Power Vs Power

New Mexico

Supercomputing Challenge

Final Report

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Team Number 12

Aspen Elementary School

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Executive Summary

Our project seeks to determine the best energy sources for our country and the major countries of the world by seeing how energy resources will be used by current societies. We have programmed a miniature world in which three major countries are competing for energy, and are growing their economies based on the resources that are available. We will show which power sources become the most popular over the next three generations (75 years), and how the most common resources today will become too costly to use within 30 years. We will base this primarily on economics, on supply and demand, and assume that countries allow the free market to determine their fate. At the end of the simulation, it becomes clear that only a few power sources will last.

1. Problem Statement

The question we would like to answer is: given the scarceness of our world's energy resources, what will happen in the future when the major countries start running out of power, how will they compete for that power, and what power sources will be best to use in the future to maintain the economic growth of these economies, especially the United States. Our purpose is not to just find the amount of power sources available, but also to see how nations will compete for them over time.

2. Description of Method Used

We performed a literature search on the different types of power sources the major countries in the world use. For example Fig. 1 shows the various power sources that are most common in the United States and other countries. This includes: nuclear power, solar power, wind power, coal power, natural gas and oil. You will notice that in the United States most of our power comes from coal, followed by natural gas, oil, nuclear, and renewable sources of energy. We also investigated the European Union, China, Russia, India, Brazil, and South Africa. However for our simulation, we decided to focus on the three major countries/groups that use the majority of the world's power: The United States of America (USA), The European Union (EU) and China (CN).

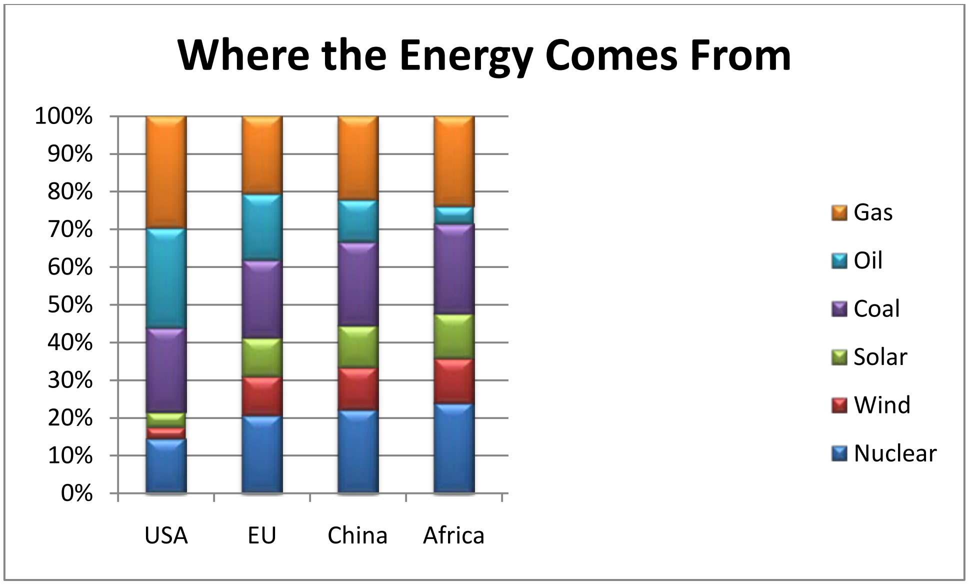


Fig. 1: Power Sources Used by Different Countries/Regions

Our simulation will compare the three major countries: USA, EU, and CN, starting with their current consumption of each major fuel [see refs: a-d, and Fig. 2]. We will assume a starting economic growth for each country that requires them to use more fuel each year to sustain their economic growth. We begin with a 4% growth rate per year for the United States, a 3% growth rate for the European Union, and an 8% growth rate per year for China. Last year, China surpassed the US for the first time as the number one consumer of energy in the world. It is expected that China's economic growth will continue at the rate of at least 8% for some time. Our simulation next assumes that the amount of power a country uses grows proportionately to its rate of economic growth. It is also true that if power is not available, or is very costly, the world economies cannot grow as quickly. We will not, at this time, address the influence of power costs on economic growth, but our simulation could be extended to include this, and ultimately we will do so.

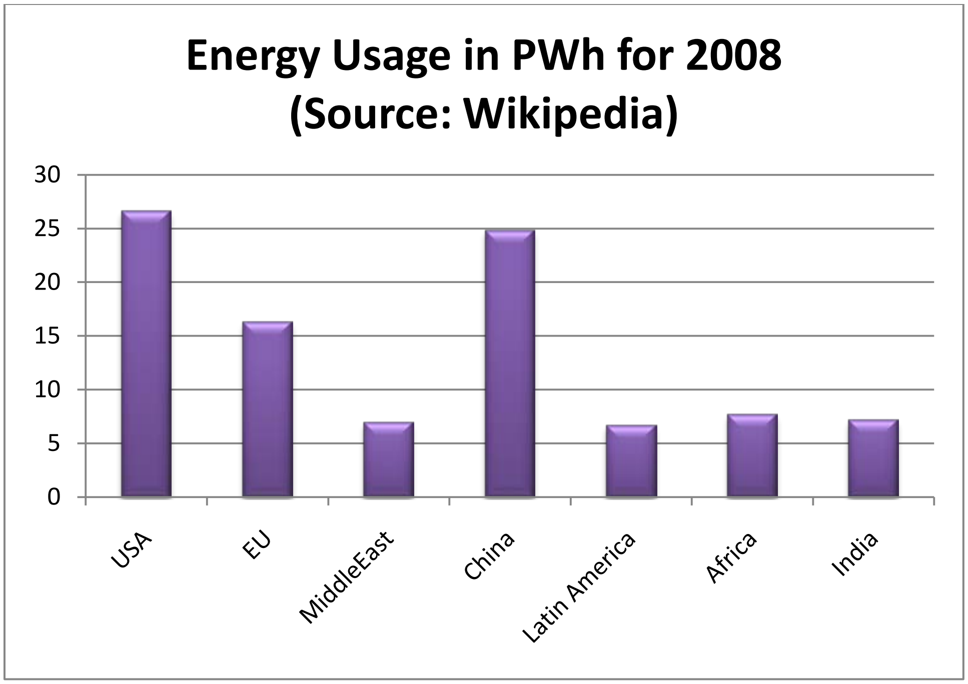


Fig. 2: Energy Usage in 2008 for Various World Economies. Note: PWh=Trillion Kilowatt-Hrs, and the three largest power consumers are the USA, EU, and China.

