# Chapter 27
# The Next Generation of Energy Landscapes

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## 27.1 Introduction

Our move through the history of energy use has produced imprints we at first did not see or chose by circumstance to ignore. Awareness of such imprints was at the outset stunted by the eagerness of our need and the vastness of our planet. The changes we now deem obvious, ubiquitous and increasingly troubling accumulated over many years from numerous disconnected and smaller efforts. Such was the case as the forests of Europe where leveled for firewood, where Appalachia was turned inside out for its coal, and where the open rangelands of Texas were replaced with a dense forest of wooden oil drilling derricks.

Today, energy projects are omnipresent and the trend over time is toward larger scale disruptions. With growth in both energy demand and the technological capability to meet it, the scale of our disruptive capability has reached scales unimaginable even 50 years ago. A single strip mine in Wyoming can yield 80 million tons each year, China's Three Gorges Dam generates ten times the electricity of Hoover Dam, and entire mountaintops are being removed in West Virginia to access the coal beneath. In each case, the Earth's surface is being reformed in ways that generations only two removed from our own would have considered a fantasy. Yet, despite the startling scale of present energy development, the trend toward bigger is not over. Today, we are on the threshold of a new era of energy development, one that will create landscapes that will be different both in scale and in form from those of the past. These will emerge by extending and expanding past practices, but also from the introduction of new ones that will be even larger. Along with growth in the size and intensity of proposed energy megaprojects will come increased controversy. Not only will they increase the threat to natural environments but they will place new burdens on those with a stake in each location.

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Energy projects of the immediate future will come in many forms and locations, but four I believe will be receiving more attention in North America. Two promise more oil for our cars and two would generate more electricity for our cities. The impacts on energy markets and economic development, if expectations for all four are met, will be transformative. The decision to move forward with any of these resources in a meaningful way will be on the scale of a megaproject.

## 27.2 Familiar But Different

The expected source of the "new" oil will be oil shale and oil sand, while the source of the "new" electricity will be solar energy and wind power. These four energy resources are in some ways familiar, but in many ways they differ from conventional supply sources. One of the differences will be spatial. Extracting oil from sands or shale, for example, will be a far more concentrated undertaking than pumping it from millions of wells sprinkled over millions of square miles of land and water. Instead, the new oil would be extracted from two comparatively small parcels of land. The oil sands of interest are found in the cold and lightly populated northeast quadrant of Alberta (Fig. 27.1). The oil shale is concentrated in popular western Colorado (Fig. 27.2). As a consequence of such geographically smaller areas, an unusual burden will be placed on other resources in the vicinity including water, land, air, infrastructure, and socioeconomic stability.

As for electricity from wind and directly from the sun, development will be more dispersed than is common practice with conventional fuels such as the fossil fuels, uranium, and hydropower. In each case today, electricity is generated at large centralized power plants. If either wind or solar electricity is to become a significant contributor in the near future, it will be generated from a dispersed network of decentralized smaller power plants. Likewise, the impacts from these activities will also be dispersed.

Another way to visualize this difference is to imagine spokes on a wheel converging at a hub. In the case of oil sands and oil shale, everything needed to squeeze product from its host material comes inward toward the hub. Once the massive extraction process is complete, the oil is transported outward by pipelines and roads toward markets. In such a scenario, most impacts, especially those affecting the land, are concentrated in the same area as the resource, and judging by all experience of oil development, they will be substantial and long-lasting. The solar resources (which include wind), on the other hand, are by nature dilute and dispersed, and so too will be the impacts associated with their development, especially when compared with their fossil counterparts. Their impacts will, also, be of a different sort, mostly aesthetic and temporary. In addition to these advantages, there will be no use of water, they will produce no air pollution, the impacts will be mostly aesthetic, and unwanted changes to the environment will be largely reversible.

