Using The
Time Value of Energy

To derive the Net Energy Profit Ratio, and the Net Present Energy Value

(NEPR$_{\text{VER 1.0}}$ **) (NPEV$_{\text{VER 1.0}}$ **)

Greg Rock

General Engineer
Summa cum Laude 2004
California Polytechnic State University
San Luis Obispo

Table of Contents

The Methodology

Executive Summary

As we enter into an energy future marked by increasing use of unconventional energy sources, conventional supply constraints, and increasing energy prices it is essential that we use an accurate methodology to analyze energy projects. This methodology should be mathematical in nature and defined by a specific set of rules. This value should take into account the following factors.

- Total energy produced over the life of the project, as defined by a set of rules.
- Total energy consumed over the life of the project, as defined by a set of rules.
- The rate and time frame in which that energy is produced and consumed.

Many net energy systems have been proposed to create a comparison tool for energy projects, but all of these have fallen short of success primarily for two reasons. First, they have no stated set of rules that energy producers must follow when calculating their values. This problem has lead to different results for the same energy project depending on who is making the calculations. These inconsistent values can not be used to accurately compare one energy sources to another. Secondly, the current net energy ratios have no established mathematical method for adjusting the value of energy according to the rate and time frame in which it is produced or consumed.

It is essential to understand that energy produced today is intrinsically more valuable than energy produced next year or next decade. If two energy projects require the same amount of energy input to produce the same amount of energy output they are not necessarily equal. If one project produces that energy in 5 years and another produces it in 50 years, the first project is intrinsically more valuable than the second. The first project could be repeated ten times during the life of the second project producing ten times the amount of energy. While this is not necessarily true for finite resources, which can be exhausted, energy produced today is more valuable to our current economy than future energy production.

In order to place a value on the rate and time frame in which energy is produced or consumed I will borrow from the economists the mathematical principal used to govern the Time Value of Money. This methodology is routinely used in engineering economics to determine the life cycle economic value of energy projects. However, this is not a very accurate method to use for energy projects because it measures cash flow, an indirect and often inaccurate, measure of energy flow. Time Value of Money calculations are normally based on the assumption that energy prices will remain constant over the life of the project. This is a dangerous assumption; rising energy prices significantly decrease the Net Present Economic Value of long lasting, and energy intensive project.

To correct this I will apply the same mathematical principals used to value money over time directly to the energy itself, creating a new methodology; the Time Value of Energy. I will use this new methodology to derive the Net Energy Profit Ratio (NEPR) and the Net Present Energy Value (NPEV). These powerful tools can accurately measure the production capabilities of a project over time, and eliminate potential design errors regardless of current or future energy prices.

List of Terms and Equations

NEPR -	Net Energy Profit Ratio
NPEV -	Net Present Energy Value
NELF -	Net Energy Loss Factor
NPEL -	Net Present Energy Lost
PEV -	Present Energy Value
FEV -	Future Energy Value
FEPV -	Future Energy Production Value
FECV -	Future Energy Consumption Value
PEPV -	Present Energy Production Value
PECV -	Present Energy Consumption Value
NPEPV -	Net Present Energy Production Value
NPECV -	Net Present Energy Consumption Value
MARR -	Minimum Attractive Rate of Return

$PEV = FEV*(1+i)^{-n}$ (Equation 1)

Where

n = Years into the project that the FEV is produced or consumed,

i = The Minimum Attractive Rate of Return (MARR)

$NPEPV = \Sigma\, FEPVn * (1+i)^{-n} = \Sigma\, PEPVn$ Equation 2)

$NPECV = \Sigma\, FECVn * (1+i)^{-n} = \Sigma\, PECVn$ Equation 3)

$NEPR = NPEPV/NPECV$ (Equation 4)

$NELF = 1/NEPR$ (Equation 5)

$NPEV = NPEPV - NPECV$ (Equation 6)

$NPEL = - NPEV$ (Equation 7)

To make this methodology easier to use I have produced excel sheets which automatically calculate the NEPR and the NPEV of a project by inputting the energy consumed and produced during each year of its life. These excel sheets can be found on www.netepr.com. This websites will also host the current MARR, and all Versions of the production and consumption rules. This website can also be used as a place where individual projects can post their NEPR results and their calculations. This is an effort to build a catalogue of different energy projects and their Net Energy Profit Ratios.