Our simulation also assumes there are renewable and non-renewable power resources. The renewable resources are solar and wind power, and the non-renewable resources are uranium for nuclear power, coal, gas, and oil. While breeder reactors make it possible for nuclear power plants to actually create more fuel than they use, we will not currently assume that breeder reactors will be used—even though we think it is a good idea—that could ultimately extend the world's growth many times over [see ref: e-f]. It is a shame that politicians are so unaware of the potential benefits of this technology, or choose to ignore it.

The non-renewable resources in our simulation have a limited lifetime. We performed a literature study to find out the total (known) resources that are available world-wide for uranium ore, coal deposits, natural gas fields, and oil fields. We only used resources that we know are able to be mined or tapped using existing technology.

Not surprisingly, oil and natural gas are relatively limited, coal has greater reserves, and nuclear energy has the greatest potential, because only a small amount of uranium gives a huge amount of power. In terms of potential energy that could be produced (in trillion kilowatt-hours), we found that oil and natural gas have reserves of 2.9 trillion kilowatt-hours, coal had reserves of 7.9 trillion kilowatt-hours, and uranium ore had reserves of 120,000 trillion kilowatt-hours! [see refs: a-d]. That is a lot of power. However, as the world economy grows, it turns out that even 120,000 trillion kilowatt-hours is not enough to supply a growing world for more than 100 years.

In our simulation, we decided that we needed to calculate the cost of each power source over time. As the fuel source becomes more scarce over time, the price will have to rise. For simplicity, we decided to use a short equation that gives the annual price of an energy resource. If the total original amount of fuel is A, and the amount remaining for use (this year) is B, Then the total cost, C, is:

$$C = C_o *(A/B)^N$$

Here, N is an exponent that we can choose, to drive the cost up faster or slower, depending on its value. We chose N=0.60 for our current results. So, when the amount remaining, B, is very small, the 2nd term will get large and make the cost go up. Each year, we determine the cost based on last year's cost.

The amount of power used each year by each country will grow according to their economic growth. However, if the cost of a particular power source is too high, obviously, the country will use less of it, or in extreme cases, none at all, as long as the cost is greater than other sources. So, we decided to include this in our simulation by adding an IF/THEN decision that checks the cost of each power source relative to the average cost of all power sources, and decides how much a country will use that year. As resources get scarce, and the price goes up, eventually, the countries will quit using those resources.

Similarly, if the cost to use an energy resource is low per kilowatt-hour (e.g. nuclear power), it will be favored, and the country will use more of this power source that year. To do this, we added IF/THEN decisions, that if an energy source is 1.5 times greater than the average power cost, a country would only increase that power by half of its normal growth. On the other hand, if the energy source is only 50% of the cost of the average power, then we would buy twice as much that year of this power source. In this way, the ratio of different power sources in each country is changeable over time, just as in reality, countries will make decisions based on cost.

The renewable sources, of course, are not 100% renewable forever. Solar power, for example, will run out of space to put panels someday. Also, there are only so many wind mills that one can place in the plains states to generate power. However, we assumed that we would not reach these limits within this simulation.

We use starting costs of each power as follows: nuclear=0.02 $/kW-Hr, solar=0.14 $/kW-Hr, wind=0.09$/kW-Hr, coal=0.03$/kW-Hr, gas=0.05$/kW-Hr, and oil=0.12$/kW-Hr. [See Ref: a-c] While these costs could vary from country to country, we assume the entire world uses a world-wide based price in the global economy. Also, data that we researched was not always consistent in the costs provided above, but we used the figures most commonly quoted.

We created our simulation in Mathematica, as we found this turned out to be the easiest to implement. We had started with StarLogoTNG, but it did not allow us the flexibility we needed. So we learned the basics of Mathematica from Dr. Maxwell, how to make lists, and how to do FOR loops and IF/THEN decisions, and then how to print our results. Our program is attached in appendix A.

3. Results

The results of the simulation, for the USA, EU, and China are shown in Figs. 3-5, respectively. The amount of each power resource is given in Trillion Kilowatt-hours for each year out to 75 years in the future. During this time, China comes to dominate the world power consumption, eventually using 10 times the power of the USA or EU. This will probably not fully be realized as shown because China's growth will probably slow down as it becomes a 1st world country. However, it is likely that China will end up using the most power in the future. Note that for all countries, coal and nuclear power are the primary sources of power in the future, as they begin at lower costs than the other power sources, so they are preferred each year for new power plants, and they run out last (among the fossil fuels). Surprisingly, oil and gas run out very quickly, within the first 30 years, and their costs soar, as shown in Fig. 6 (cost of the various power sources vs. time). Eventually, coal also runs out, and as we approach the 75 year mark, nuclear power (based on uranium only) also begins to be more expensive.

Solar and wind power hardly even register in the simulation until late in the game, as they start at very small percentages, and their initial costs are higher than the other power sources. They simply never catch up because they are not inexpensive enough, and people won't buy them. Based solely on economics, they will not win. It would require governments to force the issue for these to be used.