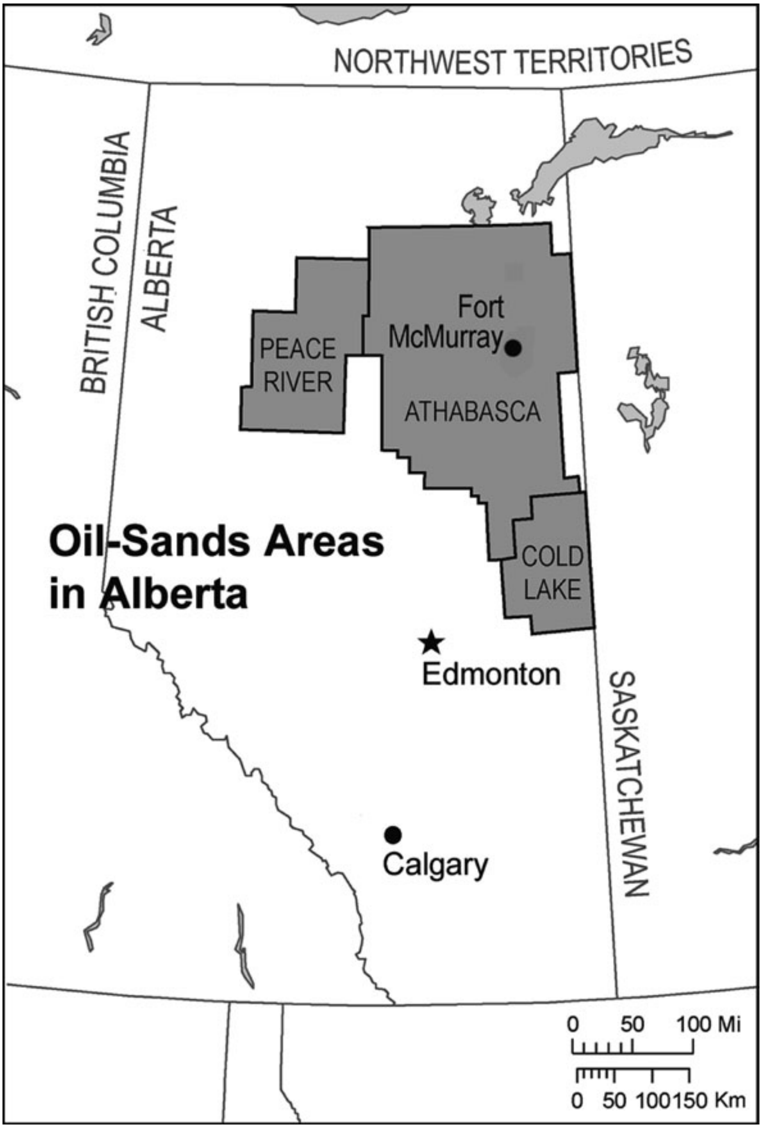

**Fig. 27.1** The oil sands of Alberta, Canada. The three areas – Athabasca, Cold Lake, and Peace River – comprise the largest oil-sand deposits in the world. The amounts of recoverable oil in the deposits place Canada second only to Saudi Arabia in reserves. (Cartography by Barbara Trapido-Lurie, School of Geographical Sciences and Urban Planning, Arizona State University)

Thought of another way, developing these new sources of oil and electricity are akin to mirrors on the past and windows on the future. Those that produce oil beckon investment because they promise continuation of profitable and familiar practices, a rearward vision. Those that produce electricity, on the other hand, entice because they offer a departure from the unpleasant experience of the past.

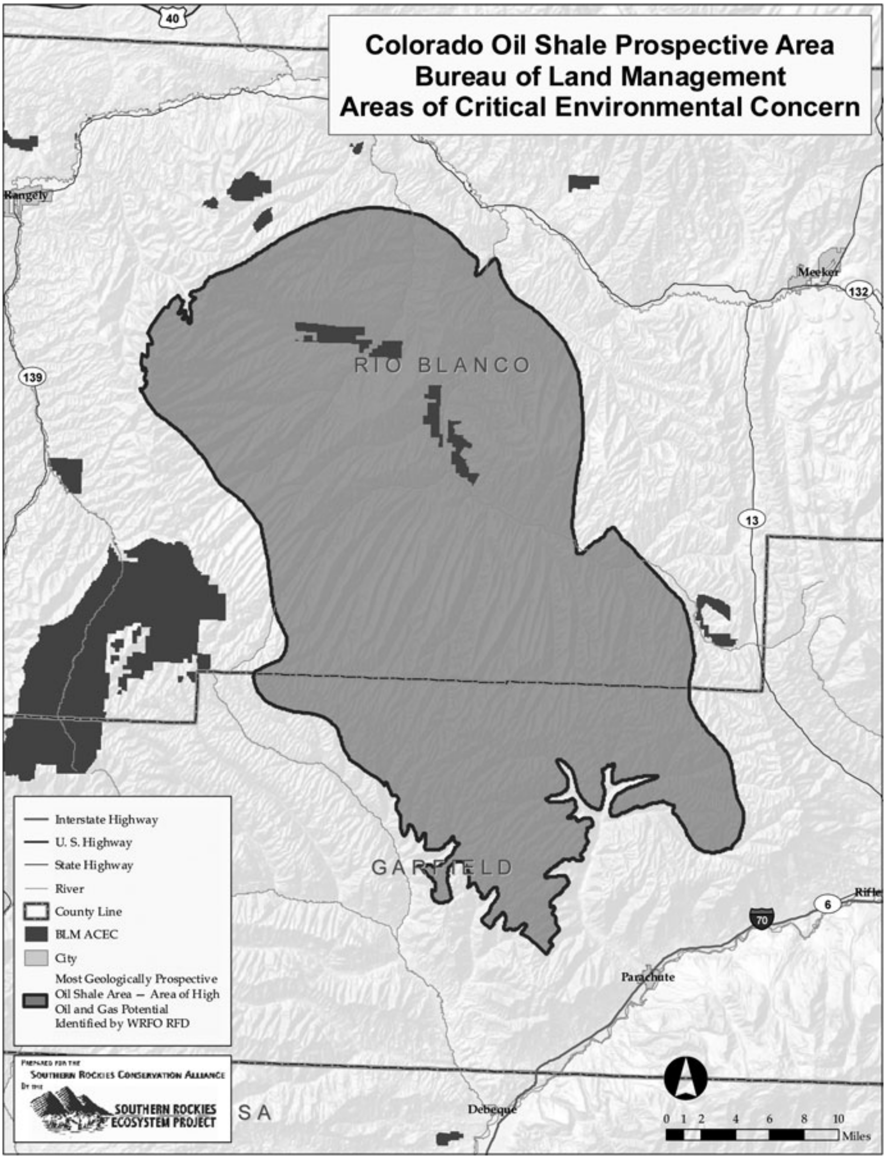

**Fig. 27.2** Colorado oil shale prospective area bureau of land management areas of critical environmental concern. (Source: http://www.oilshalefacts.org/maps/areas-of-critical.pdf)

## 27.3 A Western Emphasis

Much like the most recent history of human settlement in Canada and the U.S., energy development is concentrating in the west. Such a regional emphasis presents both challenges and opportunities. Many of the challenges attached to oil shale and oil sand are west of the 100th meridian; where they are found is either semi-arid or arid in character. Both oil shale and oil sand development require prodigious amounts of water, and there is increasing competition for what exists in the Colorado River and the Athabasca River. In addition, the aridity of the Western Slope of Colorado makes the landscape easier to damage and harder to reclaim. Alberta is similarly burdened, not just by its low rainfall, but also by its cold climate.

At least two other siting considerations add further resistance to the processing of oil from the oil shale and oil sands of western North America. First, population growth and rising economic expectations are driving greater demands for energy resources in both countries. Second, non-energy land uses of substantial commercial value, especially those areas for recreation and as sites for second homes, are incompatible with energy extraction activities.

