Energy Primer
World Energy Prospects through 2050 and Contingency Planning for Shortfalls

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Introduction

This chapter provides an overview of energy supply and demand forecasts to the year 2050. The initial conclusion is that there will be several progressively more severe energy shortfalls starting after the year 2012. These shortfalls will be unlike the oil crises of the 1970’s in that they will be of a more permanent nature because of the irreversible worldwide depletion of non-renewable energy sources. This prediction is based on the most likely scenario derived from a model first developed in 1976. Additionally, the report will examine possible strategies that could be taken to deal with future energy shortfalls. Five such strategies are examined and one strategy in particular, contingency planning is examined in detail.

The results of this study point to a “call to action” for local, state and federal governments worldwide. While some governments have implemented impressive non-renewable energy production infrastructures (see picture of a Svartsengi Geothermal Plant in Iceland) others have done very little. Unfortunately those that have done very little are the same ones that are most blatant violators of the supply/demand balance.

If this is a “call to action” than what kind of “action” do we need? The action is a mix of conservation and contingency planning. While many leaders are advocating for increased conservation these days not many are talking about contingency planning. This makes sense because it is very easy to see how politically unpopular it would be to plan for a crisis of such a crippling nature as a worldwide energy crisis.

Problem Statement

The problem is that of an insatiable worldwide demand for energy coupled with a finite and therefore dwindling non-renewable energy supply. While this does not mean ipso facto that their will be energy shortfalls in the next 50 years it does mean that shortfalls will happen sometime because if there is a chance that it can happen then it will happen. Furthermore, if it can be proven that it will happen “soon” (as this paper asserts), then the problem becomes one of how to delay its onset and what can be done about it once it does happen. While focusing primarily on the latter problem, this paper attempts to address both issues.
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Using the “Integrated Energy Model” to Predict the World Energy Future

What is most intriguing about this topic may be the dearth of literature produced since the mid-1980’s. It is almost as if the two 1970’s oil crises were fully examined by 1985 and after this year it became impossible to get research funding for energy modeling and contingency planning.\(^1\)

To examine the problem, an “Integrated Energy Model” was used which was based off of the “Integrating Model Framework” from the Federal Energy Administration’s 1976 National Energy Outlook.\(^2\) This model was chosen because it not only accounted for energy supply and demand but also accounted for such things as demographic variables and economic forecasts. While the below model is not an exact replica of the 1976 model it is the idea of integration which is carried forward within this new analysis.

As a point of interest, this model is further validated through a recent article by Dr. Arlie Skov of the Society of Petroleum Engineers (actually known for their rosy forecasting) who stated that “Forecasting energy needs 50 years into the future is inherently hazardous, but scenarios can be developed using trends in Gross Domestic Product (GDP) growth, population growth, and reductions in energy intensity (conservation).”\(^3\)

The FEA originally funneled massive data sets into complex formulas to come up with their conclusions in 1976. Due to time, data and various other limitations it was decided to use only a few different approximations for each variable so as to emulate some sort of range of outcomes that could be expected in the future. The “outcomes” are then placed on a basic price/quantity demand graph (pictured at right) to note the magnitude of the differences between supply and demand. The following projections and subsequent analysis will give the reader a range of possible scenarios.

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\(^1\) The Party’s Over: Oil, War and the Fate of Industrial Societies, Richard Heinberg, New Society Publishers, 2003, p. 74-75


Demand Predictions

Below are three demand scenarios: best, worst & middle. To fill in the necessary inputs to the Integrated Energy Model it was necessary to get a range of values on Population\(^4\), Gross Domestic Product (GDP)\(^5\) and Energy Intensity.\(^6\) These three variables yielded three very different world energy demand predictions.\(^7\)

**Best Case Scenario**
- Population: \(7,408,573,000\), 22% increase from \(6,070,581,000\) in 2000
- World GDP: \(1.0\%\) per annum (Based on low end of spectrum from SPE Report)
- Energy Intensity: \(1.4\%\) per annum reduction in energy usage
- Energy Demand: \(0.0\%\) per annum net energy growth rate or \(27\) Gboe consumed per annum up \(0\%\) from today.