We recognize that nuclear power is not the most popular. Many individuals consider it dangerous and politics have made it difficult to implement new power plants. However, it is clear the Chinese and Indians have no such fears, and are forging ahead with as many as 20 new power plants PER YEAR. They must have done this simulation themselves, and see that the end of fossil fuels is near.

Regarding pollution, obviously the fossil fuels are the worst offenders. Nuclear power plants are very green, as the smoke you always see coming out of them isn't really smoke- it's steam. However, some individuals point out the nuclear power has waste. However, the volume of this waste is immeasureably smaller than that produced by fossil fuels, and so we intentionally omit waste as an issue in the simulation. For that matter, wind mills kill thousands of birds each year. Someday, people will claim that wind power should not be used, because it has killed all the birds. Luckily, it won't be adopted, due to economics, so the birds can live! Solar appears to simply be silly, at the present costs, and only major technological cost breakthroughs could make it take off.

Nuclear power can be considered a renewable resource because the uranium fuel, which is mined from the earth, can be transmuted into plutonium fuel by a process called "breeding" which makes it much more efficient (although most reactors today don't do this) [See refs: e-f].

Even though the nuclear power plants are expensive and take a long time to build, you would only need five hundred to power the whole USA, and if the whole world used nuclear power exclusively, it would be around three to eight thousand nuclear power plants.

The only other problem about nuclear is that people are not educated about it. So everyone thinks it is a very dangerous type of energy to use, even though coal is many times more of a threat because of deaths due to mining accidents and coal-dust induced diseases. People still fear nuclear power.

When we started this project, it did appear to us that nuclear power is very safe. We still think it is safe if the power plant is built properly and located in a safe place, e.g. not near an earthquake fault. But since we started this project there has been the recent natural earthquake and tsunami disaster that then caused the Fukushima reactor problems and subsequent release of radioactivity, in Japan. However, over history, more people have died from coal power plants (pollution, cancer, mining) than have died from nuclear power. But nevertheless we still have great hopes for a future in the USA involving more nuclear energy.

4. Conclusions

We have concluded that nuclear power gives the longest potential growth for the world economy, especially if breeder reactors were used. However coal is most likely going to dominate the near future. Where possible countries should avoid gas and oil, as they will run out first, and the costs will soar very soon.

Overall, there are good and bad things about all the types of power: nuclear, fossil fuels, and solar:

First fossil fuels: fossil fuels like coal, natural gas, and oil are good because they are very cheap and there are lots of them in the earth. The bad things about these resources are they all produce carbon dioxide, some of them can cause death because when miners go and dig them up they can become sick or the mine could collapse. They will all run out soon also. These fuels could also go to better use: natural gases would be a great help in science and could help discover many new things; and coal took billions of years for the earth to make and would really influence science. We have spent a very long time researching, and have found out that a lot more people have died from coal mining than from nuclear power plants; in the last century more that 100,000 miners died in only the USA.

Second, solar: solar is very good because it doesn't have any waste and doesn't produce any carbon dioxide. Solar isn't all good though because it takes a long time to make the smallest amount of power and does make carbon dioxide during the manufacture of the solar panels. Another bad thing about solar is that it is very expensive.

Last, nuclear: nuclear is very good because not many people die from it and it does not make any carbon dioxide which means it is not a contributor to global warming. To make nuclear energy you use uranium and there is a lot of uranium in the earth. Another good thing about nuclear is that if you build a nuclear power plant you only need a few because they can give lots of power. The bad things about nuclear power are that it is very expensive to build a power plant, and it takes a long time to build a nuclear power plant. However, it even with this, it is still less expensive to operate over the long haul. Another bad thing about nuclear power is that it has waste and the waste needs to be buried. But there is little of it, compared to fossil fuels. Finally, people are afraid of nuclear power and need to be educated about it. We hope the recent events in Japan will not slow progress in nuclear power, as it may be our most important resource for the next century, at least.