Despite the overlapping demands on natural resources in northeastern Alberta and the tri-state area of Colorado, Wyoming, and Utah, these areas are as yet lightly populated, especially when compared to the major urban centers where the bulk of demand is concentrated. Were the oil shale and oil sands developed at least to the level of several million barrels per day, it would require an extensive and expanded network of pipelines to deliver the product to refineries. Existing pipelines from the Alberta oil sands already convey product to Edmonton and then to the Chicago area. Other long pipelines would be needed were production to increase, including ones to Canada's Pacific coast. Product out of the region carries "virtual" water embodied within. For oil shale, the task would have similar components but would in most ways be larger and more troublesome, for no commercial oil shale is being produced currently and water is even less plentiful than it is in Alberta. Construction of oil delivery networks would essentially begin fresh.

As for the other two resources, wind and solar energy, much of their potential is likewise in the western states, although other conditions are substantially different. In the case of solar, it is not concentrated in any subregion. For this reason, if no other, impacts of development will be diluted. Second, the commodity they would produce requires transmission lines above the ground rather than pipelines below. Third, solar photovoltaics and wind require no cooling water or auxiliary energy supply for their extraction or processing. Fourth, development of neither would degrade existing visibility. Such principal factors are important to the more detailed consideration of each of the four resources that follows.

## 27.4 Oil Shale and Oil Sands

For several decades the U.S. has been unable to satisfy its oil demand from domestic reserves. This shortfall has led to increased competition for the remaining supplies on the world market. In response, the price of oil has gone up, availability has become more problematic, political stability among trading partners more critical, trade imbalances more intense, and the search for new reserves more desperate.

If new supplies were available they would help offset reliance on imports while increasing the stability of supply, thus reducing transfer of wealth abroad and decreasing political tensions between the U.S. and supplying countries. If we are willing to pay the price, we do not have to look far. The two largest reserves are nearby: the oil sands of Canada and the oil shale of the U.S. Together, these two resources hold at least 3 trillion barrels, triple the amount of oil ever consumed. In the case of the oil sands, there are estimated 350 billion barrels of oil that are recoverable using present surface and underground techniques. This amount is about 14 times the proven reserves of conventional oil in the U.S., and 35 times the most optimistic estimates of the oil reserves within the Arctic National Wildlife Refuge (ANWR).

With such resources at hand, developing them is attracting serious interest, especially in the U.S. whose oil consumption now tops 20 million barrels a day, two-thirds of which are imported. But there is much yet to learn before we throw all our weight and wealth into a wholehearted program of exploitation. Fortunately, we might be able to share our experiences, because understanding either of these resources informs us about the other. For example, both resources are concentrated in fairly small areas of North America. Developing either would require massive challenges to the existing infrastructure. They would, for example, require quick and extensive increases in the need for housing, provision of consumer and industry services, road construction, pipeline placement, and the generation and distribution of electricity necessary to service the growing needs of every aspect of the projects (Pasqualetti, 2009). Communities in both areas have already recognized these challenges and the similarities between the two types of resources, going so far as to share their experiences. Indeed, the Mayor of Fort McMurray, the center of oil sand development in Alberta, has served as a consultant to the City of Vernal, Utah, one of the larger communities near the oil shale.

To recover this oil means thinking big. It requires about 2 million tons of oil sand to produce one million barrels of synthetic crude oil, (equivalent to about 285,223 tons of coal) and engaging in this activity has already reshaped 420 km$^2$ (152.5 mi$^2$) of territory in the oil sand areas north of Fort McMurray, including the removal of more than 50 km$^2$ (19.1 mi$^2$) of boreal forest (Woynillowicz & Severson-Baker, 2006) (Fig. 27.3). Another obvious impact comes from the accumulation of waste-products from hydrotreating, primarily waste sulfur stripped from the oil during processing. Presently, it is compressed into yellow blocks and stored on site as a massive sulfur mountain (Fig. 27.4).

Further development will broaden these changes. Approximately 3,224 oil sand scattered lease agreements are in place totaling 49,973 km$^2$ (19,145 mi$^2$), an area greater than that of Vancouver Island (Woynillowicz, Holroyd, & Dyer, 2007). The total impact of oil sand development on the ecological balance of northeastern Alberta could be devastating, an impact that can be masked by government policy. Those now in place, for example, do not call for re-establishing the land to “original condition” but only to “equivalent land capability.” This can result in land being returned not to forest but to pasture.

A second off-site impact will concern water quality and quantity on-site and in both directions (up- and down-stream), all of which further extends the impacts of oil sand development. Transporting and processing the mined bitumen uses large

**Fig. 27.3** Syncrude upgrader operations north of Fort McMurray, Alberta. (Photograph by the author, June 2006)

**Fig. 27.4** Blocks of sulfur produced during processing, stored at a Syncrude upgrader site north of Fort McMurray, Alberta. No use has yet been found for this a by-product of the upgrading process. (Photograph by the author, June 2006)

volumes of water, in the amount of 2.0–4.5 $m^3$ of water (net figures) for each cubic meter of synthetic crude produced, with additional water needed to upgrade the bitumen into lighter crude synthetic oil, whether done on-site or elsewhere (Griffiths, Taylor, & Woynillowicz, 2006). The Athabasca River is the key source for this water. The more water needed for oil sands development, the more pressure exerted on upstream supplies and downstream quality. Already, this river is precariously oversubscribed by oil sand operations. In 2006 approved oil sands mining operations held licenses to divert 359 million $m^3$ from the river, or more than twice the volume of water required to meet the annual municipal needs of the City of Calgary (Griffiths et al., 2006). Such demand constitutes a considerable impact from oil sand development, especially if growth proceeds as planned.

In addition to the rising concern for the water used in processing, another concern is waste water disposal. Producers currently send most of it to tailings ponds for recycling in ore processing. These tailing ponds already cover an area in excess of 50 km$^2$ (19.1 mi$^2$), creating what is easily the largest visible landscape signature. The ponds tempt migrating water fowl, sometimes with deadly results.[1] Downstream, concerns abound about the sustainability of the largest freshwater delta in North America, where the Athabasca River enters Lake Athabasca.