The Methodology

Time Value of Energy

The basic principal that governs the Time Value of Energy is that energy produced in the future is less valuable than energy produced today. Every year further into the future it is produced the less valuable it becomes to us today. This principal is governed by the following mathematical equation.

$$PEV = FEV*(1+i)^{-n} \qquad \text{(Equation 1)}$$

Where,

PEV = Present Energy Value
FEV = Future Energy Value
n = Years into the project that the FEV is produced or consumed,
i = The Minimum Attractive Rate of Return (MARR)

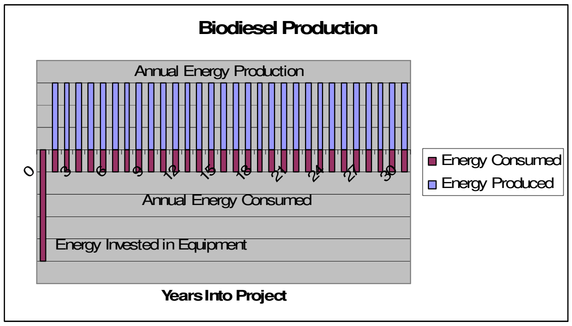
When making Time Value of Energy calculations, the variable that adjusts the effect time has on the present value of energy is the Minimum Attractive Rate of Return (MARR). With capital projects the MARR is set by companies, and represents the minimum percentage rate of return that the company wants to make on their investments. Over time the MARR for a company will go up or down normally following interest rates. When borrowing money is very expensive companies raise their MARR meaning that a project must have a very attractive rate of return to be executed. When interest rates are lower, and money is cheap, companies will accept projects with lower rates of return.

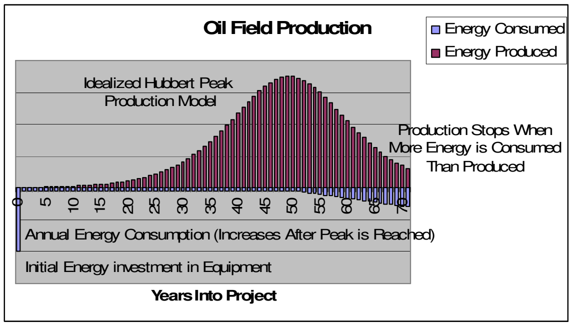
When applied to energy the MARR will perform essentially the same function. This value represents the minimum percentage rate of return on energy investments that we demand from our energy projects. When energy is cheap and plentiful a low MARR is justified allowing investments in slow but long lasting energy systems. When energy becomes expensive and we are experiencing shortages a high MARR focuses development on projects that deliver the most energy in the shortest amount of time. For today's conditions I am setting the MARR at 5%. While this is a variable that may be adjusted for different conditions it is important to recognize that changing this value will alter the results of using this methodology. When using the Time Value of Energy to compare different energy sources it is essential that all calculators use the same MARR. For this reason all people calculating the Net Energy Profit Ratio for their project must use the currently posted MARR (2006- 5%) for their publicly reported numbers.