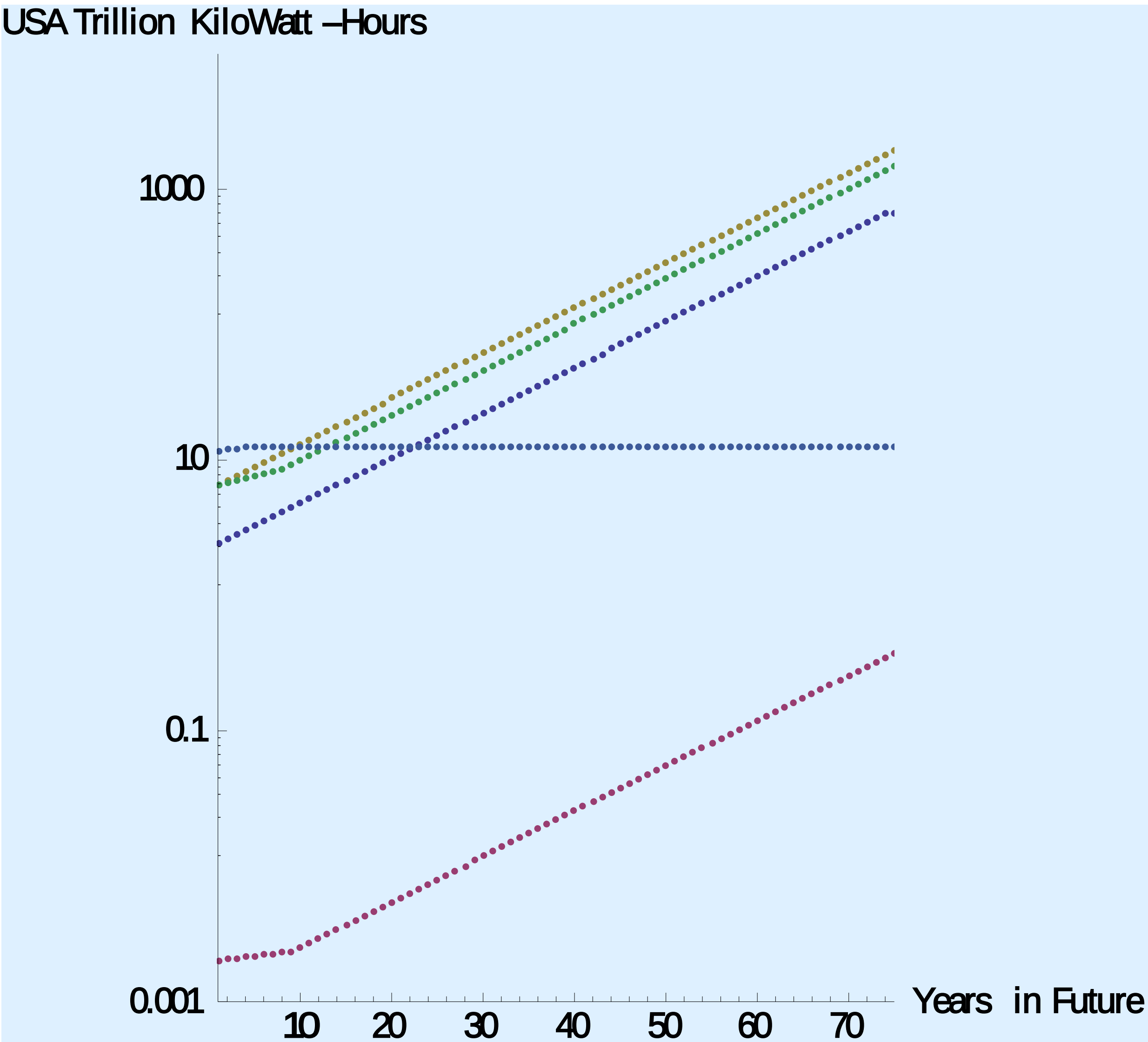
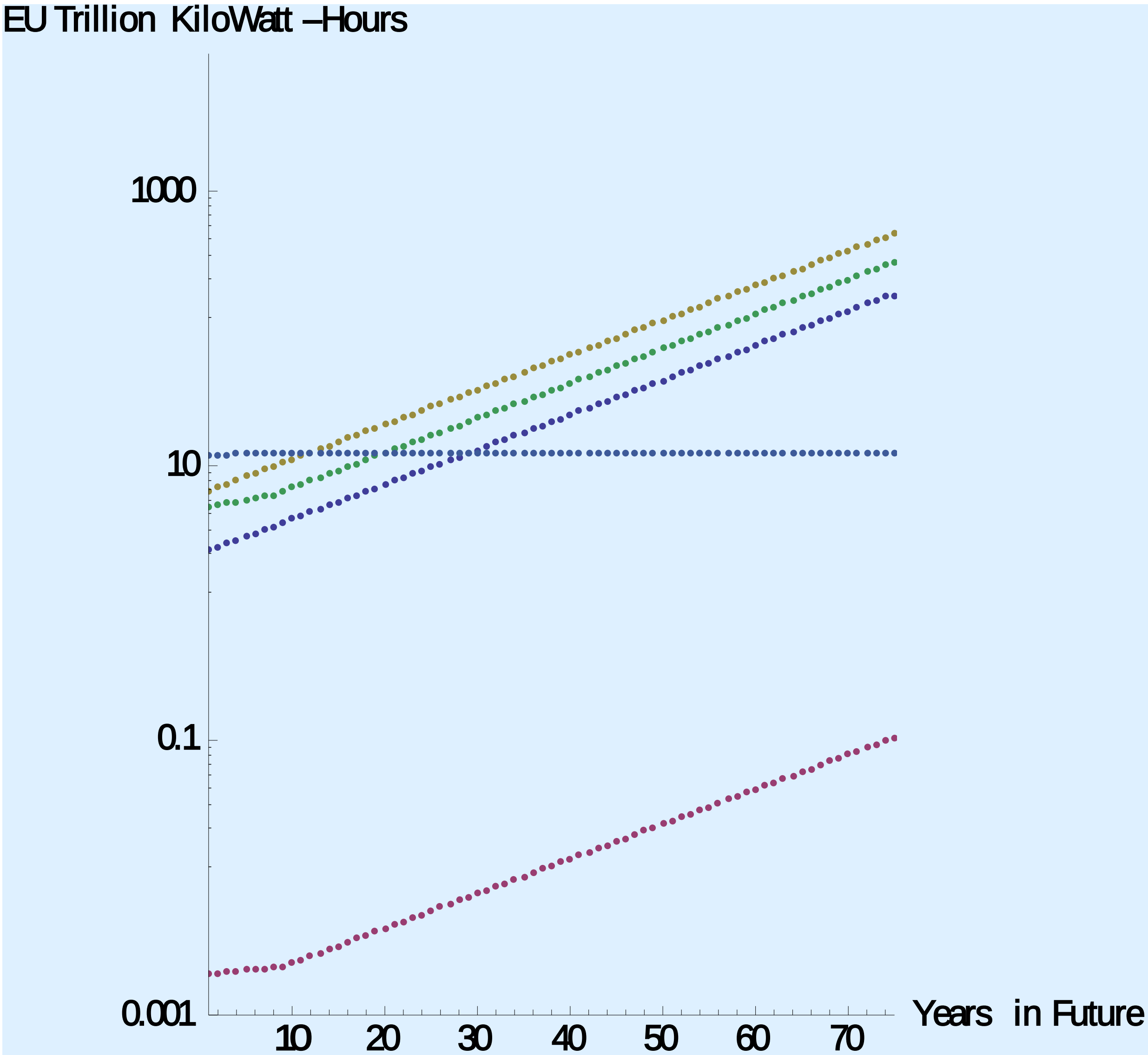


Fig. 3: Power Consumption of the USA over Time (Each Power Source is Shown Separately, from top to bottom: Coal, Nuclear, Gas, Oil, Solar)



Fig, 4: Power Consumption of the EU over Time (Each Power Source is Shown Separately, from top to bottom: Coal, Nuclear, Gas, Oil, Solar).