While many of the impacts of oil sand development are on-site and easy to observe, others are not. For example, the various methods of in-situ (underground) recovery require massive volumes of hydrogen to upgrade its highly viscosity bitumen; production and upgrading will require 1,500 ft$^3$ (42 m$^3$) per barrel produced in-situ, compared to the 750 ft$^3$ (21 m$^3$) per barrel of bitumen needed for the product from surface mining (ACR, 2004; Reguly, 2005). One source for this hydrogen could be natural gas in the Mackenzie River delta, where conditions are even colder and more fragile than near Fort McMurray. If this gas resource is tapped to help with the oil sand extraction, it will require construction of a pipeline hundreds of miles across the Arctic and expand the impacts of the oil sand.

Another impact will be the emission of greenhouse gases. Using oil from oil sands in place of light crude increases the emission an 80 kg extra for every 400 kg normally emitted, or about 20% more $CO_2$ per unit of energy. With the anticipated rise in production to 3 million barrels per day by 2020, this increase will produce a growth from 30 million tons in 2004 to 95 million tons of $CO_2$ in 2020 (Asgarpour, 2004). The oil sands are already responsible for the fastest rise in greenhouse gas emissions in Canada.

While the oil sand operations continue, almost 2,000 km (1,243 mi) to the south of Fort McMurray are the oil shale resources of the Green River Formation of Western Colorado and neighboring portions of Wyoming and Utah. This resource is even larger than the oil sands (Bunger, Crawford, & Johnson, 2004). The primary reservoir rock, the Green River Formation, holds an estimated 3.1 trillion barrels of oil, 800 billion of it recoverable (IEE, 2009) That makes the oil shale reserves 2–3 times those of the oil sands. As with the Alberta oil sands, there is a strong temptation to exploit this resource for reasons of national security, economic growth, and corporate avarice. But one might ask: Is this development such a good idea? How would oil be extracted from the rock without despoiling the environment of the area? Some analysts state that we cannot afford to overlook the potential of oil shale as a source for increased domestic production. Others declare the environmental price is too high because it will require an energy megaproject on a scale that will rival, and probably exceed, the efforts in Alberta.

In anticipation of what the future might hold for oil shale development, already opposition to the idea is mounting, just as the price of oil increases. If it were to recover price levels reached in the summer of 2008, economics may so favor oil shale development that development of the Green River Formation might be closer than it at present appears. Even under the most favorable economic conditions, however, oil shale development, just on the scale of the oil sands activities in Alberta, will likely be many years off.

Whenever oil shale development begins, even with great economic incentives, it will be more difficult to wrest oil from the shale than it is to coax it from the sands of Alberta. Nonetheless, there are several similarities between the two options. Developers of both resources, for example, can use surface and underground removal techniques. Surface operations for oil shale processing have two immediate and inherent drawbacks. Given that the oil shale expands upon heating, the volume of the waste material produced from surface mining would exceed the volume of material withdrawn, requiring large adjacent sites for waste disposal. Such sites would have to be so large as to stretch political acceptability.

The second drawback is that one of the most promising recovery techniques, called "retorting", needs about 1–3 barrels of water for each barrel of oil. For an industry producing 2.5 MMBbl/d, that equates to between 105 and 315 million gallons of water daily (DOE, 2009). In contrast to northeast Alberta, such a volume would be hard to find in the area of the Green River Formation for the simple reason that it is a drier region. It is also part of the Colorado River system, probably the most litigated and over-subscribed watershed in North America. Already, court battles are common among the various Upper and Lower Basin states over how this water should be divided, a particularly sensitive topic that is recently even more touchy given that the entire region is in the midst of a decade-long drought. Wherever water is used in the process of recovering oil from the oil shale, whether for extraction, processing, or waste disposal, it will remain perhaps the most serious concern related to the future contribution of oil shale to the national economy.

Regardless of how the oil is processed, production of oil shale (like that of oil sands) releases much more carbon dioxide than conventional oil. The lead paragraph of a recent article in *Rocky Mountain News* reports that "Oil shale projects in the western U.S. by Exxon Mobil Corp. and other producers would spew as much carbon dioxide as all the factories and vehicles in Taiwan or Brazil. . ." (Carroll, 2009). About 80–90% of emissions come from the heating that is necessary to pull the oil from the rock.

With the temptation to develop oil shale strong, the potential socioeconomic consequences loom large. The RAND Corporation estimates that with a "national production level of 3 million barrels per day, direct economic benefits in the $20 billion per year range are possible, with roughly half going to federal, state, and local governments. Also, production at this level would likely cause oil prices to fall by 3–5%, saving American oil users roughly $15 to $20 billion annually" (RAND, 2005).

Production levels of 3 million barrels per day from the oil shale would create hundreds of thousands of new jobs, mostly in western Colorado and adjoining Wyoming and Utah. The early stages would likely be similar to that experienced in Alberta when the oil sand production levels accelerated. The impacts there were considerable, as they would be if oil shale developments gained similar traction, despite its location just a three hour drive west of Denver.

Some sense of the regional costs of oil shale recovery may be approximated by examining the recent boom of coal-bed methane recovery, starting with the impact on population. Population increases of over 20% have occurred over the past 7 years in the small towns of Parachute and Rifle, which are the communities closest to the oil shale deposits (Fig. 27.5). Much like the tidal wave of workers that moved to Fort

**Fig. 27.5** Parachute, CO, situated along Interstate 70, looking north across the major oil shale fields of North America. Rifle is representative of the small towns in the area that will be susceptible to rapid growth. It had a population in July 2007 of 8,807, an increase since 2000 of 23.6%, largely as the result of the increased development of coal-bed methane and the resurgent interest in the prospect of oil shale development. (Photograph by author. August 2008)

**Fig. 27.6** Forest clearing and residential developments are part of the housing boom at Fort McMurray, Alberta. (Photograph by the author, June 2009) (For more on Fort McMurray, see Krim, 2003.)