**Worst Case Scenario**
- Population: \(10,633,422,000\), 75% increase from 2000
- World GDP: \(2.8\%\) per annum (Based on BDP from 1988-2002)
- Energy Intensity: \(0.8\%\) per annum reduction in energy usage
- Energy Demand: \(2.0\%\) per annum net energy growth rate or \(70\) Gboe consumed per annum up \(160\%\) from today.

**Middle Range Scenario**
- Population: \(8,918,724,000\), 47% increase from 2000
- World GDP: \(1.4\%\) per annum (based on a linear projection of growth rate from 1960-2000)
- Energy Intensity: \(1.1\%\) per annum reduction in energy usage
- Energy Demand: \(1.0\%\) per annum net energy growth rate or \(44\) Gboe consumed per annum up \(63\%\) from today.

Gboe = Billion barrels oil equivalent

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Supply Predictions

Dr. King Hubbert (pictured below) is the first man to effectively apply principles of geology, physics and mathematics (in combination) to the projection of future oil production from the U.S. reserve base. Said in another way, he operationalized the variable “World energy supply.” His model was released in 1957 and was quite simple: compute the ultimate (produced + reserves + yet-to-find) liquid (oil & gas) projections and then deplete the supply once it has reached a midpoint (the point at which half the supply has been used). This methodology was used to predict production declines in both the US and the former Soviet Union.

Predictions based off of this methodology are used as the basis for the supply projections for this report. For the sake of a useful sensitivity analysis the same supply prediction will be used for all three demand scenarios. While their clearly is a range of supply scenarios this range is much tighter than the range we saw on the demand side. It is hard to settle on one forecast so a more “generous” prediction of world liquid energy supply will be used. The following is a description of the supply forecast:

- Ultimate recovery: 2750 Gb
- Year midpoint is reached: 2012
- Depletion Rate: 2.2%
- 2003 annual production: 27 Gb
- 2050 annual production: 12.5 Gb
- 2003-2050 production: -53.7%

The figure to the right represents a graphical representation of the above projection (specifically the green line). It is important to note how close the squared dark blue line, which represents past world liquid energy production, follows the green line projection – the projection is right so far but will it last? Please also note the precipitous decline after 2012 even with “non-conventional” and “gas-liquid” sources projected to peak in much later years. The implication is that the downward trend in tradition oil supplies is quite substantial and will take massive amounts of new alternative energy generation (preferable renewable) to offset the dramatic supply decline after 2012.

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8 Dr. Jean Laherrère, 2000, http://www.hubbertpeak.com/laherrere/
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Model Results: Energy Shortfalls

The next step is to match the supply forecast against the three demand forecasts. The goal is to come up with a most likely scenario that can be used as a jumping off point for discussion in the next section. The demand scenarios are depicted against the supply scenario in the figure to the right. Obvious in this display is the fact that no matter what scenario there will be a significant shortfall that will have to be dealt with. For the purposes of this project we will pick the middle range demand projection as this seems to be the most likely outcome just based on the fact that it is the most moderate of the three predictions. If we display all the variables in the model it would look something like the figure to the right with the red line indicating the imbalance between supply and demand.

The assumption here is that new oil and gas reserves, technology to develop new fuels, conservation efforts, and economic and population growth rates will not change dramatically in the next 50 years. Discoveries, inventions and conservation efforts are factored into this model but are basically just projected straight-line. Without knowing what will happen in the future this is the best we can do. What’s not straight-line is supply. After 2012 there will still be oil and gas but production will fall off and what is left will be increasingly scarce and expensive. These shortfalls will look much like the price shocks of the 1970’s but they will be longer in duration and will keep reoccurring until around 2050 when the market is cleared and an equilibrium point is reached. How fast we are to respond to the crisis and reach this equilibrium point has allot to do with how well we plan for the crises before they actually happen. Part of this planning has to do with conservation but the other equally important part has to do with contingency planning. The question becomes, “who gets the scare resource and how is it distributed.” The next section on contingency planning will help answer this question when dealing specifically with US transportation systems.
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How to Plan For Energy Shortfalls in US Transportation Systems

When a system experiences a serious incident or incidents that prevent it from continuing normal operations, (this can range from a flood or fire to a serious computer malfunction or worldwide nuclear holocaust) the management of the system has the responsibility to recover from such incidents in the minimum amount of time, with minimum disruption and at minimum cost. This requires careful preparation and planning.