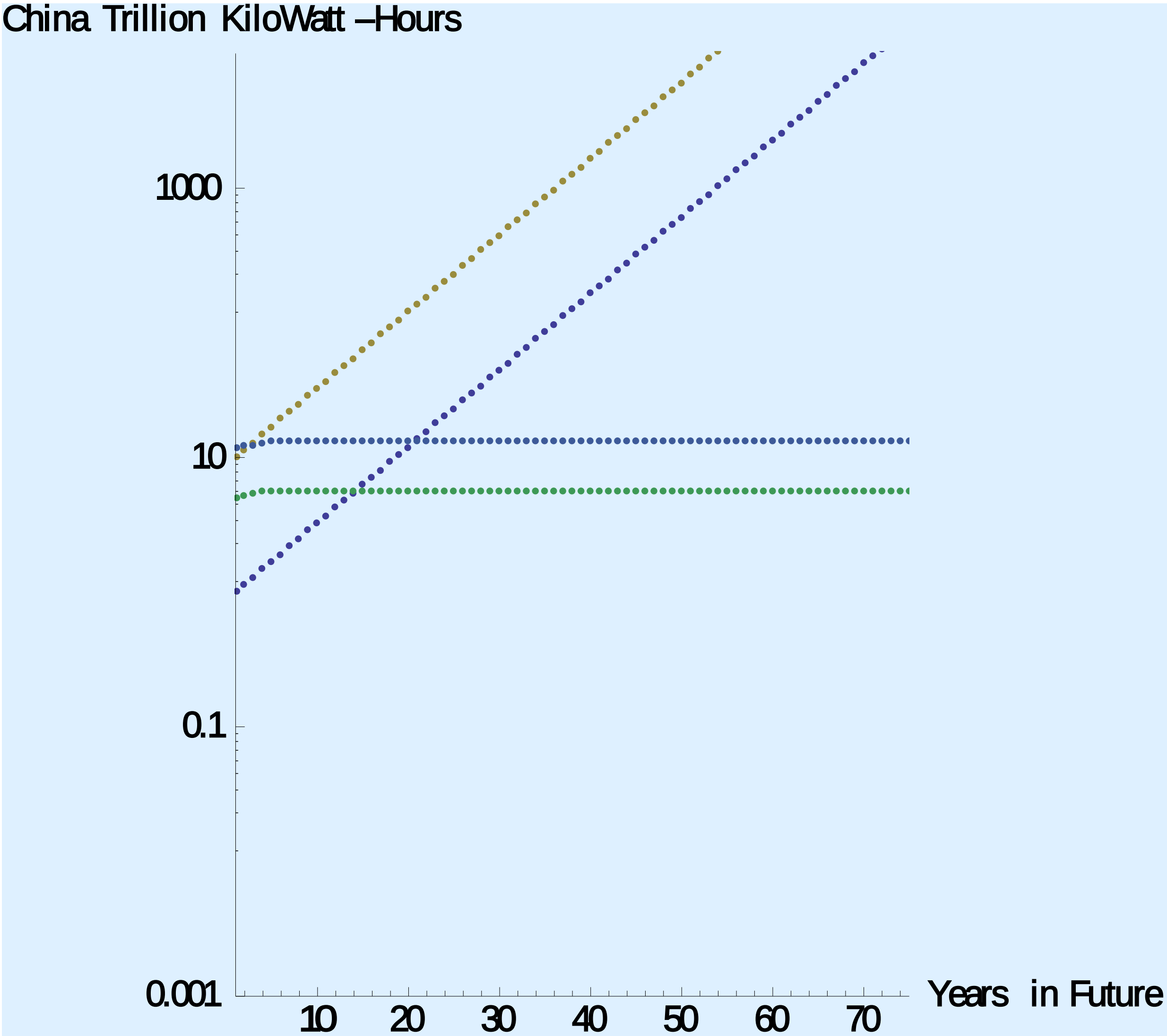


Fig. 5: Power Consumption of China over Time (Each Power Source is Shown Separately, from top to bottom: Coal, Nuclear, Gas, Oil).