**Fig. 27.7** The need for housing is already evident in the area near Parachute, CO as a result of ongoing development of coal-bed methane and the resurgent interest in oil shale. (Photograph by author. August 2008)

McMurray (Fig. 27.6) to extract and process oil sands, large-scale development of oil shale is expected to stimulate rampant growth not supportable by existing workforce or enterprises (Fig. 27.7). For Colorado, a new infusion of jobs from oil shale development would recall conditions three decades ago when federal incentives last created serious excitement over oil shale. In that case, the build-up was rapid and expansive, the bust a local economic collapse of the 1980, something no one wants to experience again (Clifford, 2002).

## 27.5 Wind and the Sun

Wind and solar power are to electrical energy as oil sand and oil shale are to conventional fuels. That is, both pair hold the hopes of the future, great promise of new supplies, and tangible excitement in energy boardrooms and the halls of government. Additional supplies of nearby oil could reduce reliance on distance imports, while allowing for continued use of traditional modes of transportation, even if they carry substantial environmental baggage in every phase from development and processing to distribution and use. New supplies of electricity from wind and the sun would avoid the air, water, and land impacts that come from the use of coal, uranium, and natural gas. Plus, because wind and solar energy are more diffuse, the impacts of their exploitation would be more diffuse as well. This is not to suggest that wind and solar power development would produce no impacts, just that these impacts would be less in total and less in any single area. Developed at a scale being envisioned for major contributions to our supply of electricity, meaningful deployment of either one will be considered as megaprojects.

Unlike oil sands and oil shale, concentrated as they are in just two small areas, wind and solar power are, relatively speaking, everywhere. At present, however, developments of both tend this ubiquity by concentrating turbines and solar arrays in large groupings. Although these do not disturb air, land and water on the scale and intensity of the oil resources we have been discussing, they are being erected by the hundreds, in dozens of countries. Collectively, they are megaprojects, and even individually some of the larger ones, especially some proposed, rise to the same status.

From a spatial perspective, the characteristic of both wind and solar is that they are diffuse resources. This results in projects spread over areas as least as large as fossil-fuel power plants. For wind, the other important characteristic is that it is site specific, so that a wind resource must be developed exactly on the site where sufficient wind is available; it cannot be moved to a more convenient location. This implies built-in potential for direct conflicts with whatever may exist already in the same place. A third salient consideration is that no matter how the wind turbines are designed, painted, erected, or spaced to make them less obtrusive or annoying, they cannot be made invisible. Consequently, controversy over their deployment should have been anticipated. One of the best-known examples of such controversy is found near Palm Springs, California (Pasqualetti, 2001, 2002). Two others, less familiar, include the proposal for the Isle of Lewis, in the U.K. and another planned for La Venta, in the state of Oaxaca, Mexico.

The Isle of Lewis proposal was for the largest wind installation in Europe and one of the largest in the world. Lewis Wind Power applied to the Scottish Executive in about 2003 under Section 36 of the Electricity Act 1989 to construct a wind farm on the Isle of Lewis with an installed capacity of 651.6 MW, plus associated infrastructure (Lewis Wind Farm, 2009). Proponents of the scheme claimed it would have generated 7% of Scotland's energy, enough to meet the average needs of one million people. After vociferous opposition, the Scottish government denied the request (BBC, 2008). In so doing, they affirmed democratic principles, but dealt a serious setback to renewable energy.

The severity of that setback was limited, however, by the isolation of the site in stark contrast to the much smaller 170 MW project in the U.S. called Cape Wind. It proposed a location between Cape Cod and Nantucket Island (Whitcomb & Williams, 2007). Unlike the summer sun and sand on crowded Cape Cod, the Isle of Lewis offers a barren, windswept, rainy, peat-covered landscape with few people. In both places, nevertheless, opposition to wind is rooted in objections over the negative effect of visual aesthetics. At Cape Cod, opposition to the wind turbines is predicated on their aesthetic intrusion to those enjoying leisure activities. On Lewis, the wind turbines were resisted on several grounds ranging from the removal of peat to hazards to birds. The chief objection, however, was that they would be visible to anyone on the island, and that they would degrade one of the finest megalithic cultural sites in the Europe called the Callanish Standing Stones

Fig. 27.8 The Callanish standing stones

(Fig. 27.8), thought to have been erected between 2500 and 3000 BC (Gray, 2009; Ittmann, 2005).

The Lewis project would have installed about 180 of the largest wind turbines in the world, in addition to over 200 pylons and conductors, all of which were illustrated in a computer visualization project during the period of public comment (Stephenson-Halliday, 2009). The 3.8 MW turbines would have a total height of 140 m (460 ft) with a rotor diameter of 107 m (358 ft). Each wind turbine would require a buried, reinforced-concrete foundation typically 22 × 22 m, up to 2 m thick (72 × 72 ft, 3–6 ft thick), with a 2 m (6 ft) high column in the middle for the tower. The wind turbines would be arranged in 9 groups. Each foundation would have adjacent a prepared area called the "hardstanding" for the installation cranes to use.

Although the primary issue on the Isle of Lewis was degraded visual aesthetics, other factors were involved. For example, occupants of the Isle are fundamentalist Presbyterians whose lives on Lewis have persisted largely unchanged for centuries. The wind project, they worried, would interfere with that steadfast isolation and jeopardize their way of life.