Why Contingency Plan?

- Because conservation alone is not enough to avert a crisis.
- "If it could happen, it will happen" So, what are we going to do when it does happen?
- Because there is no time to plan for it when it actually does happen!
- "To increase the United States ability to respond to an energy shortfall through a downward adjustment of energy demand without causing severe problems for households, for the economy in general"

Examples of Contingency Planning
Contingency planning in recent years has primarily revolved around planning for the Y2K "crisis" or plans funded by the Department of Homeland Security to address the terrorism threats. Also popular, and more immediate to our topic, is the planning that is now going on in the wake of the August 2003 Canada/US blackouts (above picture of the Cleveland skyline during blackout conditions – AP Photo) and the summer 2001 California energy supply crisis. A common thread in all these, with the exception of the Y2K fiasco, is that the contingency planning started after the "big event." Ironic that the foresight was actually there to contingency plan for Y2K but that for the most part the plans were not needed. And so it goes for contingency planning in the complex modern world – it’s done when it’s not needed and not done when it is needed. Irregardless of this cynical statement it is hoped that an adequate case has been made thus far to contingency plan for the coming energy shortfalls.

How to Contingency Plan
There are as many different types of contingency plan as there are contingency plans. However, there are plans that are specific to both energy shortfalls and planning. Unfortunately, these plans are somewhat dated in that they are from the 1970’s when it was popular to plan for such crises. Even though they are dated they are thorough and applicable to our current situation. The main question involved in this type of planning, as crass as it may sound, is: Who gets the scarce resource and how might that be decided?
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To answer this question there are 5 steps
1. Who is vulnerable to price swings and availability issues?
2. What essentials do these groups need?
3. At what stage are these essentials provided?
4. Prioritize policies based on effectiveness (work trips, short trips, long trips, etc.)
5. Implement contingency plan (note overlap)

To the right is an example of how one would organize findings from steps 1 & 2. Although this is merely a sampling of the vulnerable sectors that would be affected (is not just about everyone vulnerable?) by a worldwide energy shortfall it is useful to see how an exercise like this could be completed.

The third step would involve taking the list of vulnerable sectors and their corresponding plans and try to fit them into some sort of timeline so as to answer the question: At what stage are these essentials provided to the vulnerable groups? This is critical issue because to allocate resources to early to a group would mean to not only be inequitable to other competing uses but to also artificially inflate their expectations without having them conserve or adjust to lower energy supplies. What this would look like is to map out three to five stages that get progressively worse as they continue. If stage one is $2.75/gallon gas then stage three is $5/gallon gas. Next, place the vulnerable sectors plans within the appropriate stage. Voluntary reductions in non-work travel may happen in earlier stages while rationing and airline subsidies may happen in latter stages.

### Who is vulnerable & what do they need?

<table>
<thead>
<tr>
<th>Vulnerable Sector</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuters</td>
<td>Carpooling, Vanpooling, HOV parking and lane preference, work-at-home, 4-day work-week, rationing, etc.</td>
</tr>
<tr>
<td>Leisure Industry</td>
<td>Connect consumers and leisure via multimodal transit options.</td>
</tr>
<tr>
<td>Government</td>
<td>High quality and better information dissemination (SARS) to bolster credibility.</td>
</tr>
<tr>
<td>Low-Income</td>
<td>Increase transit capacity and better information dissemination.</td>
</tr>
<tr>
<td>Freight</td>
<td>Increase truck loading, alter truck size, increase efficiency of routing, consolidate urban deliveries, rationing, etc.</td>
</tr>
<tr>
<td>Fuel Dependant Industries</td>
<td>Subsidies for airlines, paratransit, school buses, etc.</td>
</tr>
</tbody>
</table>