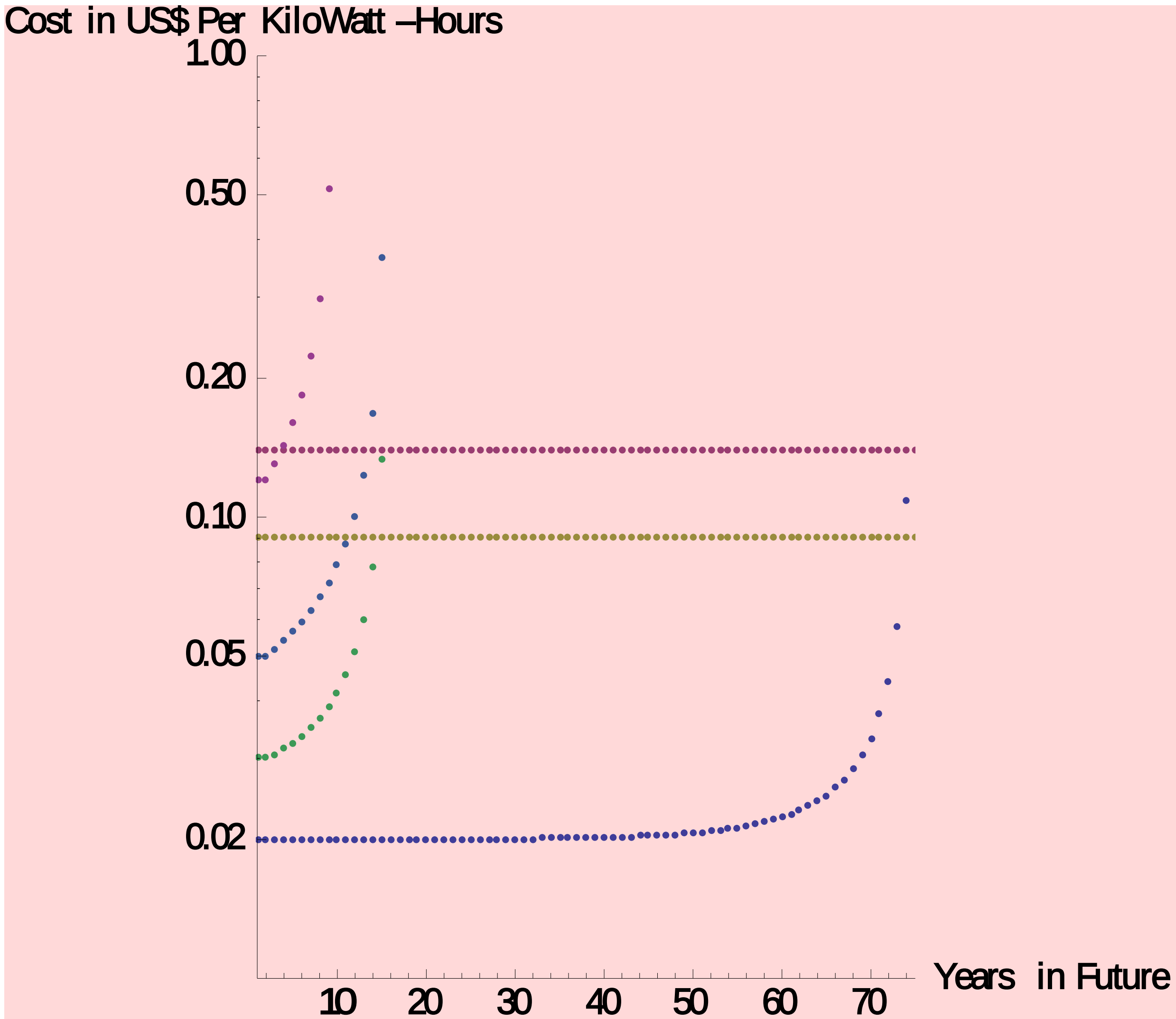


Fig. 6: Power Source Costs in kW-Hr: Oil, Gas, Coal drop out in less than 30 years. Nuclear becomes more expensive at 75 years. Solar and Wind maintain the same cost over time, assuming no major technological breakthroughs.

5. Software

The following is the entirely of our Mathematica program:

```
(* ****************************************************** *)

(* Define Variables *)

(* Define Variables for the Amount of Energy Used in Each Country That Year *)
NUC1=.;SOL1=.; WIND1=.;COAL1=.;  GAS1=.;OIL1=.;
NUC2=.;SOL2=.; WIND2=.;COAL2=.;  GAS2=.;OIL2=.;
NUC3=.;SOL3=.; WIND3=.;COAL3=.;  GAS3=.;OIL3=.;
NUC4=.;SOL4=.; WIND4=.;COAL4=.;  GAS4=.;OIL4=.;
NUC5=.;SOL5=.; WIND5=.;COAL5=.;  GAS5=.;OIL5=.;
NUC6=.;SOL6=.; WIND6=.;COAL6=.;  GAS6=.;OIL6=.;

(* Define Variables for the World-wide Cost of Energy Resources *)
NUCCOST=.;SOLCOST=.;WINDCOST=.;COALCOST=.;GASCOST=.;OILCOST=.;

(* Define Lists for the Energy Useage of Each Country *)
USANUC={}; USASOL={}; USAWIND={}; USACOAL = {};  USAGAS= {}; USAOIL={};
EUNUC={}; EUSOL={}; EUWIND={};  EUCOAL = {};  EUGAS = {};  EUOIL={};
```

```
CNNUC={}; CNSOL={}; CNWIND={};  CNCOAL = {};  CNGAS = {}; CNOIL={};


(* Define Variables for Amounts of Energy Resources *)

TOTALURANIUM=.;  URANIUMLEFT=.;  TOTALCOAL=.;  COALLEFT=.;  TOTALGAS=.;
GASLEFT=.;

(*
*******************************************************************
************************)


(* Number of Years to Calculate, plus one *)

n=76;


(* Economic Growth Rates of Each Country *)

GROWTHUSA=0.04

GROWTHEU=0.03

GROWTHCN=0.07


(* Beginning World-wide Resources for Each Energy--Units are in Trillion kW-hr
Confirmed Deposits*)

TOTALURANIUM=120000; URANIUMLEFT=TOTALURANIUM;(*FOR STARTERS*)

TOTALCOAL=710;COALLEFT=TOTALCOAL;(*FOR STARTERS*)
```

TOTALGAS=290;GASLEFT=TOTALGAS;(*FOR STARTERS*)

TOTALOIL=290;OILLEFT=TOTALOIL;(*FOR STARTERS*)

(* Initialize Lists with Beginning Energy Useage of Each Country *)

USANUC={2.41};USASOL={0.002};USAWIND={0.03};USACOAL={6.6};USAGAS={6.5};USAOIL={11.7};

EUNUC={2.41};EUSOL={0.002};EUWIND={0.03};EUCOAL={6.6};EUGAS={5};EUOIL={11.7};

CNNUC={1};CNSOL={0.00};CNWIND={0.006};CNCOAL={10};CNGAS={5};CNOIL={11.7};

(*RISE OF COST EXPONENT*)

QEXP=0.6;