Perceived and actual environmental changes continue to disrupt plans for greater development of wind power. Lifestyle change is the common denominator, and this is true whether it is on a remote and cold island in the north Atlantic or in the warm and humid Pacific lowlands of Mexico. In much the same manner as has transpired on the Isle of Lewis, the local residents in the region in the state of Oaxaca are now resisting plans for massive wind development in a region known as La Ventosa ("windy") (Fig. 27.9). In Oaxaca wind development is not speculative, it has already begun, and over 5,000 ha (12,355 acres) of land are already reserved

**Fig. 27.9** A protest poster declaring "If we plant these today, what will we plan tomorrow?" (Source: Protests in Juchitán against Wind Turbines)

in the municipalities of Juchitán de Zaragoza, Union Hidalgo, El Espinal and San Dionisio del Mar, a number expected to rise an additional 3,000 ha (7,413 acres) in the coming months (Preneal, 2009). There is one large investment involved.

> In the next three years…companies will invest $3 billion in Oaxaca in the Isthmus of Tehuantepec Wind Tunnel in the following way: 78% will be invested in purchasing wind turbines, 14% in the electrical system, 6% in civil work and 2% in other spending.
>
> (Zenteno Eduardo, 2009)

The scale is that of an energy megaproject.

The Isthmus of Tehuantepec is a natural funnel that accelerates the wind southward at 15–22 mph and always done so. Yet, it has only been recently that commercial projects have been tendered and constructed; wind energy accounts for less than 2% of electricity production in Mexico. But this status will change soon. Mexico's Energy Secretary Georgina Kessel is planning on a series of wind projects that by 2012 should generate 2,500 MW of electricity and perhaps up to 5,000 MW.

Most of that capacity is intended for the Isthmus. The Spanish company Iberdrola Renovables recently won a contract for La Venta III, a 102.85 MW wind farm, which will be Mexico's first wind generation independent power producer project. It includes a 20-year contract to supply energy to the Mexican Electricity Commission (CFE). It is under construction and slated to come on stream in November 2010. The 21 turbines will be smaller than those proposed on the Isle of Lewis. Instead of 3.8 MW turbines, those intended for Oaxaca will by 850 kW. Instead of 140 m (459 ft) in height, they will be 44 m (144 ft). And instead of a completely new energy-generating scheme, they will be added to those of the earlier developments, La Venta I and La Venta II. Iberdrola was the company that installed the 98 turbines that make up the 83 MW La Venta II project, commissioned in January 2009.

In January 2009 President Felipe Calderon announced another large project for the same vicinity that will cover 2,533 ha (6,180 acres), a $550 million enterprise. It will be rated at 250 MW, with 157 turbines, 25 of which are already operating. The rest should be on line by the end of 2009, making the project the largest of its kind in Latin America. In all, there are 20 projects already in operation or in tender for operation by 2012, with the total generating capacity to be reached by then of 2,579 MW, roughly equivalent to all the wind generating capacity in California, which has been developing its wind potential since the mid-1980s (Table 27.1). If the current turbine size is maintained throughout this initial program of installation, over 3,000 turbines will poke out of the landscape, changing it from strictly agrarian to a predominately industrial. The development of the Isthmus of Tehuantepec will rise to the status of an energy megaproject.

Some of the same geographical characteristics of the Isthmus that make it ideal of wind power today have made it appealing for other projects as well. That is, the Isthmus is the lowest and shortest route between the Gulf of Mexico and the Pacific Ocean. So convenient is the Isthmus that it for centuries it has been important for transportation, commerce, human movement, and settlement. This long history of occupation has helped facilitate a close association of the people with the land (O'Connor & Kroefges, 2008).

The attractive areas for wind farms are located near appropriately-named La Venta, within the larger municipality of Juchitán. The city itself was founded in 1486 and has a long history of political disquiet. There was a revolt there in 1834, interrupted by the Mexican-American War in 1847. In 1866 the people of Juchitán defeated the French. Porfirio Diaz, later a dictator of Mexico, populated his army mostly with citizens from Juchitán. In 1910 other members of the town organized in support of the revolutionaries Villa and Zapata. More recently, Juchitán is the seat of COCEI, an influential popular movement that matured in the 1970s combining socialists, peasants, students and indigenous groups. In 1980 it became famous for electing a left-wing, pro-socialist municipal government, the first Mexican community to do so in the 20th century. In February 2001 Juchitán received the caravan of the Zapatista Army of National Liberation. Today the city is home to about 75,000 citizens, mostly Zapotecs and Huaves.

**Table 27.1** The total of installed and announced wind development projects in coastal Oaxaca by 2012. The total capacity is comparable to that installed in California by Jan 31, 2009, over a period of 35 years

| Capacidad total | MW |
|---|---|
| Autoabastecimiento | 1,986.95 |
| CFE (Instalado) | 85.50 |
| CFE (IPP en licitación) | 101.00 |
| CFE (Oaxaca I, II, III y IV) | 405.60 |
| TOTAL | 2,579.00 |

Source: Fernando Mimiaga, Corredor Eólico del Istmo de Tehuantepec: Proyecto de Gran Visión Ejemplo En México y América Latina. 26 y 27 de marzo de 2009, Huatulco, Oax. http://www.windexpo.org/conferencias/Sesion7/Fernando_Mimiaga.pdf. Accessed June 3, 2009

The tendency for citizen activism in the area has evolved into clashes that have become increasingly common between locals and the federal government over national plans to develop wind megaprojects. Among the claims is that local residents are receiving a meager amount to lease the land to the wind developers, especially when compared to condition in the U.S. In the U.S. each turbine returns to the land owner between $3000 and $5000 per year. In Oaxaca the amount is more like $125 per ha/year for a single turbine (Sanchez, 2007). Others estimates of the compensation have been $98–$117 per ha (Karen Trejo, 2008). An official from the CFE claims that the payment is more like 6,000 pesos (about $450) per year (Fernando Mimiaga Director, Dirección de Energía Sustentable Proyectos Estratégicos, personal communication, June 7, 2009, Juchitán, Oaxaca).

