping-pong ball can be made to hover suspended on a column of air coming out of a tube.[20]

But whether a system can be understood as closed or open depends on where representational boundaries are drawn: whether the system is defined in such a way that there is energy coming from an "elsewhere" that is not counted as part of the system. A wound-up watch may be conveniently imagined as a closed system, but it becomes open as soon as we include the owner who can pick it up and wind it again. The solar system appears closed if we imagine the sun contains a limited supply of fuel that it uses up over time; but it appears open if we imagine (as some Victorians did) that the sun keeps receiving fresh supplies of energy through collisions with comets or meteors.[21] But this introduces an important complication when we turn to the representation of the earth itself. Since it receives a continuous stream of solar energy, the earth's biosphere is most assuredly *not* closed. Why, then, the emphasis on "spaceship earth" and other images of a bounded planet? In some ways, this imagery betrays deeply anthropocentric biases. As a natural energy system, the earth is not closed. But as an energy system that can continue supporting human life with its current patterns of growth and consumption, it may well be. This is the point of Malthus's rhetoric of inescapability, and why his theory is often called the Malthusian "trap": the human need for energy presses up against the limits of the environment, and the ability of the earth to supply it. It is not energy that is limited, but *available* energy. While the rise of a fossil-fuel-driven industrial order seemed to some to provide a release from Malthusian fears, it only changed the shape of the problem. An energy system that runs on fossil fuels is, for all intents and purposes, closed. Coal and oil, once converted into heat, smoke, and mechanical motion, will not return to their earlier energy-rich condition, and, as far as anyone knows, there are no more supplies on the way. Moreover, as we are increasingly coming to discover, the irreversible consumption of fossil-fuel resources creates its own irreversible environmental effects. The earth does not immediately vent all the waste heat we produce; instead, much of it remains trapped, altering the makeup of the biosphere itself. The biologist and demographer Paul Ehrlich describes the double bind in which this puts industrial civilization. The laws of thermodynamics:

> make it clear that *all* the energy used on the face of the Earth … will ultimately be degraded to heat. Here the laws catch us both coming and going, for they put limits on the efficiency with which we can manipulate this heat. Hence, they pose the danger that human society may make this planet uncomfortably warm with degraded energy long before it runs out of high-grade energy to consume.[22]

The earth remains an open system, continually fed by the sun, and nothing we do will change that. But it may cease being a place that can support our current population numbers and patterns of energy consumption.

In other words, the biosphere is open, but our resource-intensive industrial system, which increasingly comes to shape the global environment, is not. The nineteenth century had trouble with this distinction, and this is seen most clearly in its representations of the city. Like the biosphere, a city is also not a closed system; in fact, a city wouldn't be able to exist if it couldn't draw resources from beyond its boundaries. Ilya Prigogine and Isabelle Stengers write:

> When we examine a biological cell or a city, however, the situation is quite different: not only are these systems open, but also they exist only because they are open. They feed on the flux of matter and energy coming to them from the outside world … cities and cells die when cut off from their environment. They form an integral part of the world from which they draw sustenance, and they cannot be separated from the fluxes that they incessantly transform.[23]

This idea of the city as an organism that must feed continually on its external environment in order to survive was a familiar one to the Victorians. London was often represented as "an immense open-mouthed body," as Lynda Nead puts it, and there are endless examples of the city-as-consumer in Dickens, Ruskin, Mayhew, and other writers.[24] And yet, oddly, the city was *simultaneously* imagined as a kind of closed system in which usable energy was inexorably running down, and entropy mounting uncontrollably. In a recent book on the Victorian city Richard Lehan writes:

> The first two laws of thermodynamics explain the nature of entropy: first, the amount of energy in the universe is fixed, and energy can never be increased or diminished, only transformed; second, every time energy is transformed from one state to another, there is a loss in the amount of energy available to perform future work. Entropy is that loss of energy in a closed system. In an open system, negative entropy supplies an added source of entropy; plants, for example, absorb energy from the sun. A city is a closed system: nothing provides it energy outside itself.[25]