### Staging of Alternative Contingency Plans

<table>
<thead>
<tr>
<th>Scenario</th>
<th>$/Gal</th>
<th>Shortfall</th>
<th>Timeframe</th>
<th>Probability</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$2.75</td>
<td>3%</td>
<td>1 year</td>
<td>.5</td>
<td>Reduction of non-work travel</td>
</tr>
<tr>
<td>2</td>
<td>$3.50</td>
<td>10%</td>
<td>1.5</td>
<td>.3</td>
<td>Increase in transit travel</td>
</tr>
<tr>
<td>3</td>
<td>$5.00</td>
<td>20%</td>
<td>2</td>
<td>.2</td>
<td>Rationing</td>
</tr>
</tbody>
</table>

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9 The “5 steps” are culled from various resources within Transportation Energy Contingency Planning, Special Report 191, Transportation Research Board, Washington D.C., 1980.
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Once these plans are in some sort of a timeline it will then be imperative to prioritize the given policies based on effectiveness. One way to prioritize is to rank the transportation types by Vehicle Miles Traveled (VMT). In this way we can be assured that critical functions can continue unimpeded. These “High-Priority” functions can be seen in the table to the right.

The last step is to implement the plan. It is important to implement the plan immediately upon completion because it must be realized that we are always in some stage of a contingency planning process not unlike the Homeland Security Threat Advisory System (“code orange”, etc.). A more relevant example to this study is California’s Energy Emergency Contingency Plan (http://www.energy.ca.gov/contingency/) which directs the state’s response to natural and man-made energy emergencies. When visiting the site the viewer is able to see that the Energy Commission is in the “Readiness Phase of its Energy Emergency Contingency Plan for Petroleum.” This impressive plan does all the right things that a contingency plan at a state level could possible do. It is now up to other states and the federal government to emulate such a plan.

### Prioritize Based on Effectiveness

<table>
<thead>
<tr>
<th>Type</th>
<th>VMT</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Trips</td>
<td>38%</td>
<td>High-Priority</td>
</tr>
<tr>
<td>Freight Trips</td>
<td>13%</td>
<td>High-Priority</td>
</tr>
<tr>
<td>Social Trips</td>
<td>15%</td>
<td>Mid-Priority</td>
</tr>
<tr>
<td>Shopping Trips</td>
<td>15%</td>
<td>Mid-Priority</td>
</tr>
<tr>
<td>Rural Travel</td>
<td>10%</td>
<td>Low-Priority</td>
</tr>
<tr>
<td>Long Trips</td>
<td>6%</td>
<td>Low-Priority</td>
</tr>
<tr>
<td>Trips &lt;1 mile</td>
<td>3%</td>
<td>Low-Priority</td>
</tr>
</tbody>
</table>

**Strategies for a World Living with Energy Shortfalls**

Contingency planning is not the only way that a governmental entity can deal with shortfalls. There are several other strategies, several of which are explored below. That said, the following strategies are not mutually exclusive and contingency planning, to a varying degree, could be a part of any of the strategies although would probably fit most neatly under the “pseudo-market response.”

**Pure Market Response: Letting the Market Correct Market Failures**

Because everyone faces the problem of choosing how to use limited resources, markets are there to facilitate the achievement of diverse goals by individuals and institutions populating a complex society by letting the parties communicate information through a single number – in this case the price of fuel at $1.59/gallon. Complex and valuable information is communicated through this single
number to facilitate efficiently allocating limited resources. When supply and demand are not in balance the price of fuel will fluctuate to represent that change. When the price becomes too high consumers will shift to a lower cost alternative and the market imbalance will clear as the demand for gas recedes. While this is painful it is argued that this is also the most efficient and time-effective way to shift to other energy sources say proponents of this method.

Concerns
- Lag time in deployment of new energies could breed economic instability
- Will affect low-income population disproportionately

Pseudo-Market Response: Directing the Market to Correct Market Failures

This could very much look like the contingency planning example above where a governmental entity would define vulnerable sectors then identify allocation priorities and implement a plan. This theory of market intervention is based on the fact is that individual decision makers in a totally free market will not receive all the benefits and bear all the costs of their choices when they purchase a gallon of gas and drive their car. The environmental externalities are shifted away from the purchaser to future generations and other parts of the world. Because of these negative externalities and market failures it is argued that it is imperative to step into the market and set out a plan for conservation and contingency planning which could include rationing, subsidies and rules that limit driving and consumption.