The alleged inequity from the modest development is already in place and is one of the principal reasons for the formation of opposition organizations such as the Gruppo Solidario de la Venta (Girón Carrasco, 2007). Disgruntled locals believe they are not being treated fairly, a sentiment that would seem destined to grow as wind development spreads and intensifies according to plan. Already, there are questions. One of the present questions is why local communities are not benefitting from projects that are being constructed on community held lands. As the National Wind Watch phrases the impasse:

> The growing resistance to wind farm construction in southern Oaxaca. . .is based on local landowners' negative negotiating experiences with the CFE, discomfort with the broad freedoms seemingly granted to multinational corporations and an increasing concern about the possible environmental consequences of the wind farms themselves. . ..
>
> (Sanchez, 2007)

Such views have taken on tangible form, including barricading of roads leading to the wind sites, and protesters holding anti-wind banners. There have been incidents of rock throwing, accompanied by some minor injuries. A local leftist farm group known as the Assembly in Defense of Land has complained about the treatment received by the local, saying: "They promise progress and jobs, and talk about millions in investment in clean energy from the winds that blow through our region, but the investments will only benefit businessmen, all the technology will be imported. . .and the power won't be for local inhabitants." The group is calling on supporters to "defend the land we inherited from our ancestors" (Stevenson, 2009). They have put out the call for everyone to say: "No to the wind energy megaproject in the isthmus that desecrates our lands and cultural heritage" (Assembly in Defense of Land and Territory, 2008).

In an attempt to grasp at any possible legitimate objection to the wind developments, local opposition has also complained about the potential harm of the turbines to birds. Being the narrowest stretch in Mexico, the region is heavily used by migrating birds. There have been some plans suggested that would have the operators brake the spinning turbines when large flocks of bird approached, although nothing along these lines has been finalized.

Despite objections, internet articles, worries about birds, and protests, nothing has yet threatened the expansion of the wind projects. On the contrary, the projects are proceeding without delay, while the developers, along with the CFE, claim that anti-wind protests have been minor, misguided, and inconsequential (Fernando Mimiaga Director, Dirección de Energía Sustentable Proyectos Estratégicos, personal communication, June 7, 2009, Juchitán, Oaxaca). Yet, for those in the wind industry who follow such resistance, even if the negative reactions around La Venta area include relatively small numbers, they can, as has been demonstrated by the successful campaign against the Isle of Lewis proposal, pose significant obstacles to further wind megaprojects.

Regardless of the outcome from public concern over wind projects, to some they will only ever be a partial solution to our alternative energy needs. They point to an array of other alternatives that are available, particularly various solar options, as the eventual dominant alternative energy form. Ultimately, most futurists look to a time when our lives are powered by direct use of the sun, both to provide hot water and to make electricity (Jha, 2009).

There are many ways to collect solar energy for our use, but whatever form a solar revolution may take, the early years will likely stress megaprojects. It is an inevitable development. While, logically, solar energy should evolve into a dominantly distributed deployment, the earliest stages will be in the form of large-scale projects that fit most amenably into the existing large centralized model of most utility companies.

The amount of land that such centralized solar plants will take is one of the most common complaints about the resource. Yet, proponents like to drive home the huge potential contribution from solar energy by pointing out that even at present conversion efficiencies, photovoltaic cells covering less than 10% of Arizona could supply all the electrical needs of the U.S. Of course, such a claim, while technically accurate, ignores a host of practical matters such as distribution. It does, however, provide a sense of how much solar energy is available.

Much of southwestern U.S. and northwestern Mexico receive in excess of 7 kWh/m$^2$/day, values that are equaled or exceeded across most of the low-latitude deserts on the planet. These can be tempting values to solar energy developers. The U.S. Department of Energy estimates that about 8,000,000 MW could be developed just on land that has no primary use today.

In 2002 Congress asked the Department of Energy to fill a goal of 1,000 MW of solar thermal in the southwestern U.S. In June 2004, the Western's Governor's Association resolved to diversify their energy resources by developing 30,000 MW of “clean” energy in the West. According to the ensuing report of the Solar Energy Task Force, as much as 8,000 megawatts of capacity could be installed with a combination of distributed solar electricity systems and central concentrating solar power (CSP) plants, while another 2,000 MW (thermal) of solar hot water would be realistically available (WGA, 2006). Such scaled projects would be ideal for local economic development. For example, installation of each 1,000 MW of Concentrating Solar Power generating facilities would create 7,000 new jobs.[2]

Were several of such projects erected, they would require large tracts of land. For example, for the 8,000,000 MW of potential identified in Arizona, Nevada, California, and New Mexico, deployment would require a land area of about 157,990 km$^2$ (61,000 mi$^2$). This area, which is one and one half the size of Pennsylvania, includes only land for which there is no primary use today, largely federally owned. Of course, not all of the area involved in such proposed projects should be considered part of near-term projects, but it will not take long for such number to be reached.

The California deserts offer a convenient and useful measure of the growing interest in large-scale solar projects, including the growing land requirements that would ensue. As of March 2009, 71 solar thermal projects were received by the Bureau of Land Management in California. They would cover an area of 258,372 ha (638,452 acres) (BLM, 2009). These projects, were they all constructed as proposed, would produce a total generating capacity of about 48,000 MW. This is in addition to about 350 MW already built and operating in California (Fig. 27.10),[3] a capacity that is about one-third that of a typical nuclear reactor.[4] In addition, 800 MW of photovoltaics (PV) have been announced, a capacity that is expected to greatly increase once costs for electricity generated by PVs is more competitive with other solar options.

When people think of solar power as the "ultimate" renewable energy resource, they often do not anticipate public opposition to its deployment. They see solar as being unlimited, absent of both greenhouses gas and long-term wastes, needing no cooling water and producing no noise. Nevertheless, all is not calm on the solar

**Fig. 27.10** SEGS (Solar Energy Generating Plant) at Kramer junction, west of Barstow, California. These installations are concentrating solar power facilities, using parabolic trough with single-axis tracking. They occupy a low-priority patch of land. Source: Wikipedia Commons. http://upload.wikimedia.org/wikipedia/commons/4/44/Solarplant-050406-04.jpg

front. As one example of this resistance, for years Home Owners' Associations have stymied the installation of roof-top solar equipment on aesthetic grounds.