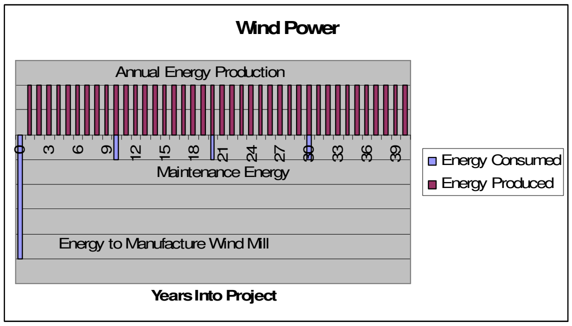
Energy Time Line

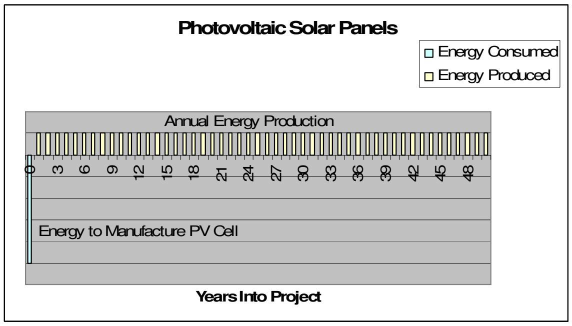
The first step in producing an energy life cycle analysis is to produce an energy time line. The time line shows the energy produced or consumed each year during the life of the project. Energy time lines are graphical representation of a project's annual rates of production and consumption.

Below are some hypothetical energy time lines for different energy projects. Please note these energy lines are not to scale, or based on any factual information, they are simply used here to show hypothetical points in time for the energy production and consumption of different types of energy projects.









When using the Time Value of Energy to analyze these projects all future energy values are adjusted to their relative energy value to us today, called their Present Energy Value. The sum of all Future Energy Production Values (FEPV) adjusted to their Present Energy Production Value (PEPV) is called the Net Present Energy Production Value (NPEPV). The sum of all Future Energy Consumption Values (FECV) adjusted to their Present Energy Consumption Value (PECV) is called the Net Present Energy Consumption Value (NPECV).

$$NPEPV = \Sigma\, PEPVn = \Sigma\, (FEPVn * (1+i)^{-n}) \qquad \text{(Equation 2)}$$
$$NPECV = \Sigma\, PECVn = \Sigma\, (FECVn * (1+i)^{-n}) \qquad \text{(Equation 3)}$$

These Net Present Energy Values are used to complete an energy life cycle analysis of the project. Unlike an economic life cycle analysis the focus is on producing the most net energy rather than the most net currency. This is the best investment method for analyzing energy production projects, and energy intensive infrastructure developments whose costs are highly dependent on energy prices. The Net Present Economic Values of these projects are highly dependent on energy prices. If energy prices increase significantly the Net Present Economic Value of these projects will drop rapidly. The projects that produce the most net energy, or achieve the most while consuming the least, will become the most profitable.

Net Energy Profit Ratio (NEPR)

The Net Energy Profit Ratio (NEPR) is equal to the Net Present Energy Production Value divided by the Net Present Energy Consumption Value. The Net Energy Profit Ratio (NEPR) is the ratio of how much more presently valued energy is produced, versus consumed over the life of the project.

NEPR = NPEPV/NPECV (Equation 4)

The Net Energy Profit Ratio is the most accurate tool to use when comparing one projects net energy production capability to another. A project that returns a NEPR equal to or greater than one means that over its life it produced not only more energy than it consumed, but also at a rate at or above the MARR on energy. A project that returns a NEPR value less than one means that over its lifetime it produced energy at less than the MARR on energy. When looking at energy consuming projects that have a fractional NEPR it may be useful to use the inverse of this value called the Net Energy Loss Factor (NELF) to compare projects. Projects with a high NELF are bigger energy sinks than those with low NELF's.

NELF = 1/NEPR (Equation 5)

The primary purpose of an energy producing project is to produce a net positive quantity of energy. The energy project that has the highest NEPR is the most successful project at achieving this goal. Unfortunately, many investors and decision makers choose projects based on their life cycle economic return. While this seems like a good idea the engineering economics used for these calculations is arbitrary because it is dependent on an unknown variable, the price of energy. If the primary goal of a project is to produce energy we should use a direct energy analysis not an indirect economic analysis to achieve that goal.

A good example is Canadian oil sand production. According Bob Dunbar, Canadian oil sand consultant, roughly 75% of the cost to produce oil sands comes from purchasing natural gas as a feedstock for production. Using an economic analysis he claimed that oil sand production is profitable at a world crude price of $35 per barrel. He did this assuming that the price of natural gas was $7 per million Btu. Unfortunately for him, at the time of his presentation the current price of natural gas was $14 per million Btu. Because the price of natural gas had doubled, the cost to operate his project had increased by 75%. With the higher natural gas prices the oil sand project would need to sell its crude oil for $61 per barrel to maintain the same profit margin.

An uncontrollable factor, the price of energy, has completely changed the economics of this energy investment. The power of the NEPR is that it eliminates this dependency, and remains constant for a project regardless of changes in energy prices. Due to the energy intensive nature of unconventional resources, and the growing uncertainty surrounding energy prices I propose that the NPEV becomes the predominate method for valuing new energy production projects.

Net Present Energy Value (NPEV)

The Net Present Energy Value is equal to the Net Present Energy Production Value minus the Net Present Energy Consumption Value. The Net Present Energy Value (NPEV) is the quantity of presently valued energy that is brought to the marketplace during the projects life.

$$NPEV = NPEPV - NPECV \qquad \text{(Equation 6)}$$

It is important to realize that this value is not necessarily equivalent for all projects, and some other equalizing factor must be used. For example a 20 million dollar photovoltaic project will likely bring more energy to the market than a 20 thousand dollar oil project. To make these projects Net Present Energy Values equivalent we must compare a 20 million dollar photovoltaic project to a 20 million dollars oil project. Another good equalizing factor would be an environmental damage index. If both projects create the same environmental damage, the Net Present Energy Value would show which project brings the most presently valued energy to the market for that quantity of environmental damage.

While it holds some value to political and economic decision makers the NPEV is primarily a design tool. If an engineer maximizes the NPEV of a project it will become as productive and energy efficient as possible. Today, infrastructure systems are predominantly designed using engineering economics and the Time Value of Money. With this methodology the engineer's goal is to maximize the Net Present Economic Value. If energy prices change during the life of the project the Net Present Economic Value will become incorrect because it was calculated using current energy prices. If energy prices double or quadruple in the next 10 years we will find that most long lasting, and energy intensive projects have been incorrectly designed. These projects will end up costing us more energy and more money than if they were originally designed using energy engineering.

A good example is a piping system. When an engineer designs this system he or she knows that the wider the diameter of the pipe the less energy that is needed to pump the fluid through it. But at the same time wider pipes are more expensive than narrower pipes. Using engineering economics, with today's energy prices, engineers optimize the system to have the smallest Net Present Economic Cost over the life of the project. The result is that they downsize the pipes and oversize the pump. This system takes more energy to operate, but the presently valued cost of that energy over the life of the project is less than the original cost of purchasing the larger pipes.

This is true at today's energy prices, but if prices increase during the life of the project the original calculation is suddenly incorrect. With higher energy prices the presently valued cost of the energy to operate the pump is more expensive than the cost to purchase the wider pipes. The optimal engineering economics design changes daily with our energy prices. It would only be correct if we knew exactly what the price of energy was going to be for every day of the projects existence. Unfortunately, there is no way of knowing what energy prices will do in the future. Most engineers assume that they will remain constant; other engineer's will try to factor in increasing energy prices over the life of the project. Both of these practices make our economy dangerously dependent on an engineer's ability to predict the future.

Guessing that prices would remain constant has been acceptable assumption because inflation adjusted energy prices have been relatively stable over the last hundred years. Stable aside from the occasional energy price spike caused by political events. However recent energy price increases have been predominantly unrelated to political events. This indicates that there may be an underlying supply and demand issues emerging in the energy sector which will create an entirely new price paradigm. Many professional including, geologist (Colin Campbell), politician (Roscoe Bartlett), and investment bankers (Matt Simmons) have proposed that energy prices will continue to increase, at an accelerating rate, as we start using more and more unconventional energy resources to offset conventional energy depletion. This is because most unconventional energy projects not only cost more money, but also require more energy input than conventional energy projects.

Prudent risk management would not have us designing our long term, and energy intensive infrastructure using a methodology that is dependent on something as potentially volatile as energy prices. I propose that for these project types the Time Value of Energy methodology and energy engineering be adopted. Engineers should optimize projects by maximizing the Net Present Energy Value, producing a project that is more energy efficient; and less vulnerable to economic loss in the face of rising energy prices. In my opinion, utilization of this methodology will result in increasing the bottom line of these projects because energy prices are more likely to increase, than decrease based on the foreseeable energy price outlook.

When applied to the piping system described above, rather than looking at the cost of the wider pipes energy engineering would look at the energy invested in the wider pipes. They require more material and thus more energy to produce. By maximizing the Net Present Energy Value rather than the Net Present Economic Value engineers will design systems that make the most sense from an energy standpoint, something that will remain constant irregardless of the price of energy. This may come at an economic cost if energy prices decrease. However, this is an upfront and affordable cost unlike, the sudden and unexpected costs associated with operating an inefficient project during a massive energy price spike. Regardless of what energy prices do, infrastructure developed using energy engineering will be more energy efficient than a system designed using the engineering economics.

Conclusion

As decision makers choose what energy sources and projects will power our future the Net Energy Profit Ratio should be one of the most valuable tools in their arsenal. It holds the power to accurately compare the true energy production value of different projects by taking into account the Time Value of Energy. Most importantly it creates a comparison value that is independent of unpredictable energy prices. While this value will be extremely useful to decision makers they must also take into consideration many other factors when choosing which projects offer the most value to society. The most notable factors are: the type of energy source (Finite or Renewable), the type of energy produced (Liquid or Electrical), and the environmental degradation created by the energy project.

Along with offering a new tool for comparing different energy production projects the Time Value of Energy methodology is also valuable when designing projects, or choosing which infrastructure projects we should undertake. Adopting energy engineering will inherently make our infrastructure developments more energy efficient, and our economy less vulnerable to massive economic losses. This will be an important issue as we choose to make investments in public transportation systems, energy efficient homes, and distribution systems. All of these infrastructure systems, if designed properly will make our economy more capable of prospering in spite of higher energy prices.

Clearly no methodology is perfect for making the complex energy production, and infrastructure investments necessary in the coming decades. However, engineering economics commonly used today is a flawed theory when used to analyze long term, and energy intensive projects. This old method has been successful over the past decades because we have historically had stable energy prices. However, going forward this use of a methodology dependent on stable energy prices is an unacceptable level of risk. Using the Time Value of Energy methodology eliminates this attachment to the price of energy, and offers a much more accurate method for comparing and designing energy producing and consuming projects. It is my hope that this methodology's inherent value is recognized and adopted on a large scale before many more misinformed decisions are made about our future infrastructure and energy production projects.

"When designing an energy intensive project, if a variable like energy price cannot be predicted, it should be removed from our analytical method, not assumed to remain constant."

Greg Rock – General Engineer

Considerations and Limitations

When using NEPR or NPEV to compare different energy projects it is important to realize that this is all you are doing. Comparing the value of different energy projects is possible, but comparing the value of different energy sources is impossible. For example Bio-fuel production can be accomplished by using natural gas based fertilizer and petroleum based pesticides. This Bio-fuel project would likely yield a much different NEPR than a project which eliminated the needs for those energy inputs by using manure based fertilizers and naturally produced Bio-fumigants. This methodology can only compare different energy projects, and their specific harvesting techniques, not the different types of energy sources themselves.

Attempting to capture many of our available energy sources with current technology may yield fractional NEPR's. This however, does not mean that future production methods will not make harvesting that energy source successful. A project resulting in a fractional NEPR does not prove that a certain energy source is worthless, only that the methods used for recovering it need to be improved before it can be recovered at an acceptable rate of energy return.

It is also important that decisions makers realize that the project with the highest NEPR is not necessarily the most beneficial project to society. Most obviously this value does not take into account any form of environmental degradation. A separate Environmental Damage Index should be created and used in coordination with the NEPR to determine the complete energy production and environmental value of a project. A project that creates massive environmental degradation and only yields a slightly higher NEPR is probably less valuable to society than the latter project even though it has a higher NEPR.

It is also important to understand that not all energy sources and forms are equal. When producing energy, liquid fuel is normally more valuable because it can be used for transportation or electrical generation purposes. When consuming energy it should be recognized that finite and renewable energy sources are intrinsically different. A finite energy source will most likely yield a higher NEPR than a renewable energy source, due to the nature of releasing stored energy, versus capturing current energy flow. Decision makers should account for the fact that finite resources are depleted, while renewable energy sources can be used indefinitely. This may be a more important issue than the net energy production capabilities of different projects.

Perhaps one of the biggest concerns about this methodology is that it creates incentives for producers to increase their NEPR by increasing the rate of energy production. While this is advantageous for renewable energy sources, higher rates of production will lead to quicker depletion of our finite energy sources. The purpose of this analytical technique is to inform decision makers which energy projects can produce the most net energy, and deliver it in the shortest amount of time. While this is valuable information it should not be taken as a motto for our energy production projects. In fact, restricting production rates of finite energy sources may very well be in the best long term interests of this country and the world. However, these are matters of public policy and they do not affect the mathematical method for comparing the energy production capabilities of different energy projects

One of the most challenging parts of this methodology is getting it into common usage. Pressure to use the Time Value of Energy methodology should come from: federal and state agencies, public and private investors, and education facilities. Hopefully energy engineering education will occur soon enough to save investors the money they will likely lose if they continue relying on engineering economics to design long lasting and energy intensive projects.

Calculation Rules
(Version 1.0)

When calculating the energy production and consumption values it is extremely important that it is clear which types of energy are to be included in this analysis. A set of rules and principals must be followed when calculating these values for any energy project. These rules can be found below and are denoted as Version 1.0. These rules will require some adjustment over time so they can be upgraded through the posting of new versions. Any published NEPR or NPEV must be posted with its version number attached to it, and all new calculations should be done using the most current set of rules.

Many of the values needed to calculate the NEPR will not be available and may need to be estimated at the time of its calculation. When the actual value is not available it will be created by taking the best available estimate and decreasing the Future Energy Production Value by 10%, and increasing the Future Energy Consumption Value by 10%.

If either the Net Present Energy Production Value or the Net Present Energy Consumption Value are produced with over 20% of their numerical value based on estimates an asterisk must be added to the published NEPR or NPEV numbers.

In the future if the Present Energy Consumption and Production Values can be produced using less than 20% of their numerical values from estimated figures the asterisk can be removed from its new publication. Because best estimates have to be increased or decreased by 10% it will create incentives for producers to use actual values whenever possible, and to reproduce their Net Energy Profit Ratios after actual production and consumption values become available.

If an energy production on consumption value is known with a 90% certainty, due to industry experience, these values do not need to be increased or decreased by 10%. However, the asterisk can not be removed from the projects reported NEPR or NPEV until after it, or a complete project cycle, has been completed and actual production and consumption figures exist.

If the NEPR is calculated using version 1.0 as a set of rules, and 20% of either the Net Present Energy Production or Consumption Value has been estimated the NEPR would be published as follows.

$\text{NEPR}_{\text{ver1.0}} = 4.5^*$

Accounting for Energy Consumption

When creating the energy time line the Direct, Indirect and Material Energy must be accounted for during the Production, Processing, and Distribution aspects of the energy project. Net Energy Profit Ratio calculations must include energy that is used for Construction, Operation, Maintenance and Labor on the energy project. All aspects of bringing the energy to the market must be accounted for whether your energy project is specifically responsible for them or not. The total quantity of energy consumed each year is placed as a negative value on that year of the energy time line. This may seem like a lot of calculations but this type of inclusive energy analysis is commonly done by many industries such as “Well to Wheel” analysis in the automobile industry.

Aspects of an Energy Production System:

Production – Everything associated with producing the crude energy from its source.

Processing – Everything associated with processing the crude energy into a market ready product.

Distribution – Everything associated with transporting the crude energy to its processing facility, and transporting the market ready energy product to the retail distributor, or end user.

Categories of Energy Consumption:

Construction - Energy used to construct facilities, and equipment necessary for the project.

Operation – Energy used during regular operations.

Maintenance - Energy that is used for repair and maintenance of the projects facilities and equipment.

Labor – Some of the energy used to feed, house and transport human and animal laborers.

Types of Energy:

Direct Energy – Energy that is directly inputted into any aspect of the energy project.

Indirect Energy – Energy that is indirectly necessary for any aspect of the energy project

Material Energy – The embodied energy used to harvest, and manufacture a material into the form that it is delivered to the energy project. Material energy also includes the energy used to transport the raw or processed materials from the mine to the processing site and to the end purchaser. Material Energy does not include stored chemical energy.

Reporting Energy Consumed By The Project

Calculators of the NEPR must report for each energy consumption category the quantities that are used as Direct, Indirect and Material energy. The following energy consumption categories and rules must be applied to each aspect of the energy project including: production, processing and distribution.

Construction

Direct Energy - Energy used to power the operation of the construction equipment and crew.

Indirect Energy - Energy used to construct commonly used facilities or equipment that any aspect of the energy project is dependent on. This value is based on the total energy invested (Material and Direct) in the common facility or equipment's construction multiplied by your projects usage percentage. Usage percentage is the portion of the common facility or equipment's total life the energy project consumes. If the energy project has a usage percentage less than 5% this value can be ignored for that facility or equipment.

Material Energy - The embodied energy of all the materials used to construct your energy projects facilities, equipment or product.

Operation

Direct Energy - Energy that is used to power facilities and equipment that are used during the operation of any aspect of the energy product.

Indirect Energy - Energy used to operate commonly used facilities or equipment that any aspect of the energy project depends on. This value is based on the total energy invested (Material and Direct) in the common facility or equipments operation multiplied by the energy project's usage percentage. If the energy project has a usage percentage less than 5% this value can be ignored for that facility or equipment. Common facilities and equipment are often part of the distribution aspect of an energy project. Examples are roads, transmission lines, and railroads.

Material Energy – You must account for the embodied and distribution energy of any materials or resources, including water, used during the operation of the project. Projects should also look at their material flows to see if any material usage represents a large portion of energy consumption. Any material whose embodied energy is over 1% of the energy project's Net Present Energy Consumption Value must be included.

Maintenance

Direct Energy – The actual energy used to repair or replace any old or broken parts of the energy project.

Indirect Energy – The material and direct energy used to construct the tools used for maintenance. If your maintenance crew works on many other projects this number can be a function of your project usage percentage. If the energy projects usage percentage is less than 5% its value can be ignored for that tool.

Material Energy – The embodied energy of any replacement parts for the energy project.

Labor

Direct Energy – Refers to the energy content of the food used to feed the labor pool. Food for humans can be ignored because they exist, and require nutrition regardless of the energy projects existence. Animal labor however might be raised and fed specifically to work on an energy project. If animal feed is used, the energy to grow, harvest and transport that feed must be accounted for. If the animals are range fed you must account for any energy inputs you put into that process. This could include energy for irrigation, fertilizers, tilling etc.

Indirect Energy - Energy to house and transport your labor pool. For humans the housing impact can be ignored because humans need homes regardless of the energy projects existence. If onsite housing is constructed for employees, the energy used for constructing and operating these facilities can be removed from the above categories. For animals, if a storage facility is constructed all of its energy must be accounted for in the construction and operation categories. If employees live off site, their transportation impact must be accounted for. Transportation impacts can be calculated by multiplying the total number of employees living offsite by the average commute distance and dividing this by the average U.S. vehicle fleet efficiency. The resulting gallons of gasoline can be converted into the proper energy units. If the site has access to public transportation car trips can be reduced based on employee ridership rates. Direct energy used for moving employees on a mass transit system and the remaining employees that still drive automobiles must be accounted for. Indirect and material energy can be ignored when calculating a public transportation system or an automobile’s energy impact. If a transportation system is constructed specifically for getting employees to the energy project site only the energy used to operate the system needs to be accounted for. A transportation system used for moving employees around the project site must be included as part of the energy projects facilities.

Material Energy – Embodied energy found in special employee clothing or provisions. Standard material clothing can be ignored but if special energy intensive materials are needed for your employee’s safety equipment it must be accounted for.

Accounting for Energy Production

The rate and quantity of energy production is highly dependent on not only the crude energy source, but also the type of technology used for extraction. It is difficult to create a set of rules that will govern all forms of energy production. When applicable, calculations of the NEPR must take into account the following principals when determining the quantity of energy produced during each year of their projects life.

- Over the life of a project finite energy sources can only produce the Project's Specific Proven Reserves.

- Project Specific Proven Reserves refers to the total quantity of crude energy that can be produced, and is available for production, based on that specific energy project's current technology and resource rights.

- Project Specific Proven Reserves must either be based on tapped reserves, or the reserves base that is 90% likely to exist, based on calculations by industry experts.

- If improved technology is installed in the future new energy consumption and production reports are created producing a new NEPR.

- If an energy project can only produce a portion of the resource's total proven reserves, it may only account for its actual, or estimated production based again on a 90th percentile of certainty.

- The production of any resource is usually inconsistent and scattered, but when calculating a NEPR an idealized and smooth model of the industry standard should be used.

- If production of the resource is restricted by any public policies these restrictions can be ignored for the NEPR calculation but should be noted when reporting your results.

If multiple useable products are produced by an energy project they can be accounted for, or used, in one of two ways. A useable product is defined as something that can be reused as a feedstock to the process, or can be sold into a free market.

- If the resulting product can be used directly as a feedstock to the energy project it can be used to reduce the energy value consumed by the project. An extra product that is used on the project site can be ignored on both the production and consumption side of the NEPR analysis.

- If the resulting product is sold into the marketplace it has an embodied energy value. This energy value must be accounted for when using the NEPR analysis.

- If a byproduct can be produced by itself its energy value is represented by the most direct and energy efficient method of production.

- If a byproduct can not be produced separately than you must establish a relative value for your byproducts. This value will be set by the retail prices of the products when it is calculated. If you produce $1000 worth of energy, and $250 worth of byproducts the energy value of the byproducts is equal to 25% of the energy produced by the project.

If another form of energy is produced and used on the site, but it is unrelated or unnecessary to the original project it should be ignored for the NEPR analysis.

- Example, an oil project uses solar panels to provide electricity for its facilities. This energy does not offset the energy value consumed by the project, nor is the energy used to produce the solar panels included in the analysis.

- If a complete NEPR of a site producing multiple sources of energy is desired it can be produced using a weighted average of each individual projects. The weighted average is the sum of each project's NEPR multiplied by its NPEV's percentage portion of the entire sites NPEV.

Most energy production falls into one of these categories: Constant, Cyclical, Degrading, Growth/Peak/Decline, Exponential Growth followed by Collapse.

- Seasonal or cyclical energy production can be estimated using the average production rate during one complete cycle. Data can then be analyzed in the same manner as a constant energy production project.

- Degrading energy projects must account for reduced production over time due to the aging of technology, or slowing resource flows.

- Exponential growth followed by collapse is rarely seen in energy projects, and must be explicitly proven if used as a production model.

- Production of a finite resource normally follows a bell shaped production curve. Widely studied in oil fields, finite resources reach a peak in production between an exponential growth, and decline period. When modeling production of finite resources, unless otherwise proven through existing energy projects, they should be modeled using M. King Hubbert's mathematical model for unrestricted production of a finite resource.

Other potential production models obviously exist and should be used when applicable. It should also be noted that no energy production project will actually follow an idealized production model. But for consistency sake, when projecting future energy production, it should be modeled with some commonly accepted idealized model.