Power Struggle Response: The Powerful Define the Crisis

This may be what is currently happing in the world as the United States and other powerful countries assert their influence over the politics of poorer countries with energy producing capabilities. The most obvious example is arguable the United States war in Iraq. More interesting is what occurs “under the radar” in various other parts of the world outside of the Mideast. Recently reported was an event in Bolivia in October 2003 where protesters blocked a road leading to a natural gas mine. The protest was sparked by opposition to a government plan to export natural gas to the United States and Mexico. Over 70 protesters were killed and 400 injured as they were fired upon by a regime that had the “full support” of the US government even a full week after the incident.¹¹

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This power struggle need not happen just on an international stage. Within the United States this could also be an issue with the wealthy asserting their power and influence over policy decisions and markets to their own benefit (see above cartoon).

Grassroots Response: Localism over Globalization

This strategy is rooted in the idea that all complex systems will eventually fail. The common example is that hunter-gatherer societies have existed since the beginning of man but the Romans only lasted a few hundred years. Why? The more complex a system gets the less it takes to bring that system down. This could not be truer of the interdependent nature of the worldwide energy distribution system. A pipeline breaks in Siberia and the whole world pays for it in increased prices. What would happen if a town in the U.S. managed to wean itself off of outside energy sources and thus were completely unaffected by an isolated event in Siberia? This is the argument for this strategy. Albeit a bit idealist, the idea is sound and is currently taking shape in the form of “intentional communities” and “ecovillages” at various places around the globe. These are “urban or rural communities that strive to integrate a supportive social environment with a low-impact way of living.”

Compost, landfill-gas, wind power, solar power, bio-diesel, ridesharing, green building, organic gardening, small farming, consensus decision making and even running vehicles on vegetable oil are all strategies that these communities have employed. One example of such a community is Soldiers Grove, Wisconsin (http://www.sustainable.doe.gov/freshstart/case/soldiers.htm).

Benevolent Response

An idea that employs elements of all the above strategies is “The Danish Model” which views energy production as the motor of the related processes of technological modernization and economic growth. A symbol of this is the evolution of the impressive Danish

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wind industry hegemony (see above picture of the worlds largest wind farm off the coast of Denmark). How did such a tiny country get to control 60% of the world wind turbine sales? Simply put: cooperation between private and public sectors. In 1976 Denmark approved a national energy plan (interestingly enough the U.S. is currently without any national energy plan) that had as its main objective to make Denmark less reliant on imported energy.\textsuperscript{14} The plan contained subsidies for manufacturers, research and development funds and government certification of turbines for quality assurance. The formula worked and now Denmark is the world leader not only in turbine manufacturing but also is the second most reliant country on wind power to fulfill their energy needs. Thanks in no small part to the emergence of wind power the Danes are now wholly self sufficient with their energy needs. What does this mean for other countries and specifically the United States? Governments must take an active role in encouraging the development of new innovations and the adoption of new innovations by the private sector. All countries, including the US (re: the automobile), have a long successful history in doing just this.

Conclusion

Cooperation is the key to innovative solutions to our energy supply shortfalls. While the benevolent example of Denmark’s success with wind innovation is a lesson to heed it must be coupled with a degree of realism for the United States and the rest of the world. That is, shortfalls are imminent despite the benefits of cooperation, the power of markets to clear, the increase of conservation, ecovillages, and the like. Part of urban planning is planning for growth while the other part is planning for decline. To sustain future generation we must plan for the growth of conservation while at the same time conduct contingency planning as a way to plan for the decline of tradition energy sources.

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References


Useful Web Pages

The Coming Global Oil Crisis: The Hubbert Peak of Production
http://www.hubbertpeak.com/

U.S. Department of Energy
http://www.energy.gov/engine/content.do

U.S. Energy Information Administration
http://www.eia.doe.gov/

California Energy Commission’s Energy Emergency Contingency Plan
http://www.energy.ca.gov/contingency/

Danish Wind Industry Association
http://www.windpower.org/

Renewable Energy Policy Project
http://solstice.crest.org/