But it is not just objections from private citizens that are confounding solar energy developers. Most recently, U.S. Senators have been building barriers too. Most notable in this regard is the action by the senior Senator from California, Diane Feinstein. Sen. Feinstein seeks to block solar power from 500,000 acres (202,350 ha) of the Mojave Desert because such development, she says, threatens desert species and is contrary to the intent of those who had donated the land for purposes of conversation. She is proposing the area as a national monument, which would block future development (Freking, 2009). It is significant to note that she is not attempting to block an individual solar proposal, but a large number of them. This example illustrates why a future with solar power must be considered in terms of any megaproject; while solar developments may be scalable from small size to thousands of megawatts, the feasibility of meaningful solar energy assumes megaprojects; the success or failure of each project, at any scale, will influence the future of a solar energy future.

## 27.6 Discussion

The 6.5 billion people on our planet collectively require about 18 terawatt hours of energy per year, a number that will continue to grow along with the increasing demand from burgeoning economies in China, India, Brazil, and elsewhere. Improvements in energy efficiency so far have helpfully retarded the rate of growth, especially in the OECD countries. Inevitably, however, we will run short of opportunities for meaningful improvements in energy efficiency and we must prepare new approaches to satisfy our energy needs. Because the demand for energy is rising so quickly, many governments and intergovernmental agencies are looking to megaprojects to rescue us from our own appetite. For energy liquids, some are looking to the oil sands of Alberta and the oil shale of the Intermountain West, despite the environmental havoc such developments are sure to bring. For electricity, hopes are centering on wind and especially solar as a way to skirt the more egregious drawbacks that large fossil projects produce on existing land use and ways of life.

How can we reconcile our need for energy and the problems energy provision produces? How can we supply the energy we need in a form we need but in a manner that does not produce irreversible harm to the physical and social environment in which we live? Will there continue to be an expansion in the scale of energy megaprojects such as has transpired over the past 100 years? Coal mining, for example, has moved from shallow pits to mountain top removal. Will the future bring more of the same, or will the trend for larger and larger solutions abate? Have we gone as far as we should go?

I argue, and it is an admittedly self-evident declaration, that the world cannot simultaneously support the continued rise of population and the lock-step growth of energy supply to support it, at least not at the same pace and in the same forms as in the past. Such a scenario is clearly not sustainable. Put another way, for reasons of sheer logic, energy megaprojects must be considered a dying model if we are to slip relatively unscathed into the future. We need to hold ourselves back from traveling on the same path. Such change of habit will not be easy and it will perhaps not happen quickly as it should, but there are two changes that would ameliorate the costs to our planet and to ourselves.

First, as I have argued elsewhere in some detail, we must accept that megaprojects, like oil sand development in Alberta, cannot be considered a suitable answer to our energy needs (Pasqualetti, 2009). The costs – to air, land, and water are too high – whether we are considering the natural environment or its residents. Nor, for even more compelling reasons, should we be looking to oil shale development in the Intermountain West for our salvation. Caution over these particular resources, moreover, should be extended to other energy megaprojects that struggle to pass a "sustainability test". That means that we must wean ourselves from coal, oil, uranium, and even natural gas (especially coal-bed methane). Megaprojects involving these resources have unacceptable environmental impacts and unaccountable social costs that are largely irreversible and hazardous, and that at best defy the elemental principles of sustainability. Taking steps toward further large-scale development of these types of energy development will move us in the wrong direction.

Second, we should accelerate development of wind and solar power. In the early stages, as we have seen, developments are likely to be large, but this is not necessarily bad. Moreover, they need not always be so, especially for solar power, which is a naturally distributed asset. While the use of solar energy, in all its many forms, is unlikely to become the entire near-term solution, the more we strive for its widespread deployment, the more sensible and surefooted our future energy supply will appear.

From a long look at history, we find that the farther we go in our development of energy, the larger the projects have become. There are several reasons for this trend, many of them financial and geopolitical. But it is not the spatial scale of the energy projects that is the inherent problem, but the resource and the processes we employ to make them available for our use. Were we to choose the path toward gentle resources such as the sun and wind over paths toward more intense resource such as coal and uranium, we would be moving in the right direction. And we would neither poison ourselves nor risk global instability in the process. That is the choice before us as we begin moving toward the next generation of energy megaprojects.

## Notes

1. Noise mimicking the report of guns deters birds from landing on the water.
2. Based on the University of Nevada, Las Vegas Center for Business and Economic Research study on the potential impact of constructing and operating solar power generation facilities in Nevada. http://www.nrel.gov/docs/fy04osti/35037.pdf. Accessed May 27, 2009.
3. Prior to the Renewable Portfolio Standards in 2002, 13 solar thermal power projects were planned in California, with 11 of those filing applications with the Energy Commission. Nine projects (Solar Energy Generating Station – SEGS I to IX), totaling 354 MW, were built. SEGS III to IX are owned by NextEra Energy Resources (formerly FPL Energy) and SEGS I and II

are owned by Cogentrix Solar Services – a wholly owned subsidiary of Cogentrix Energy LLC (Charlotte, NC), which purchased former owner Sunray Energy Inc. in early 2009.

4. A note of clarification is useful here as to the number of solar proposals that have been submitted. There is no master list, but it is well over 100. The Bureau of Land Management lists 71 applications that have been submitted to BLM. The California Energy Commission lists other solar proposals that have filed for an Application for Certification (AFC). Many of the BLM applications have not submitted an AFC to the CEC. The CEC has jurisdiction only over solar thermal projects greater than 50 MW. There are many BLM applications that are photovoltaic that CEC has no jurisdiction over. There are also some AFCs with the CEC that are on private land where BLM has no jurisdiction. Therefore, there are many applications that CEC will not have listed that BLM does, and some applications the CEC has listed that BLM does not.

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