(* Define Parameters that Control OVERALL Growth or Decrease of all Energy Sectors--Strength of Change vs Costs *)

BUYMORE=2.0;

BUYLESS=0.5;

BUYNOMORE=0;

```
(* Define Initial Parameters that Control the Growth or Decrease of Each Type of Energy Sector *)
NUCFACTOR=1;SOLFACTOR=1;WINDFACTOR=1;COALFACTOR=1;GASFACTOR=1;OILFACTOR=1;

(* Define Parameters for the Starting Costs of Each Type of Energy--Units are in Dollars Per KiloWatt-Hr *)
URANIUMSTARTINGCOST=0.02;
SOLSTARTINGCOST=0.14;
WINDSTARTINGCOST=0.09;
COALSTARTINGCOST=0.03;
GASSTARTINGCOST=0.05;
OILSTARTINGCOST=0.12;

(* Define Lists for the Cost of Each Type of Energy *)
RUNNINGNUCCOST={};RUNNINGNUCCOST={URANIUMSTARTINGCOST};
RUNNINGSOLCOST={};RUNNINGSOLCOST={SOLSTARTINGCOST};
RUNNINGWINDCOST={};RUNNINGWINDCOST={WINDSTARTINGCOST};
RUNNINGCOALCOST={};RUNNINGCOALCOST={COALSTARTINGCOST};
RUNNINGGASCOST={};RUNNINGGASCOST={GASSTARTINGCOST};
RUNNINGOILCOST={};RUNNINGOILCOST={OILSTARTINGCOST};
```

```
(* ************************************************************** *)

(* Calculate Each Year in Succession *)

For[j=2, j<n,j++,

 (*Costs for Nuclear*)

NUCCOST=URANIUMSTARTINGCOST*(TOTALURANIUM/URANIUMLEFT)^QEXP;

RUNNINGNUCCOST=Append[RUNNINGNUCCOST,NUCCOST];

(*Costs for Solar*)

SOLCOST=SOLSTARTINGCOST;

RUNNINGSOLCOST=Append[RUNNINGSOLCOST,SOLCOST];

(*Costs for Wind*)

WINDCOST=WINDSTARTINGCOST;

RUNNINGWINDCOST=Append[RUNNINGWINDCOST,WINDCOST];

(*Costs for Coal*)

COALCOST=COALSTARTINGCOST*(TOTALCOAL/(COALLEFT))^QEXP;

RUNNINGCOALCOST=Append[RUNNINGCOALCOST,COALCOST];

(*Costs for Gas*)

GASCOST=GASSTARTINGCOST*(TOTALGAS/(GASLEFT))^QEXP;

RUNNINGGASCOST=Append[RUNNINGGASCOST,GASCOST];
```

```
(*Costs for Oil*)

OILCOST=OILSTARTINGCOST*(TOTALOIL/(OILLEFT))^QEXP;
RUNNINGOILCOST=Append[RUNNINGOILCOST,OILCOST];

(*Calculate Average Costs*)

AVECOST=(NUCCOST+SOLCOST+WINDCOST+COALCOST+GASCOST+OILCOST)/6;


(* Calculates This Years Energy Cost for Each Sector *)


Which[NUCCOST<0.5*AVECOST,NUCFACTOR=BUYMORE];

Which[NUCCOST>1.5*AVECOST,NUCFACTOR=BUYLESS];

Which[NUCCOST>2.0*AVECOST,NUCFACTOR=BUYNOMORE];

Which[NUCCOST>2.5*AVECOST,NUC1=0; NUC2=0; NUC3=0;];


Which[SOLCOST<0.5*AVECOST,SOLFACTOR=BUYMORE];

Which[SOLCOST>1.5*AVECOST,SOLFACTOR=BUYLESS];

Which[ SOLCOST>2.0*AVECOST,SOLFACTOR=BUYNOMORE];

Which[SOLCOST>2.5*AVECOST,SOL1=0;SOL2=0;SOL3=0;];


Which[WINDCOST<0.5*AVECOST,WINDFACTOR=BUYMORE];

Which[WINDCOST>1.5*AVECOST,WINDFACTOR=BUYLESS];

Which[WINDCOST>2.0*AVECOST,WINDFACTOR=BUYNOMORE];
```

```
Which[WINDCOST>2.5*AVECOST,WIND1=0;WIND2=0;WIND3=0;];


Which[COALCOST<0.5*AVECOST,COALFACTOR=BUYMORE];

Which[COALCOST>1.5*AVECOST,COALFACTOR=BUYLESS];

Which[COALCOST>2.0*AVECOST,COALFACTOR=BUYNOMORE];

Which[COALCOST>2.5*AVECOST,COAL1=0;COAL2=0;COAL3=0;];


Which[GASCOST<0.5*AVECOST,GASFACTOR=BUYMORE];

Which[GASCOST>1.5*AVECOST,GASFACTOR=BUYLESS];

Which[GASCOST>2.0*AVECOST,GASFACTOR=BUYNOMORE];

Which[GASCOST>2.5*AVECOST,GAS1=0;GAS2=0;GAS3=0;];


Which[OILCOST<0.5*AVECOST,OILFACTOR=BUYMORE];

Which[OILCOST>1.5*AVECOST,OILFACTOR=BUYLESS];

Which[OILCOST>2.0*AVECOST,OILFACTOR=BUYNOMORE];

Which[OILCOST>2.5*AVECOST,OIL1=0;OIL2=0;OIL3=0;];


(* ********************************************** *)


(* USA Energy in Trillion KiloWatt-Hrs *)
```

```
NUC1=USANUC[[j-1]]+NUCFACTOR*GROWTHUSA*USANUC[[j-1]];

USANUC=Append[USANUC, NUC1];

SOL1=USASOL[[j-1]]+SOLFACTOR*GROWTHUSA*USASOL[[j-1]];

USASOL=Append[USASOL, SOL1];

COAL1=USACOAL[[j-1]]+COALFACTOR*GROWTHUSA*USACOAL[[j-1]];

USACOAL=Append[USACOAL, COAL1];

GAS1=USAGAS[[j-1]]+GASFACTOR*GROWTHUSA*USAGAS[[j-1]];

USAGAS=Append[USAGAS, GAS1];

OIL1=USAOIL[[j-1]]+OILFACTOR*GROWTHUSA*USAOIL[[j-1]];

USAOIL=Append[USAOIL, OIL1];


AVECOSTUSA=NUCCOST*NUC1+SOLCOST*SOL1+COALCOST*COAL1+GASCOST*G
AS1+OILCOST*OIL1;

Print[{OILLEFT}] ;


(* EU Energy *)

NUC2=EUNUC[[j-1]]+NUCFACTOR*GROWTHEU*EUNUC[[j-1]];

EUNUC=Append[EUNUC, NUC2];

SOL2=EUSOL[[j-1]]+SOLFACTOR*GROWTHEU*EUSOL[[j-1]];

EUSOL=Append[EUSOL, SOL2];

COAL2=EUCOAL[[j-1]]+COALFACTOR*GROWTHEU*EUCOAL[[j-1]];
```

```
EUCOAL=Append[EUCOAL, COAL2];

GAS2=EUGAS[[j-1]]+GASFACTOR*GROWTHEU*EUGAS[[j-1]];

EUGAS=Append[EUGAS, GAS2];

OIL2=EUOIL[[j-1]]+OILFACTOR*GROWTHEU*EUOIL[[j-1]];

EUOIL=Append[EUOIL, OIL2];


(* China Energy *)

NUC3=CNNUC[[j-1]]+NUCFACTOR*GROWTHCN*CNNUC[[j-1]];

CNNUC=Append[CNNUC, NUC3];

SOL3=CNSOL[[j-1]]+SOLFACTOR*GROWTHCN*CNSOL[[j-1]];

CNSOL=Append[CNSOL, SOL3];

COAL3=CNCOAL[[j-1]]+COALFACTOR*GROWTHCN*CNCOAL[[j-1]];

CNCOAL=Append[CNCOAL, COAL3];

GAS3=CNGAS[[j-1]]+OILFACTOR*GROWTHCN*CNGAS[[j-1]];

CNGAS=Append[CNGAS, GAS3];

OIL3=CNOIL[[j-1]]+OILFACTOR*GROWTHCN*CNOIL[[j-1]];

CNOIL=Append[CNOIL, OIL3];


(* Costs of Resources *)

URANIUMLEFT=URANIUMLEFT-(NUC1+NUC2 + NUC3);
```

```
Which[URANIUMLEFT<=0.000000001, NUCCOST=100];

Which[URANIUMLEFT<0, URANIUMLEFT=0.000000001];


COALLEFT=N[COALLEFT-(COAL1+COAL2+COAL3)];

Which[COALLEFT<=0.000000001, COALCOST=100];

Which[COALLEFT<0, COALLEFT=0.000000001];


GASLEFT =N[GASLEFT - (GAS1 + GAS2 + GAS3)];

Which[GASLEFT<=0.000000001, GASCOST=100];

Which[GASLEFT<0, GASLEFT=0.000000001];


OILLEFT =N[OILLEFT - (OIL1 + OIL2 + OIL3)];

Which[OILLEFT<=0.000000001, OILCOST=100];

Which[OILLEFT<0, OILLEFT=0.000000001];


  ];  (* END OF LOOP *)


(* Print Graphs *)

ListLogPlot[{USANUC, USASOL, USACOAL, USAGAS, USAOIL}, PlotRange->{{1,75},{0.001, 10000}}, AxesLabel->{"Years in Future", "USA Trillion KiloWatt-Hours"}, PlotStyle->{Thick,Dashing[Large]}, AspectRatio->1.4, Background-
```

```
>LightBlue, LabelStyle->Directive[Bold, FontFamily->"Ariel", FontWeight->"Bold",
FontSize->14]]

ListLogPlot[{EUNUC, EUSOL, EUCOAL, EUGAS, EUOIL}, PlotRange->{{1,75},{0.001,
10000}}, AxesLabel->{"Years in Future", "EU Trillion KiloWatt-Hours"}, PlotStyle-
>{Thick,Dashing[Large]}, AspectRatio->1.4, Background->LightBlue, LabelStyle-
>Directive[Bold, FontFamily->"Ariel", FontWeight->"Bold", FontSize->14]]

ListLogPlot[{CNNUC, CNSOL, CNCOAL, CNGAS, CNOIL}, PlotRange->{{1,75},{0.001,
10000}}, AxesLabel->{"Years in Future", "China Trillion KiloWatt-Hours"},
PlotStyle->{Thick,Dashing[Large]}, AspectRatio->1.4, Background->LightBlue,
LabelStyle->Directive[Bold, FontFamily->"Ariel", FontWeight->"Bold", FontSize-
>14]]
(* ListPlot[RUNNINGNUCCOST]; RUNNINGNUCCOST  *)

ListLogPlot[{RUNNINGNUCCOST,RUNNINGSOLCOST,RUNNINGWINDCOST,RUNNIN
GCOALCOST,RUNNINGGASCOST,RUNNINGOILCOST}, PlotRange->{{1,75},{0.01,
1}}, AxesLabel->{"Years in Future", "Cost in US$ Per KiloWatt-Hours"}, PlotStyle-
>{Thick,Dashing[Large]}, AspectRatio->1.4, Background->LightRed, LabelStyle-
>Directive[Bold, FontFamily->"Ariel", FontWeight->"Bold", FontSize->14]]
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6. References

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8. Most Significant Major Achievement

Learned Mathematica, how to program, and economic principles.