My point is not that Lehan is wrong; it's that he's *right*, in a way. That is, although in thermodynamic terms, that last sentence is incorrect, it speaks to a crucial feeling about, and a common mode of representation of, the city in the nineteenth-century imaginary – that it was a bounded space irreversibly consuming its own energy and suffocating in its own detritus and waste heat. For what makes widespread energy waste a problem, what makes the city *seem* like a closed system, is the development of an urban-industrial complex that depends, increasingly, on fuels drawn from the earth's limited resource base. Not the city itself, but a mode of production and social organization *embodied* in the city creates a closed system of non-renewable resource dependence, where the consumption of energy outpaces the intake. As William Stanley Jevons notes, "A farm, however far pushed, will under proper cultivation continue to yield for ever a constant crop. But in a mine there is no reproduction, and the produce once pushed to the utmost will soon begin to fail and sink towards zero."[26] A city does not grow like a field; as the Victorians knew well, it depended, increasingly, on coal for its heat, its light, its commerce, even for its water. An economic system premised on the use of finite stocks of resources has limits – what we would today call the "limits to growth" – and the city, overcrowded, saturated with pollution, expending energy in prodigious, even spectacular fashion, made these limits imaginatively available to novelists, critics, scientists, economists, artists, and others.

As twentieth-century ecological economist Nicholas Georgescu-Roegen argues, "There is … a difference between returns in mining and returns in agriculture. In mining, we tap the stocks of various forms of low entropy contained in the crust of the planet on which we live; in agriculture, we tap primarily the flow of low entropy that reaches the earth as solar radiation."[27] There is a fundamental asymmetry between solar and terrestrial sources of energy: the former flows from the sun at a rate that we have no control over, but it flows, for our purposes, indefinitely; the latter, in contrast, flows at a rate that is, to a growing extent, determined by human capacities and wants – as Georgescu-Roegen notes, we could theoretically harvest all of our coal and burn it all at once if we chose.[28] But terrestrial energy will *not* flow indefinitely; it burns irreversibly, and once it is gone, it will not come back. For Malthus, population and resources oscillated around the flow of energy in a dynamic but essentially stable equilibrium. There was room for historical development in Malthus's world, but it was determined by the rate of flow and by the continual push-and-pull of consumption and reproduction. Dependence upon terrestrial stocks of energy introduces a new dynamic, one defined not by equilibration but by unidirectionality.[29] With our hand on the proverbial spigot, there is an illusion of control over the energy of the planet, and that sense of control is sustained by a faith in ever-increasing technological perfectibility. But it is also haunted by the question of irreversible depletion, by the knowledge that the tap leads to a reservoir that is not being refilled. The dependence upon fossil-fuel resources (and chemical fertilizers) thus introduces a very different relationship between human growth and the energy of the natural world, and that new relationship was most evident at the mouth of the spigot – the nineteenth-century urban environment.

This at the root of Lehan's remark: it suggests a common vision of the city as a stand-in for the entire industrial order, enclosed in its dependence upon finite terrestrial resources. George Levine makes a similarly telling comment in his discussion of *Little Dorrit*: "While the total energy remains the same, the total available energy diminishes so that within any closed system (like the world) the movement is always toward increased cooling and increased disorder and decreased energy available to do work."[30] To see the world as a closed system, as a domain in which usable energy is constantly decreasing, is, in fact, a sign of the way in which urban-industrial logic surreptitiously comes to structure the representation of *everything*. The "world" in this case is not distinguishable from London: just as there is no escape from the Marshalsea for Mr. Dorrit even when he is outside its walls, there is no escape from the totalizing system of energy relations represented in and through the city. The city, the world, the cosmos – all of these seem analogously "closed," with entropy mounting and energy sinking towards zero, because each subsists on a finite supply of resources. Thus, as I will discuss at greater length in Chapter 2, visions of solar decay become intimately tied to visions of urban collapse.

Anxiety about environmental limits, whether in the form of overpopulation, industrial contamination, energy exhaustion, or some combination of these (interlocking) problems, shaped the representation of urban centers in the nineteenth century, because cities could suggest, in their seemingly unstoppable growth patterns, a future in which the entire globe would be given over to the demands of a fully urbanized civilization. We see such imaginings in some of H. G. Wells's science fiction – the totalized future city of *When the Sleeper Awakes*, or, as I will discuss in some detail in the final chapter, the covertly urban landscapes of *The Time Machine*. We see it in mid-century works, in the suffocating London of later Dickens, the contaminating reach of which always extends into unexpected, non-urbanized locations: Chesney Wold in *Bleak House*, or the marshes in *Great Expectations*. We even see it in John Stuart Mill, who contemplates:

> the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture ploughed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture.[31]

This, Mill cautions, is the logical endpoint of an economic system that posits unending growth on a finite base of land and resources. John Ruskin comments on this passage: