FLEXIBLE FUTURES

facilitating a green energy future through adaptive planning

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ABSTRACT

Energy consumption is steadily increasing, coupled with a political drive to identify affordable domestic sources of energy has lead us to exploit our finite resources with little consideration for long-term economic and environmental sustainability.

The extractable Natural Gas found within the Marcellus Shale deposit provides us with a unique opportunity to meet the energy needs but also provide a bridge to greater reliance on renewable energies. In the short-term, its economic, environmental, and social longevity is limited by the characteristics of finite resources. Natural gas cannot fulfill all our long-term energy demands, but it offers us a secure capital resource that other energy sources individually cannot.

Single source energy production is not the solution to our long-term energy, social, economic, and environmental sustainability; however, the combination of energy sources within a flexible framework, offer the ability to solve the problems associated with our energy demands over the long term, through responsible planning, placement and implementation of Marcellus drilling within the future alternative energy landscape.

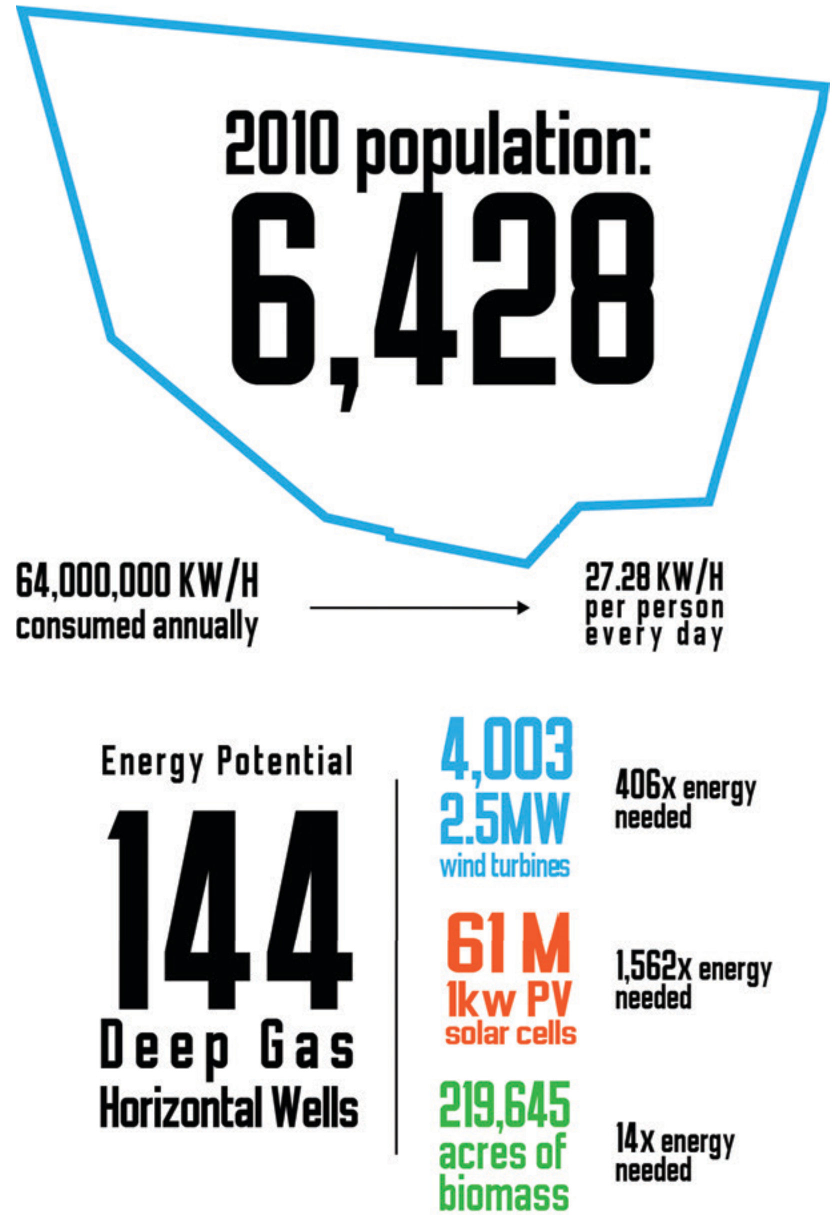
SULLIVAN COUNTY ENERGY

Located in the Northeastern part of Pennsylvania, Sullivan County lies directly in the path of Marcellus development. As the second smallest counties and one of the poorest counties within Pennsylvania, it may facing long-term economic, social, and environmental volatility after natural gas development ends.

Energy Development within Sullivan County directly impacts eight watersheds that eventually feed into the Chesapeake Bay Watershed. The production of energy within Lake Makoma can have an environment impact at the largest of scales; however, the responsible development of energy sources can provide sustainable economies, communities, and environments on not only the local scale but also the larger regional scale.

Currently Sullivan County is a net energy consumer and produces little to no energy in comparison to other counties. However, Natural Gas development has started to gain a foothold in this region.

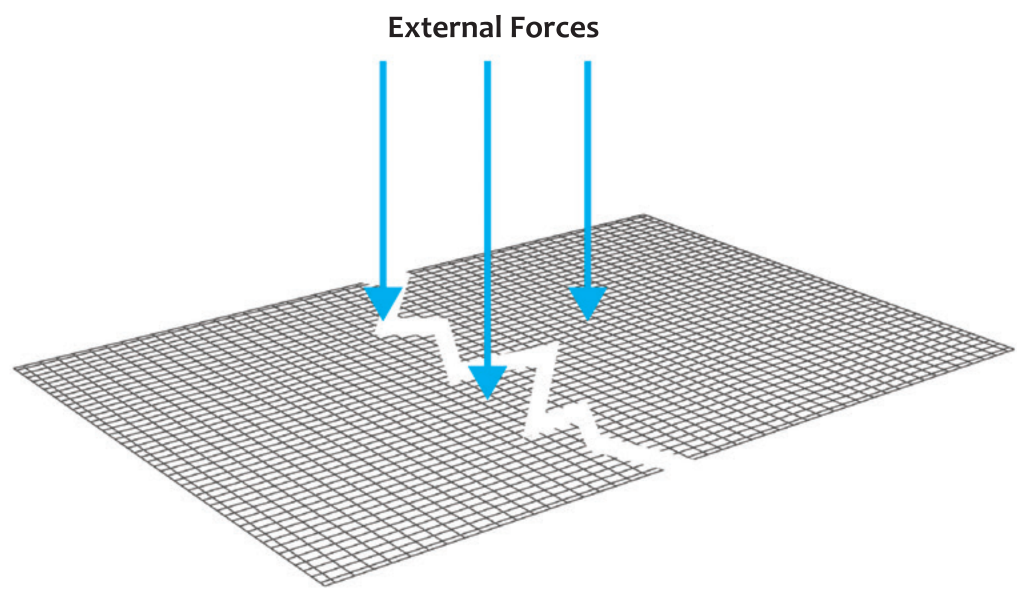
Sullivan County is not widely recognized as an area of Pennsylvania that could help us meet the vast needs fo our energy future. However, this project indicates that Sullivan County has the potential to produce not only the energy it needs to sustain itself, but also to supply energy over a larger network.



SYSTEMS

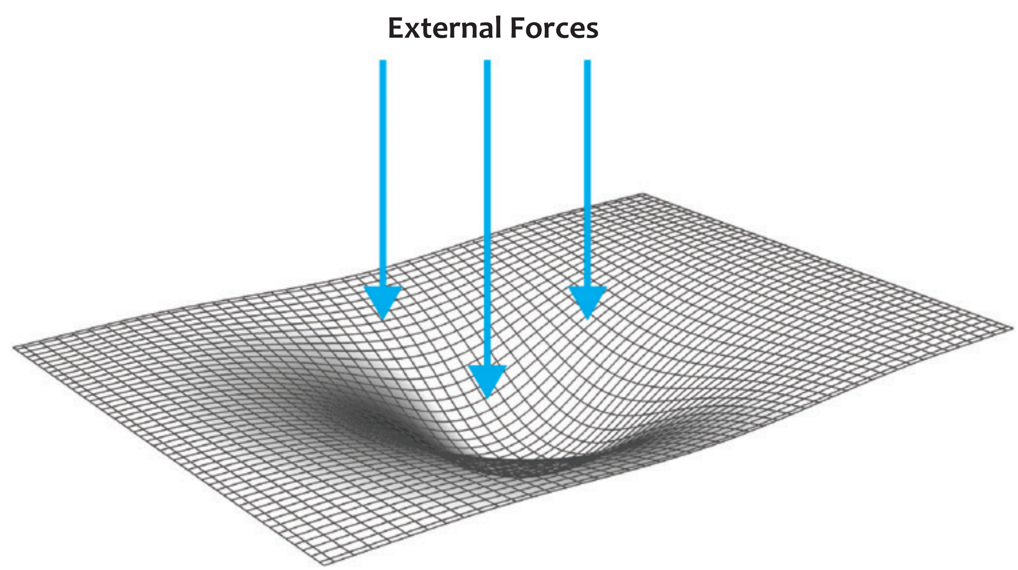
Traditional Energy

Traditional energy systems are static, rigid, and unable to react timely in the market as demands increase and decrease. The result is blackouts, increased energy costs, and excess energy is often discarded useless and wasted. (book, 201)



Flexible Energy

Smart grids allow for the flexible generation and distribution of energy at various scales as the market demand increases and decreases. (book, 201)



TRADITIONAL ENERGY SOURCES

1. NATURAL GAS

Natural gas is one of the fastest growing sources of energy within the United States. It is replacing our coal plants and providing landowners with vast quantities of new wealth; however, the benefits of this resource will only last a short period of time.

2. Coal

Coal is one of the most abundant energy resources in the world that can be produced cheaply and used to generate electricity. Although coal is cleaner today than it once was—it still heavily pollutes the atmosphere.

3. Hydroelectric Power

Hydropower is a great source of large, cheap, renewable energy production through the use of falling water. The downside to this energy source is that it causes extreme amounts of damage to rivers and aquatic ecosystems.

4. Nuclear Power

Nuclear energy is a highly renewable source of energy; however, its environmental health impacts are greatly disputed. The mining operations that extract uranium for these plants create a lot of carbon.

RENEWABLE ENERGY SOURCES

1. LARGE WIND TURBINES

Large wind turbines are the most economical of the wind turbines for large-scale power generation. They have the potential to provide enough energy to be deployed into grids and distributed at regional scales.

2. MEDIUM WIND TURBINES

Medium wind turbines offer larger power outputs than small wind turbines, reducing the cost of implementation and providing energy at the community scale. The scale of these turbines makes them less visually intrusive vertically than large wind turbines.

3. SMALL WIND TURBINES

Small wind turbines can be placed within residential areas without significant impact to views. In most cases these turbines are stylish, enhance the landscape and can be easily incorporated into structures as both vertical and horizontal elements.

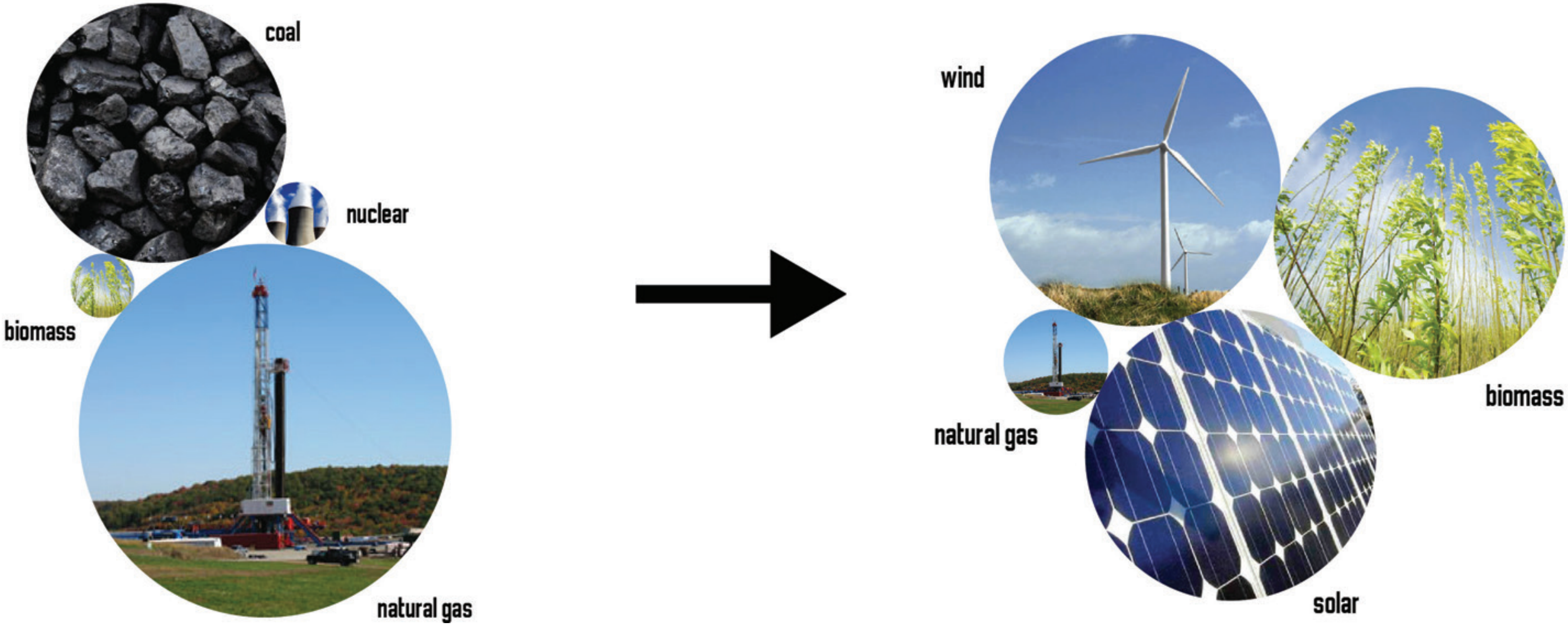
4. SOLAR ENERGY

Solar energy has the highest energy output potential of any alternative energy source; however, its costs make it less viable as a commercial source of energy. At the household scale the implantation of this energy source is economical. Solar energy can be implemented at both large and small scales.

5. BIOMASS ENERGY

Biomass can come from a number of organic sources such as grass, trees, and agricultural crops. These sources of energy can be converted into fuel, heat or electricity. Additionally, these energy sources offer the ability to be stored and utilized as needed.

FLEX AS AN IDEA



Current

The current energy market heavily relies on our finite resources centralizing the production of energy to feed our national electric grid. Energy production is operated on one site that produces the product and then transports that product to the various locations where demand is high.

Future

A flexible energy system implements a variety of energy sources (both spatially and temporally) allowing for the reduction of finite resource consumption. The energy production for these grids can distributed at a variety of scales in order to provide a balanced framework of energy generation. This energy can then be fed through local and national energy systems.

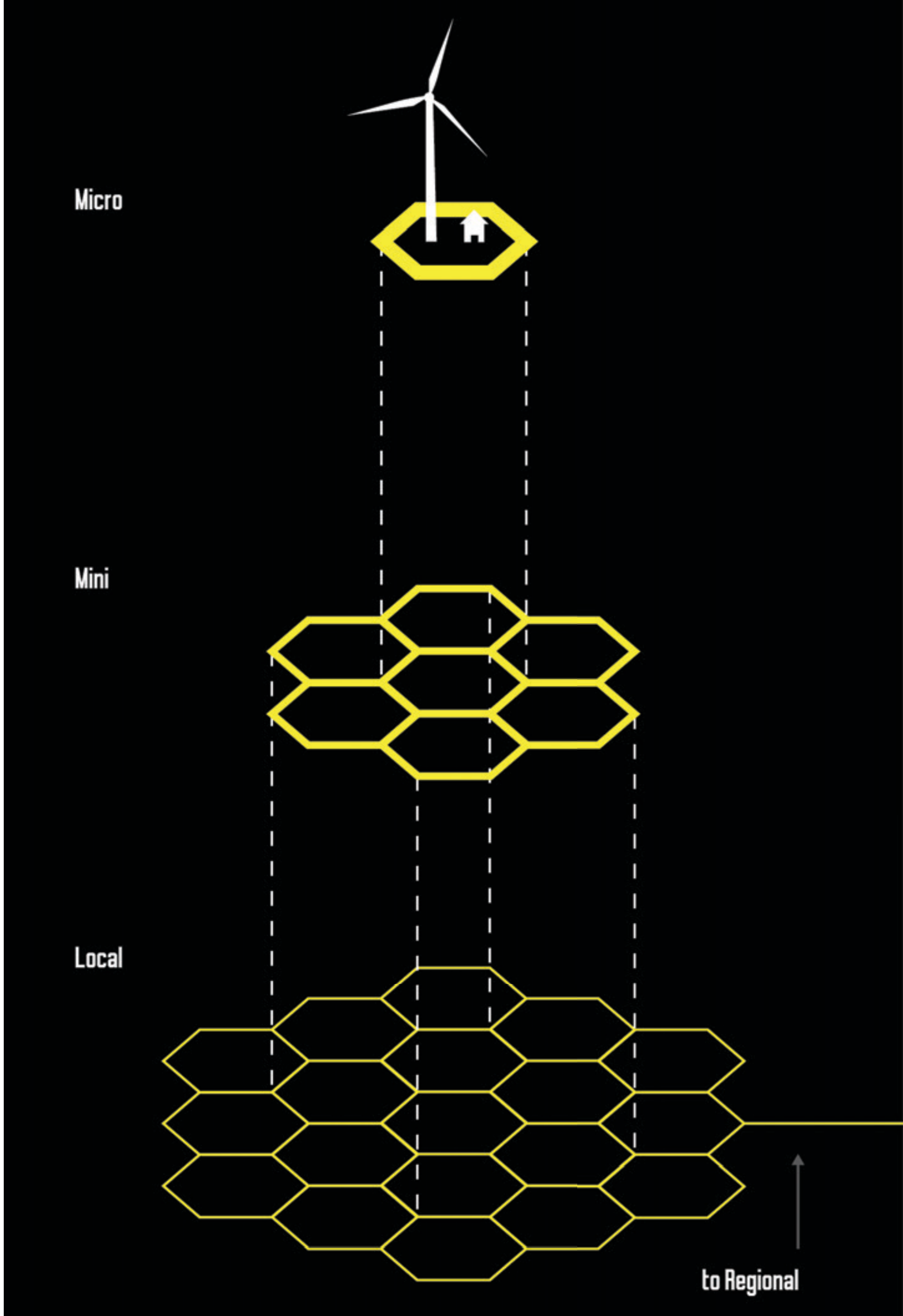
DISTRIBUTION

A heirarchial smart grid could be implemented in order to promote adaptive generation, distribution and consumption of energy. This grid consists of three scales (Micro, Mid-Range and Macro) - each of which would export excess energy to a larger grid. This flexible system allows for energy production and consumption to adapt to the current market conditions without distrupting the flow of energy.

Micro
The micro scale provides energy generation, and consumption at the household scale with excess electricity feeding into the medium grid.

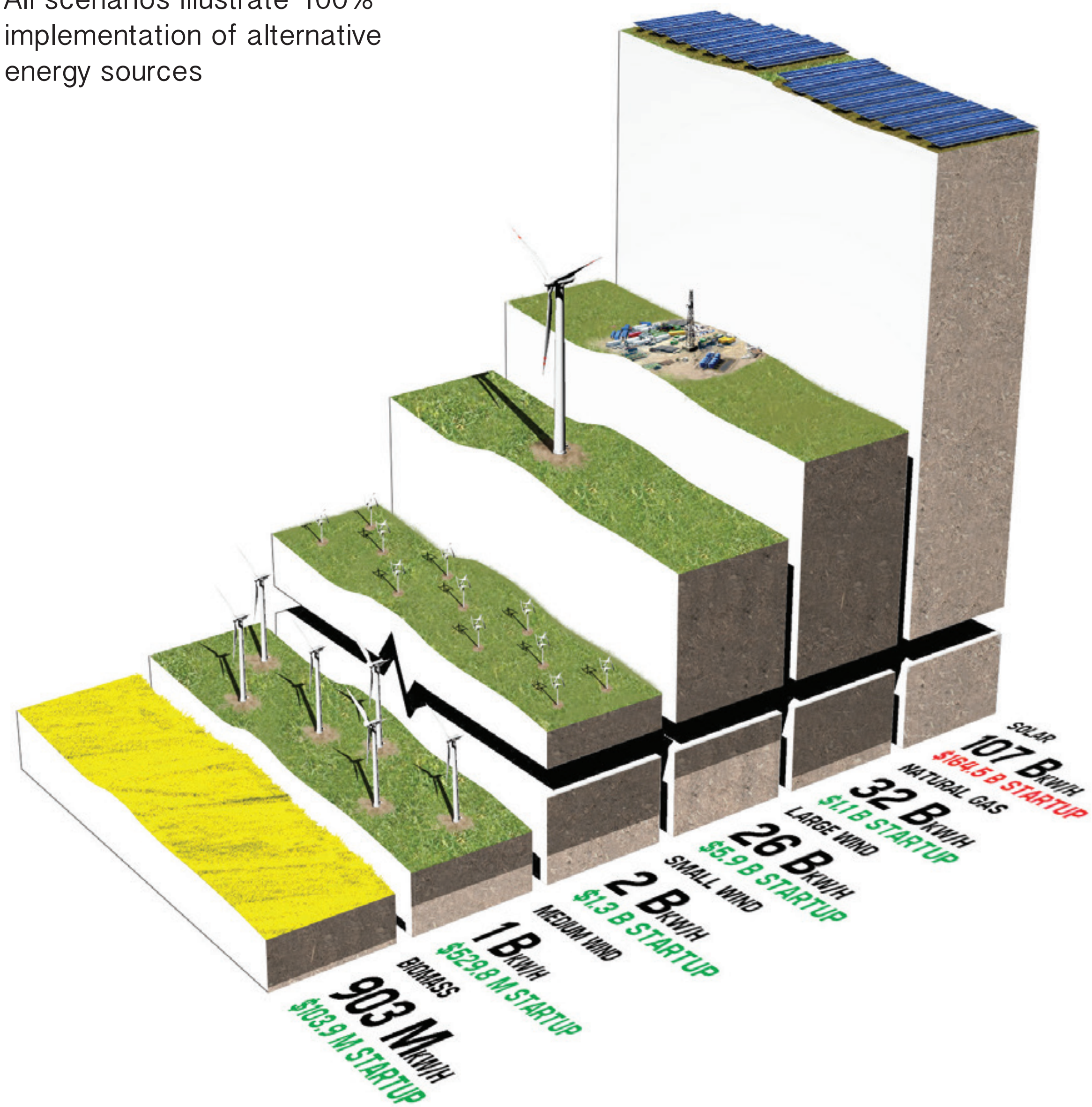
Mid-Range
The mid-range grid circulates excess energy from the micro grid amongst local communities and generates electricity at a larger collective scale through the linking of micro grids. Excess electricity from this grid is then feed into the macro grid.

Macro
The macro grid is a regional/national grid system that links medium sized grids together and circulates excess electricity to communities with higher demands.



ALTERNATIVE VIABILITY

All scenarios illustrate 100% implementation of alternative energy sources



The potential annual energy yields of various energy sources along with the initial subsidized investment cost are shown to the left. Solar energy has the highest energy yield over all potential energy sources; however, the initial investment far exceeds the commercial viability over a twenty year subsidized return period. At the commercial level a 100% transition to solar energy is not viable as an investment; however, at the consumer or household scale it has the potential to be a viable investment.

Marcellus Gas can achieve the highest capital gain over a twenty-year period. This makes Marcellus an extremely viable comercial resource. Wind energy closely follows natural gas in energy production. Although the initial investment of wind is larger than natural gas its twenty year subsidized return on investment is close to that of Marcellus Gas. Biomass, although relatively small in output compared to other energy sources, has a relatively low initial investment and can provide for all the energy needs of Sullivan County.

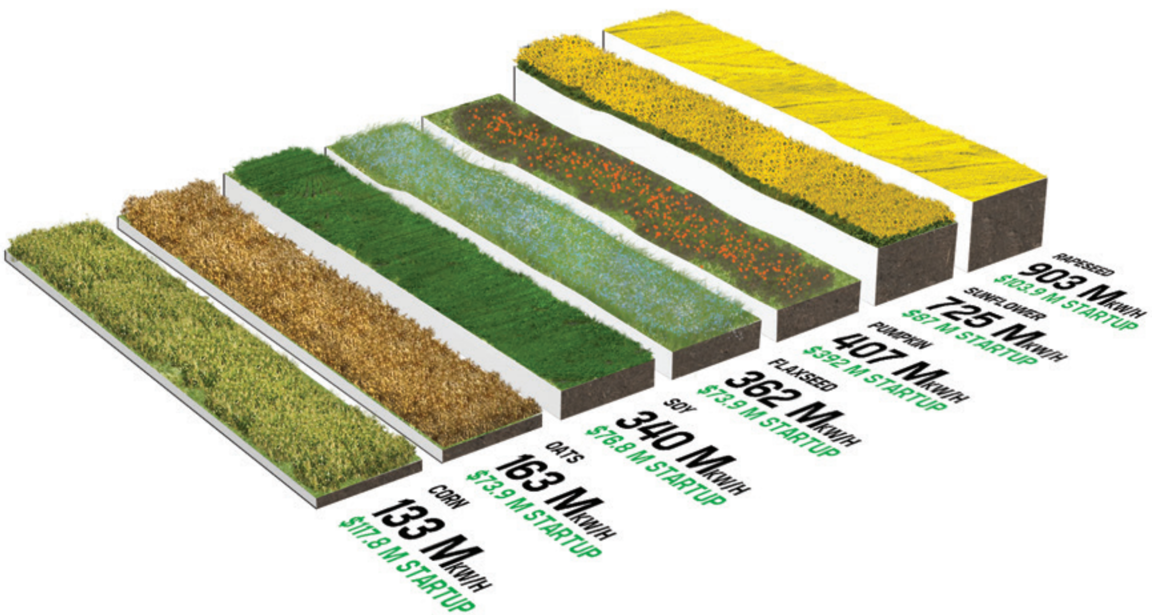
BIOMASS VIABILITY

The commercially viability of Biomass as an energy source has been questioned. Unfortunately, politics have led us to invest in the least viable energy yielding biomasses - corn and soy.

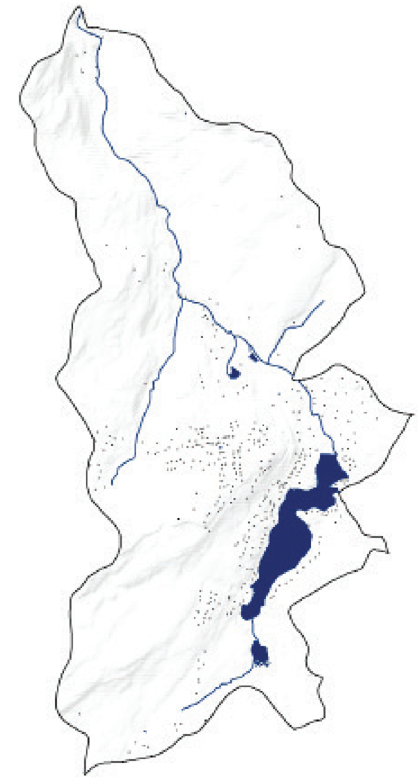
Corn and soybeans are highly regarded as the crops that will supply ethanol for the future. However, other crops such as rapeseed have the potential to supply eleven times more energy per acre than corn.

This graph shows a range of biomass crops that are suitable to be grown within the Northeastern Pennsylvania. It becomes noticeable how our perceptions of the benefits of crops are skewed by agricultural politics and policies.

Notice how the common biomass crops are some of the lowest energy yielding crops available while the highest yielding crops are not as well known.



VIABLE IMPLEMENTATION SCALES



Regional Scale

The regional scale within this case study consists of the eight watersheds that are directly connected to Sullivan County. By defining regional areas by the watersheds that counties directly impact we are able to create a networked grid that overlaps with one another at the county level eliminating the disjointed county lines and municipalities. Through the connection of regional area the electric grid is able to better work in conjunction with its surrounding communities.

Community Scale

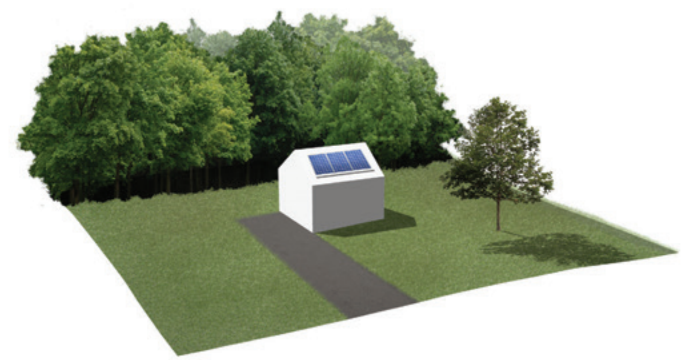
Community is an important aspect of not only design but also to the health and happiness of people. This project heavily emphasis the importance of community in energy production and illustrates how the community can help generate a connected grid to benefit themselves and their neighbors.

These communities come together to form a conglomerate grid of electricity that they each have a vital role of importance in. By initiating the community in their own electricity production we are able reconnect the community on a common level.

SMALL SCALE IMPLEMENTATION

MicroWind
In addition to Macro and Medium scale wind implementation, small wind turbines can be installed to homes and businesses. Some pieces of property can support multiple turbines.

Micro Solar
Solar power has an extremely high yield, but it can be a challenge to cover the startup costs for PV solar cells. Through government subsides, individual homes have the potential to provide solar power to the smart grid.

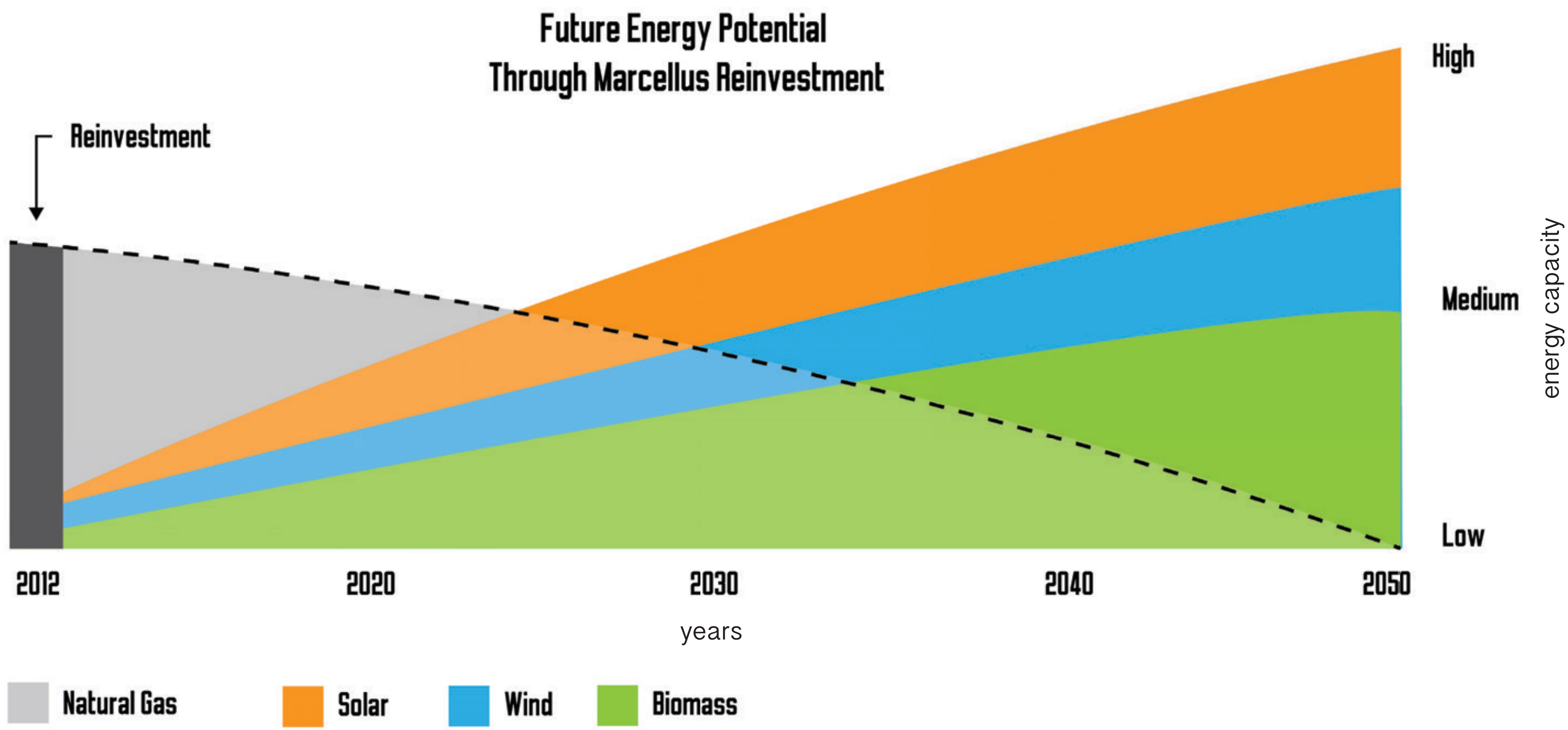


Micro Hybridization
Micro scale wind and solar technologies could be combined in order to maximize the energy generation of a particular piece of property.

ALTERNATIVES THROUGH MARCELLUS

The cost of implementing alternative energies is relatively high and often exceeds the cost to extract finite resources such as Marcellus Shale natural gas.

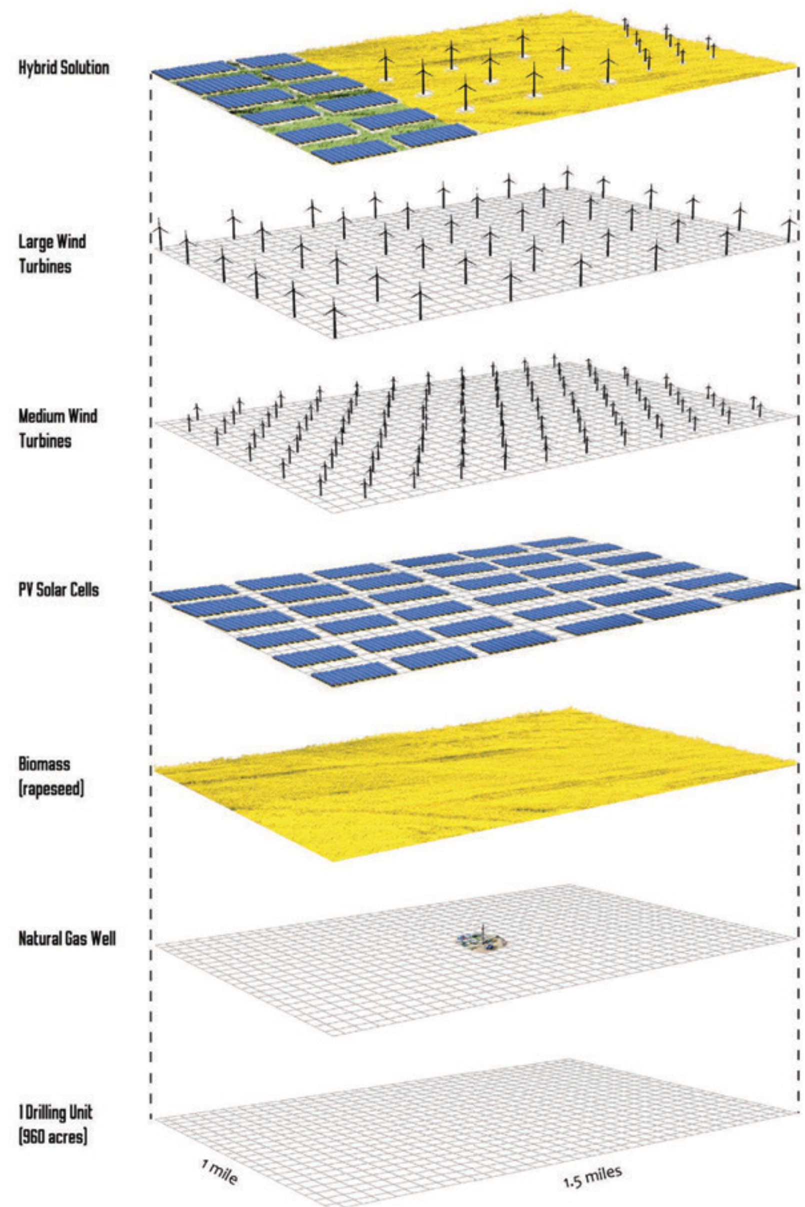
However, the reinvestment of these capital gains from Marcellus Shale into the initial investment of alternatives can transform short-term capital gains into a sustainable long-term investment.



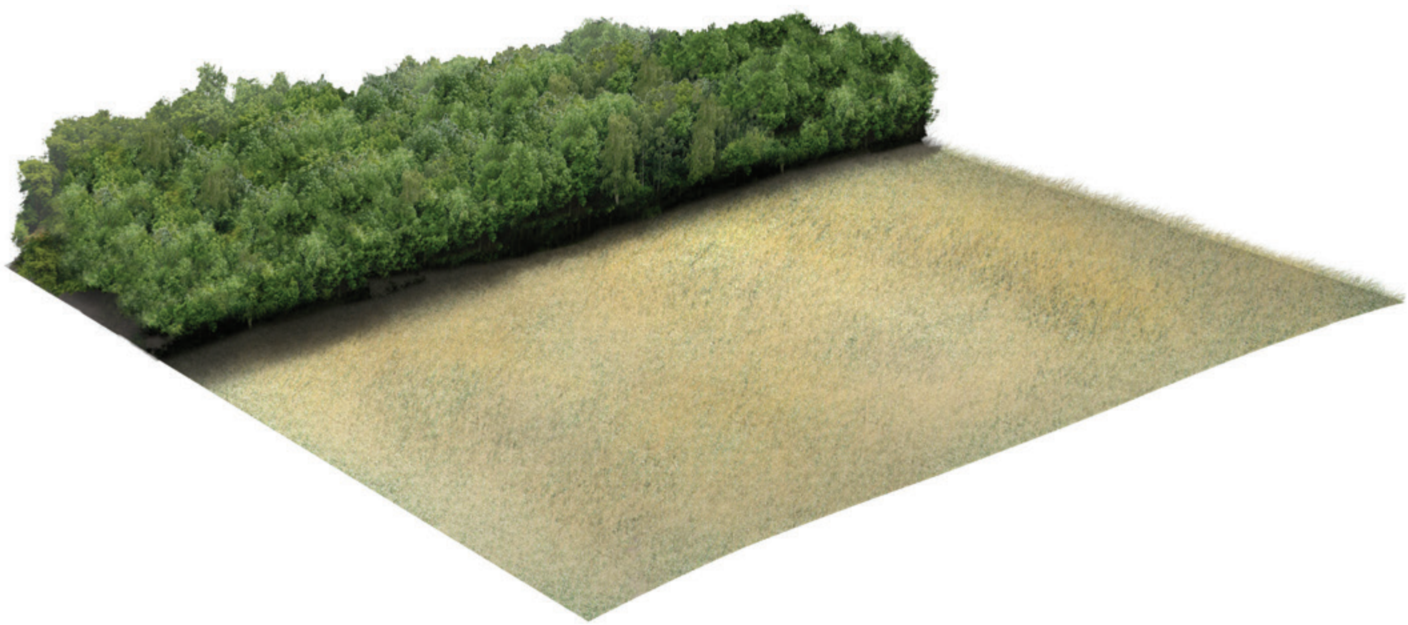
HYBRIDIZATION OF FLEXIBLE SYSTEMS

A typical Marcellus Natural Gas drilling unit consists of an area measuring roughly 1.5 miles x 1 mile. A single Natural Gas drill pad can support up to eight individual horizontal wells. Because of this, the typical 5 acre drill pad actually has a significantly larger subterranian footprint.

This large amount of area can support massive amounts of alternative energies. However, implementing singular forms of alternative energies may be expensive and proper amounts of suitable land may not exist, we propose that variable renewable energies be combined in order to for a hybrid system of energy production.



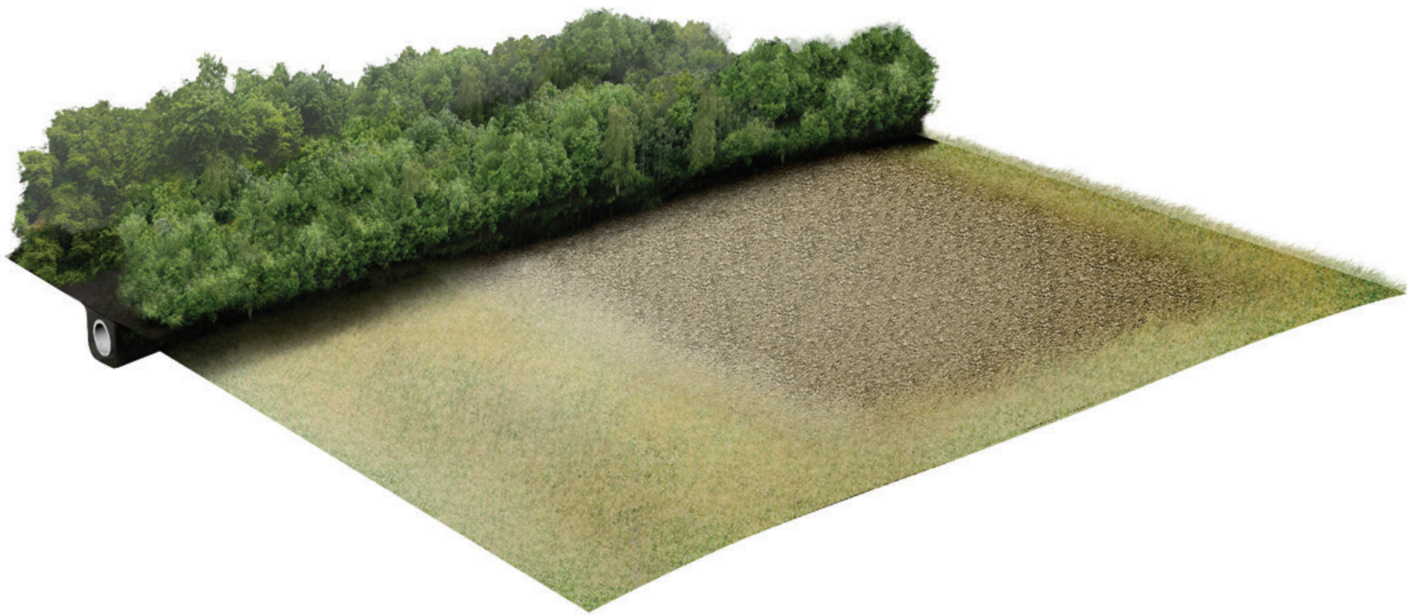
HYBRID APPROACH



15 ACRE EXAMPLE SITE

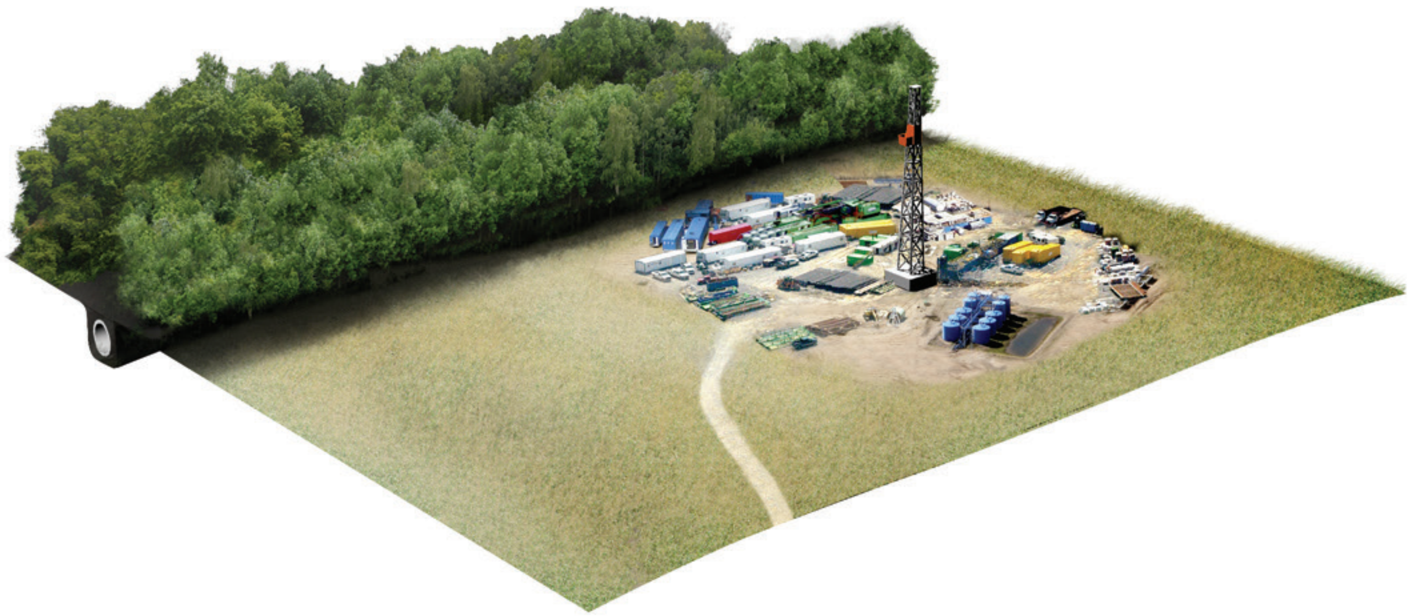
A fallow field site that has been previously identified as having alternative energy potential

HYBRID APPROACH



NATURAL GAS INFRASTRUCTURE
Pipeline, deforestation earth moving and well pad construction

HYBRID APPROACH



NATURAL GAS DEVELOPMENT
Access road installed, well drilled, pad occupied by machinery

HYBRID APPROACH

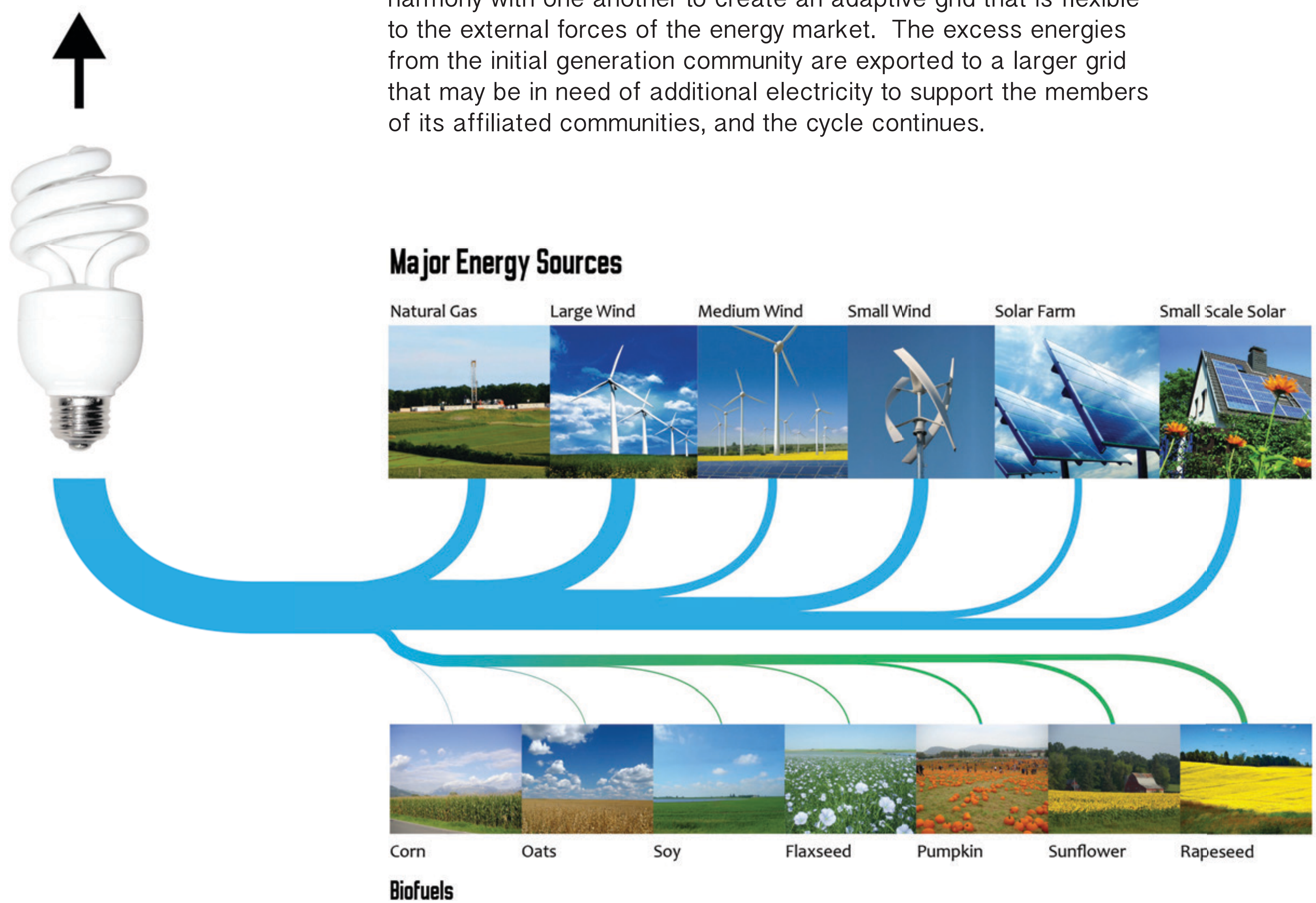
LAND CONVERSION

cap well, reduce size of well pad, install alternative energy sources (wind, solar), reclaim land with high yield biofuels (rapeseed, sunflower) and re-use gas infrastructure for smart grid deployment

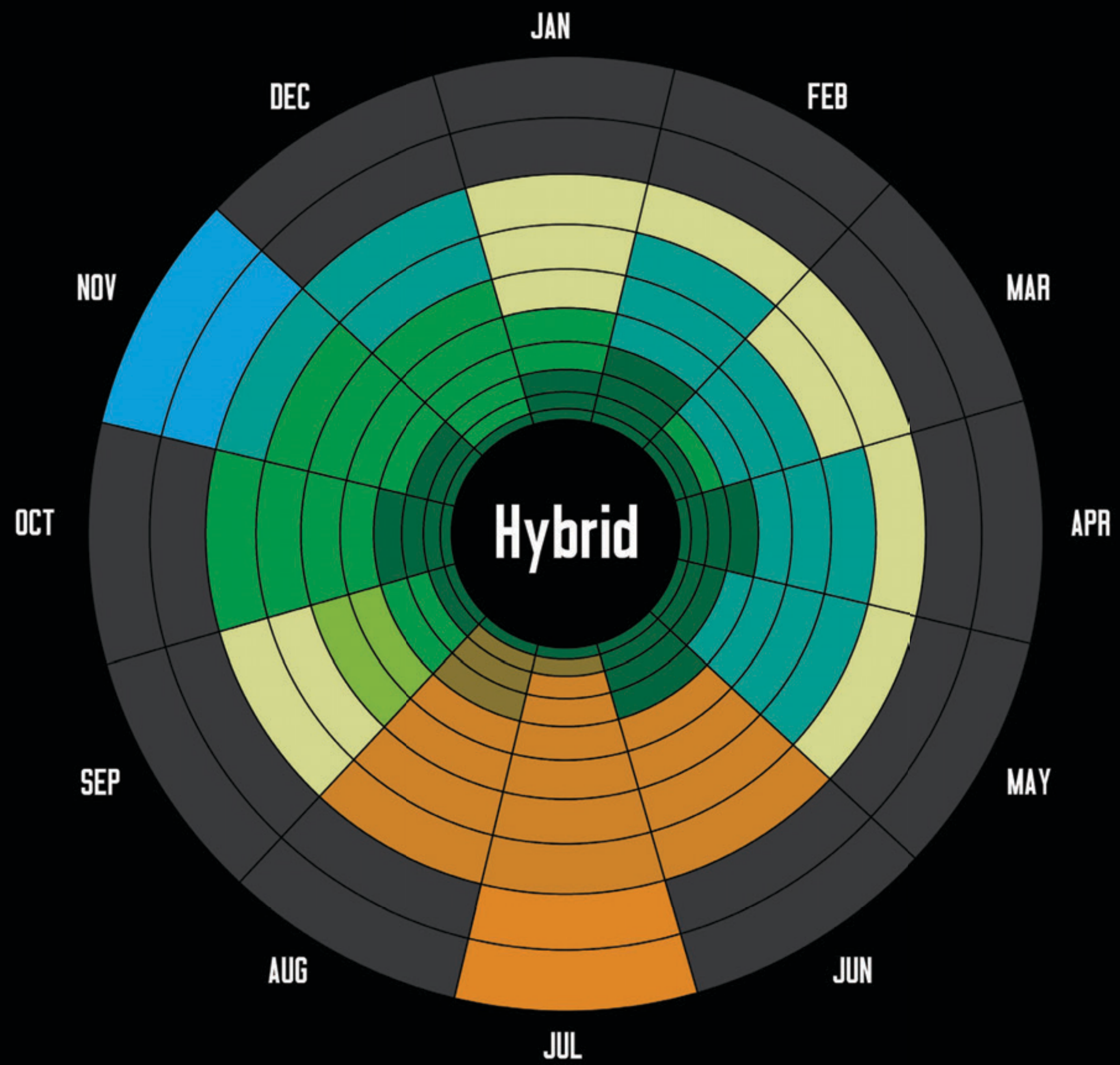
ENERGY FLOW

With a future smart grid, all of these energy resources can work in harmony with one another to create an adaptive grid that is flexible to the external forces of the energy market. The excess energies from the initial generation community are exported to a larger grid that may be in need of additional electricity to support the members of its affiliated communities, and the cycle continues.

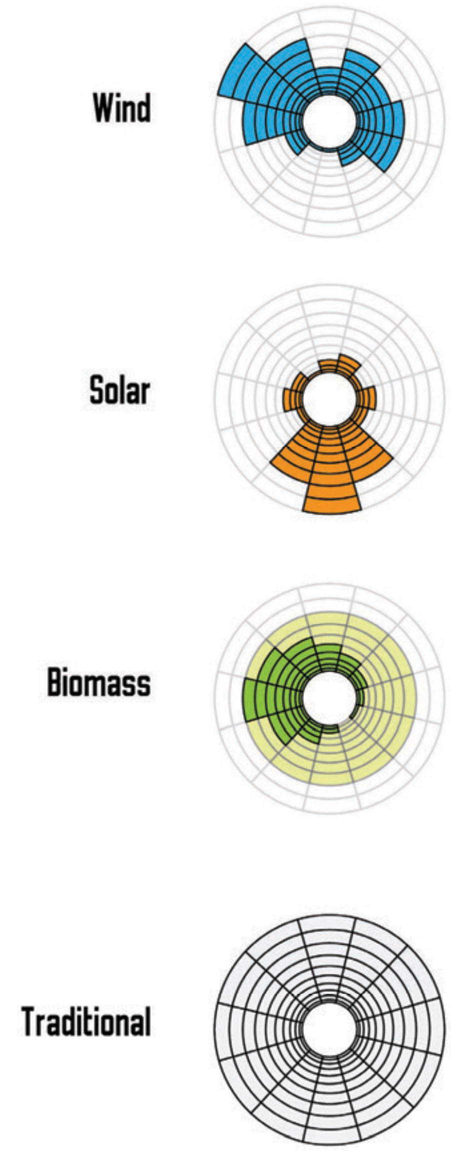
Excess to Grid



ANNUAL ENERGY POTENTIAL

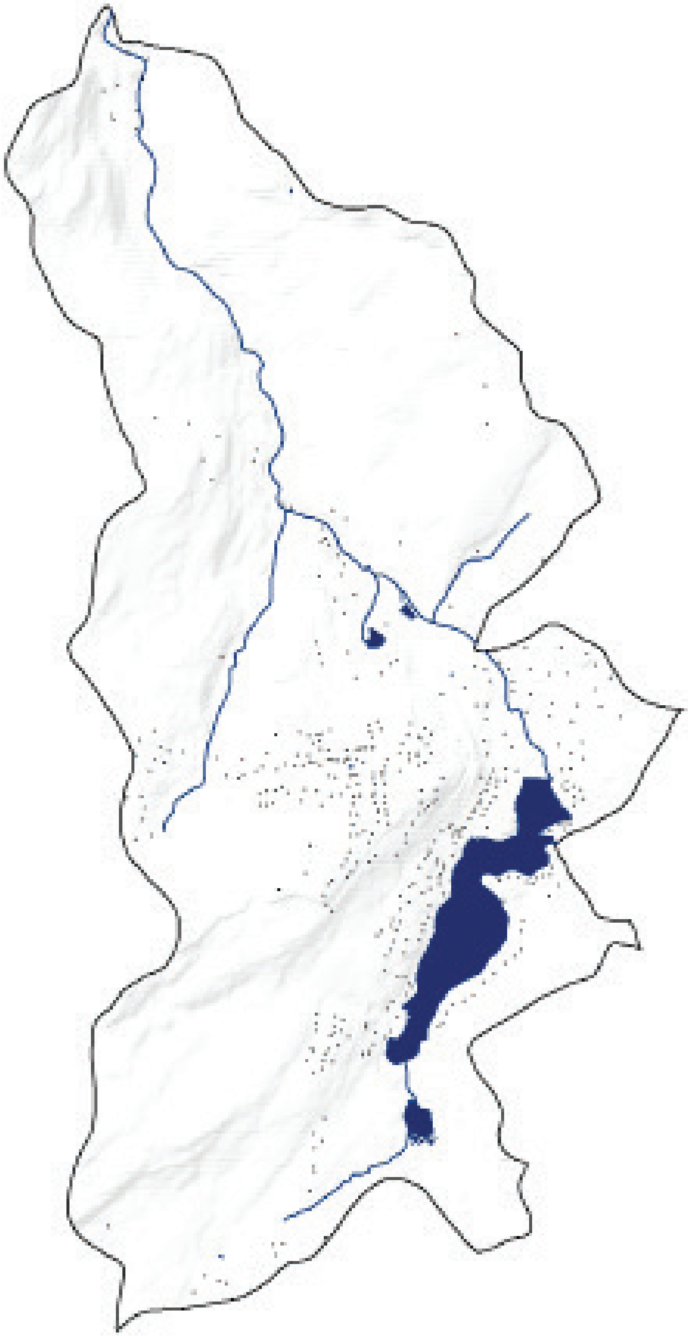


Seasonal Potential

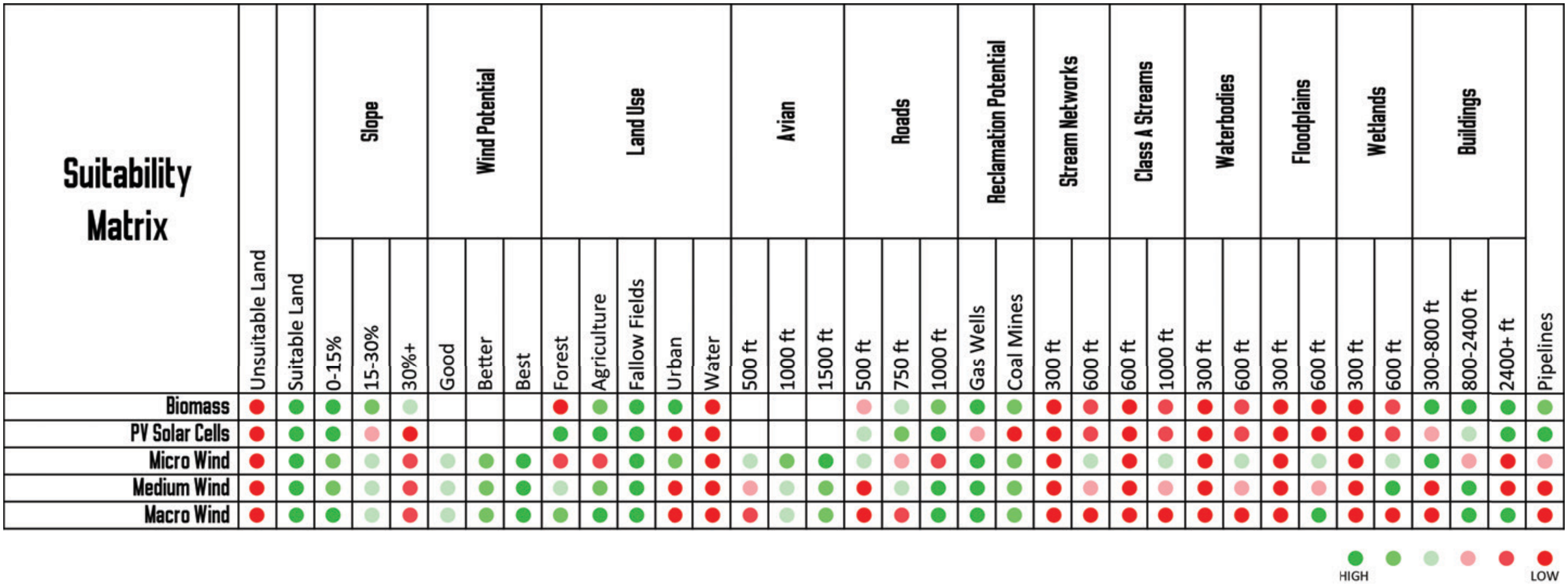


LAKE MOKOMA

Lake Mokoma is a seasonal community located within Sullivan County who leased their land for natural gas development in order to pay for the reconstruction of their dam. Many residents expressed concerns that gas development may overshadow the picturesque surrounding landscape.

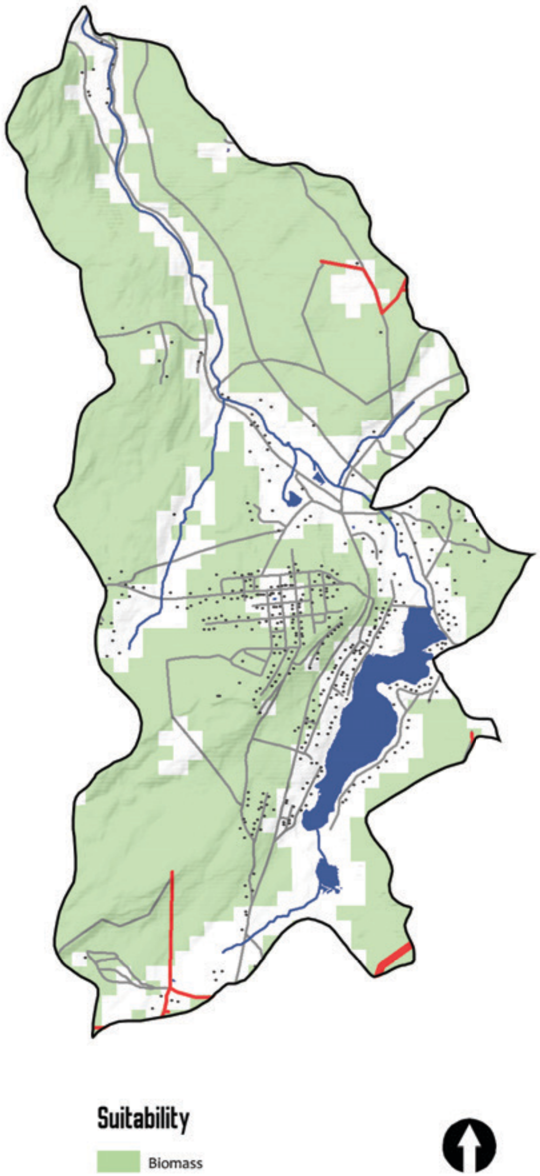


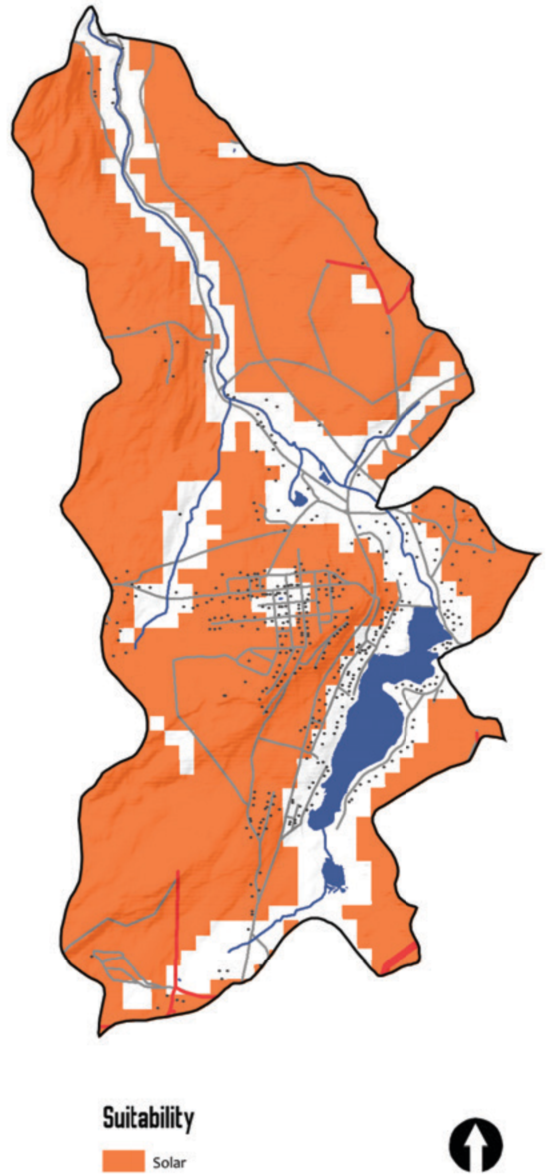
SUITABILITY ANALYSIS

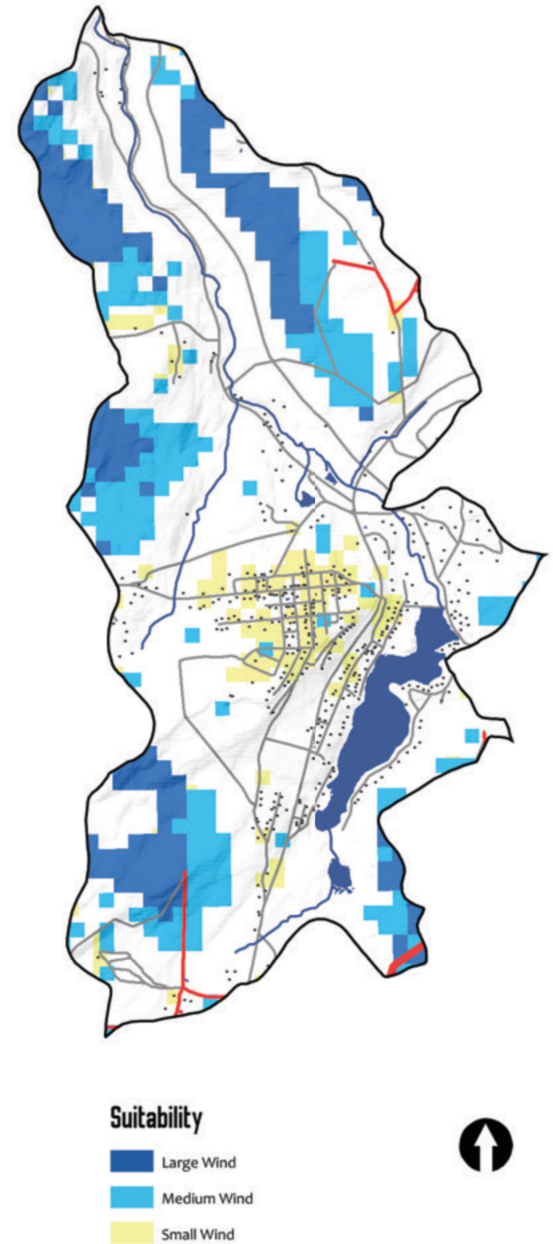


The table above illustrates our design process and the parameters that were used to create the suitability analyses for the various scales of this project.
Green represents parameters in which the source of energy is suitable and red represents the parameters that are less suitable for the implementation of various alternative energies.

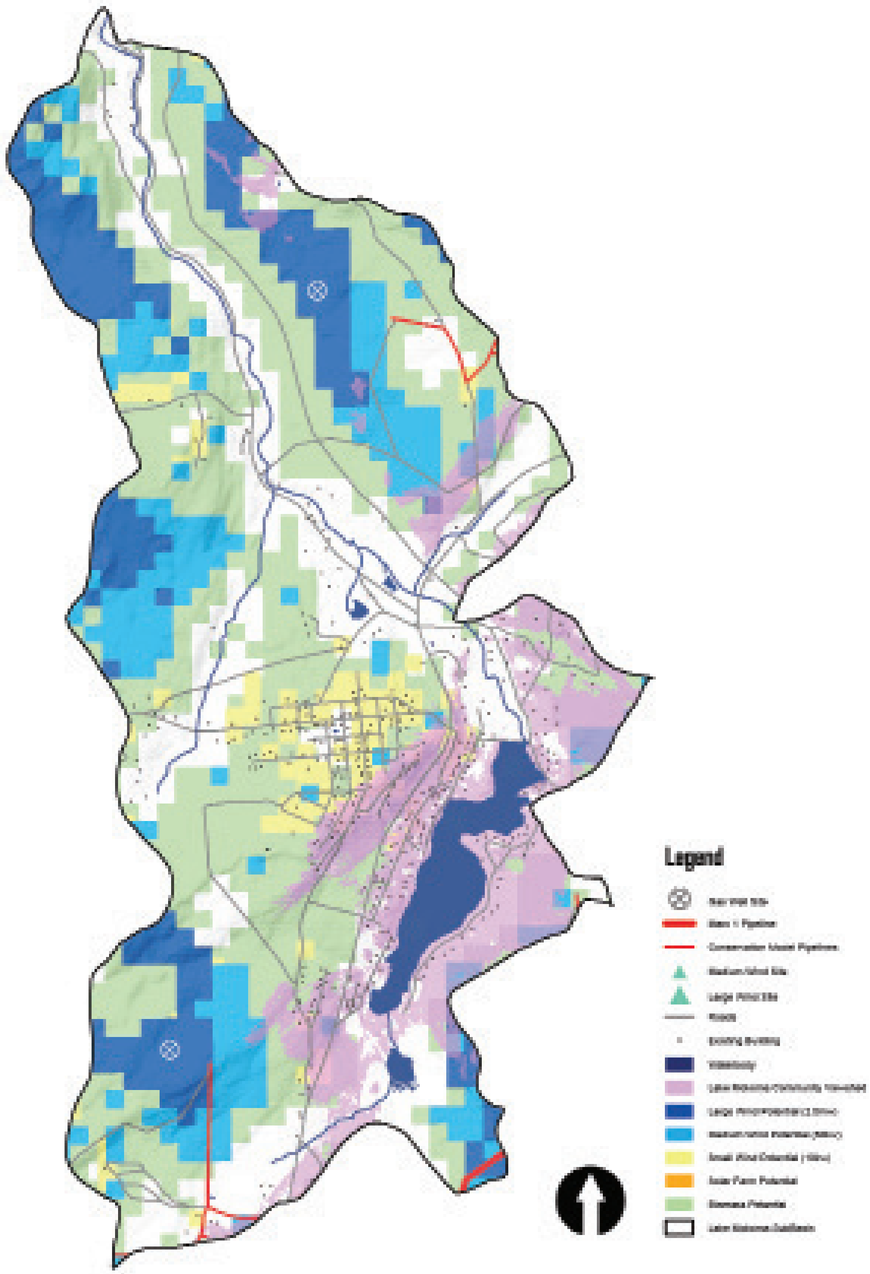
SUITABILITY ANALYSIS







PLANNED IMPLEMENTATION



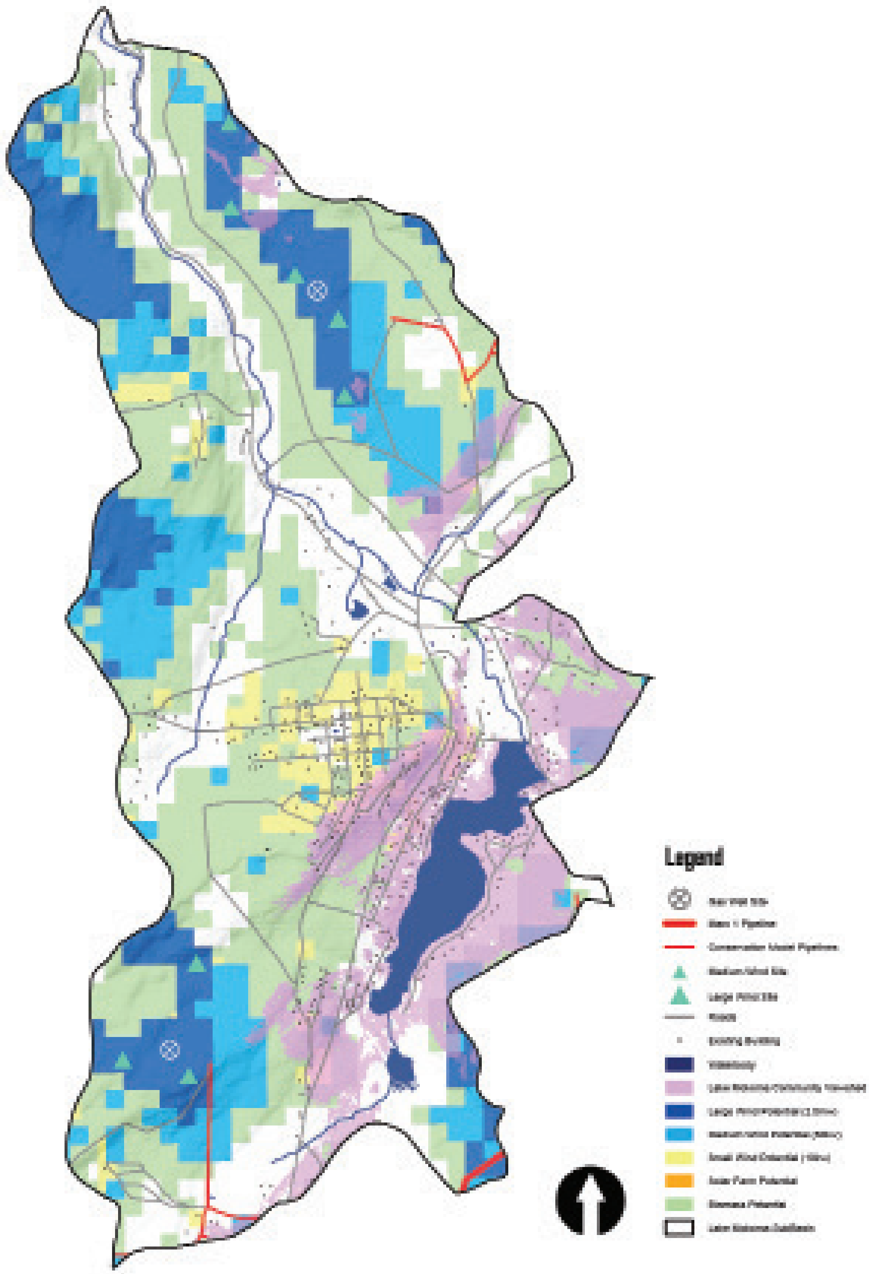
Drill Reclaim Expand

To accomplish a flexible energy future Marcellus Shale development is being used as a catalyst for future green energy development.

The adaptive placement and planning of Marcellus wells within suitable alternative energy areas is key to they success of the future implementation of alternatives.

A single Marcellus gas well occupies a larger area of land compared to singular alternative energies such as wind or solar.

PLANNED IMPLEMENTATION

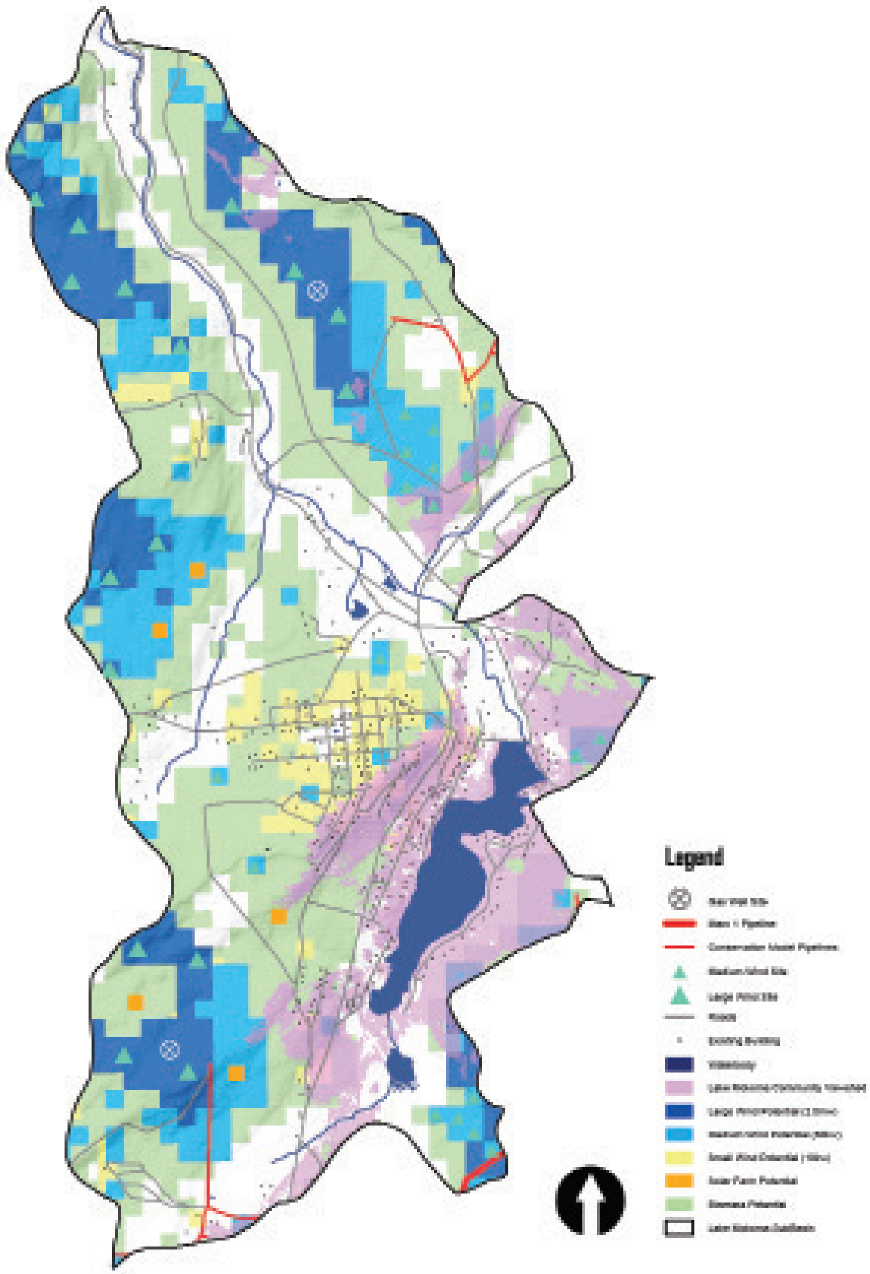


Drill Reclaim Expand

This map identifies sites that have the potential to support large scale wind energies on land that was used for Marcellus natural gas drilling.

Two areas that were previously identifies as having high wind suitability were drilled for natural gas. These wells are then capped and the land can be reclaimed while implementing large scale wind turbines and varying biomass production at the ground level.

PLANNED IMPLEMENTATION



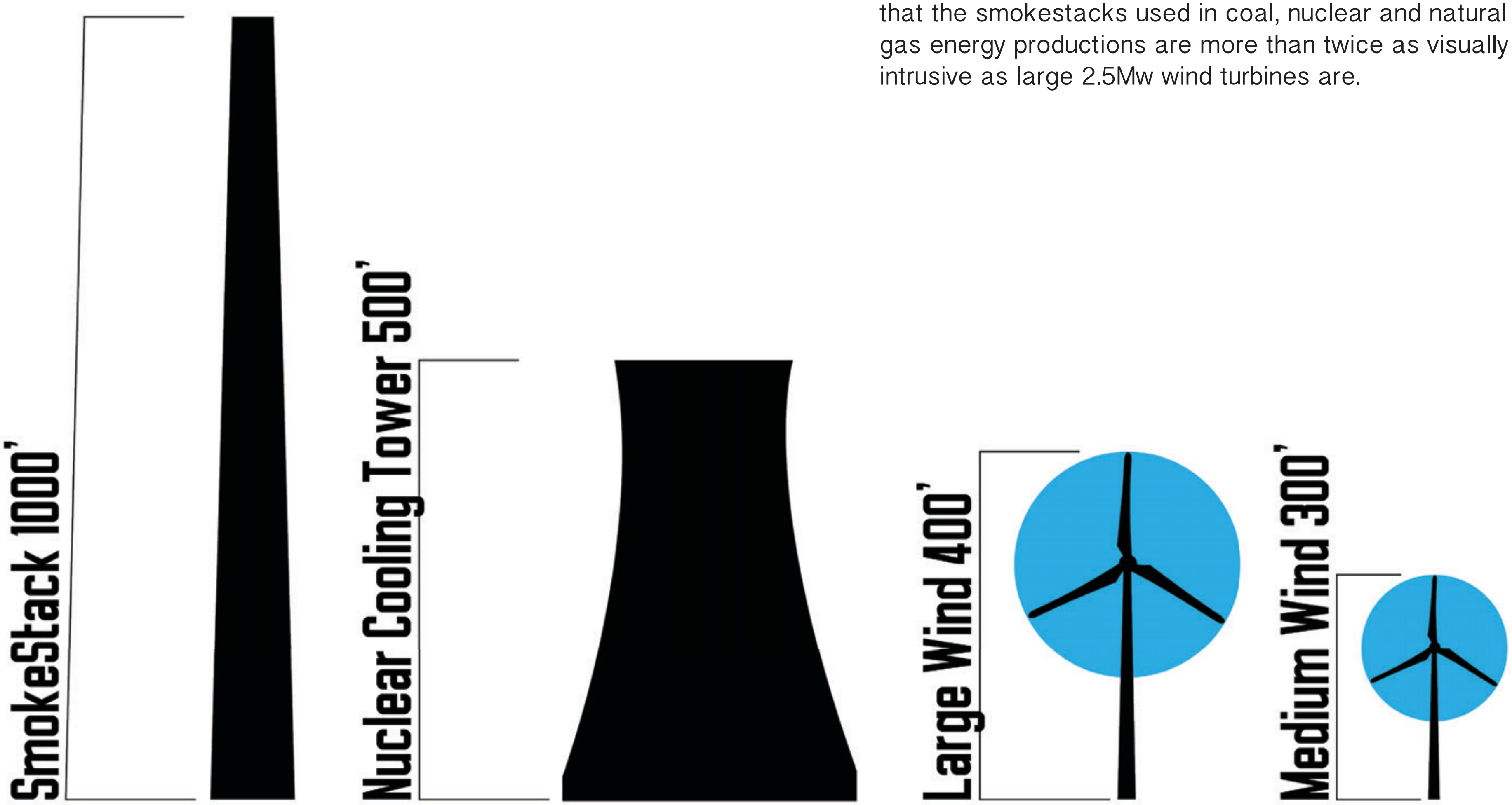
Drill Reclaim **Expand**

Following the initial reclamation process, alternative energy sources will be expanded using the original reclaimed sites as starting points.

This development on suitable sites will create a large network of power stations throughout region, providing an adaptive, flexible energy framework that can supply power to thousands of people.

VISUAL IMPACT - SCALE

The common misconception is that all wind turbines are more visually intrusive than other sources of energies used throughout the United States. This image illustrates the various heights of towers used in the energy generation process. It is clearly noticeable that the smokestacks used in coal, nuclear and natural gas energy productions are more than twice as visually intrusive as large 2.5Mw wind turbines are.



VISUAL IMPACT

Before

After

VISUAL IMPACT

Before

After

LARGE SCALE OPPORTUNITIES

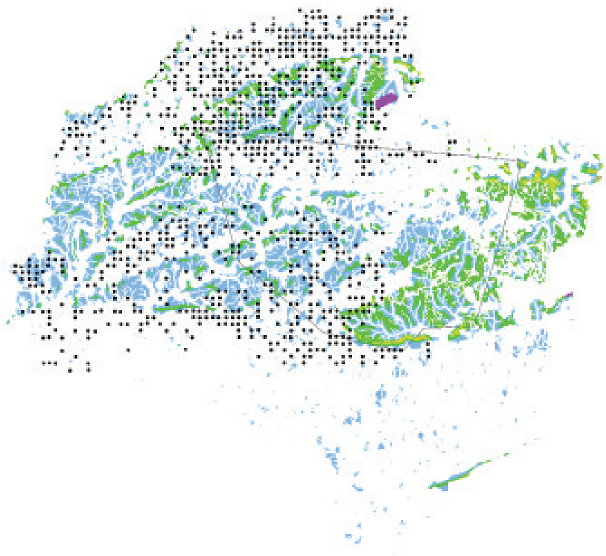
PA Act 13 Drillable Area

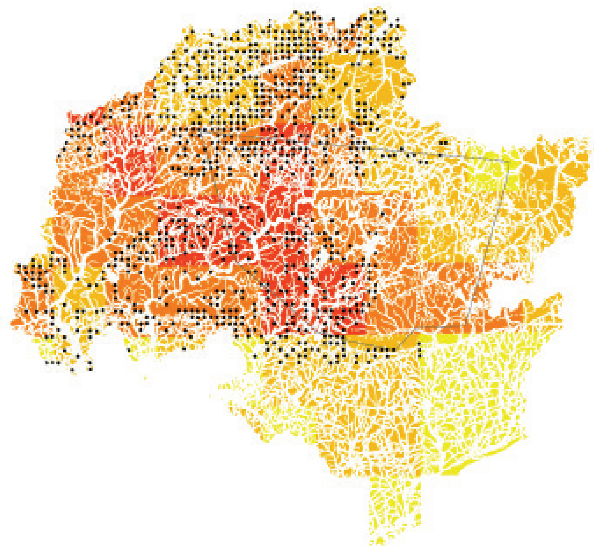
The following map shows the vast areas that can be drilled for Marcellus Gas within the eight watersheds that make up Sullivan County.

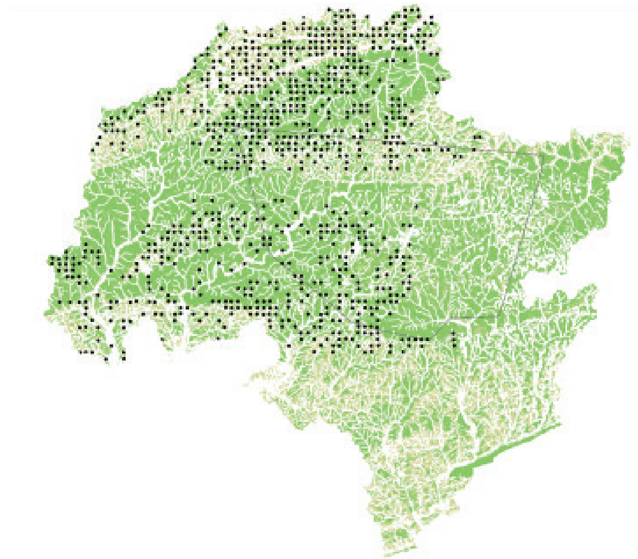
In order to create this suitability map , existing data from the Pennsylvania Act 13 that specifies the offset requirements of areas that are to be drilled was used.

These requirements were then expanded to match stricter guidelines used for the implementation of alternative energies such as offsets from wetlands and floodplains.

LARGE SCALE OPPORTUNITIES







Wind Potential

Wind energies can be implemented in select areas within the eight watersheds that make up Sullivan County.

Blue identifies areas that can support wind energy development while the green, yellow and red areas identify areas with significant wind energy potential. Purple points note the current placement of wind energies.

Black points identify Nature Conservancy projected natural gas well locations.

Solar Potential

Solar energies can be implemented across a wide range of the eight watersheds that make up Sullivan County.

A color ramp ranging from red to yellow identifies areas that have a high (yellow) or low (red) wind potential.

Black points identify Nature Conservancy projected natural gas well locations.

Biomass Potential

Biomass can be implemented across a wide range of the eight watersheds that make up Sullivan County.

Green identifies areas that are suitable for woody biomass production while tan identifies areas that are suitable for agricultural biomass production.

Black points identify Nature Conservancy projected natural gas well locations.

BENEFITS + CONCLUSIONS

Natural Gas development can be used as a catalyst for the establishment of a future green energy framework. This project illustrates that alternative energy expansion can come from the most unlikely of sources and situations.

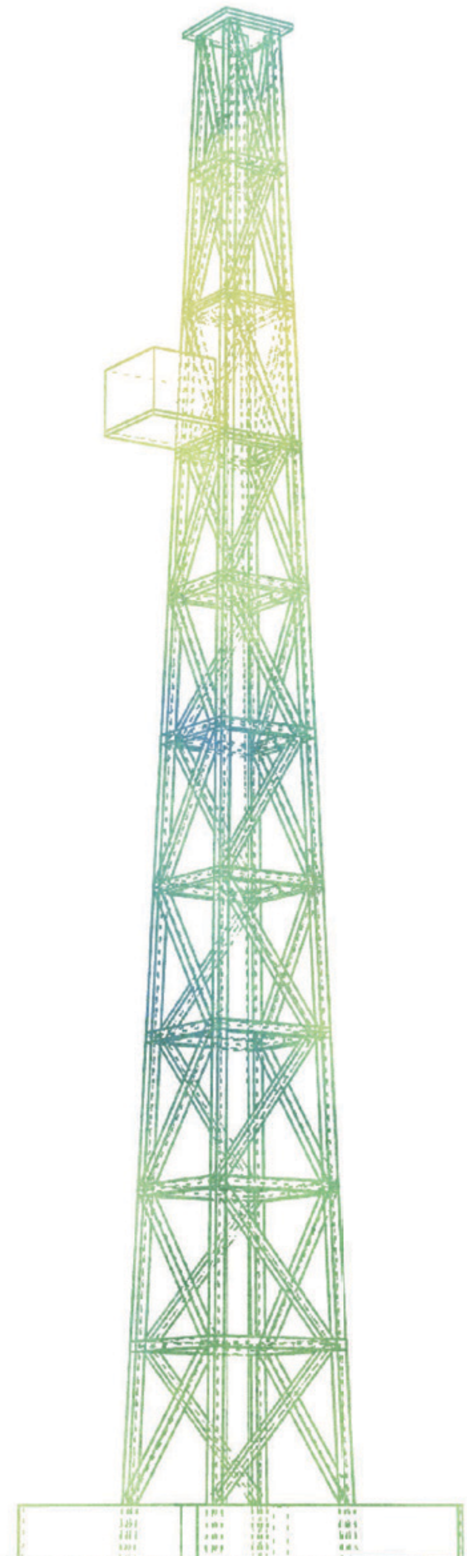
Currently the energy market is driven by external forces such as: politics, varying supply / demand, rising source costs and an inconsistent system of environmental regulations. The current system is static and does not adapt effectively to changing external pressures.

A paradigm shift in the way we view the energy system must occur from all sides and scales in order for a system such as this to flourish. However, the use of natural gas development as a driver for alternative energies could help to open one's eyes.

Through the implementation of a variable renewable energy framework based upon a hierarchial smart grid, energy production, distribution and consumption can respond to varying market conditions and external forces.

We must re-evaluate our energy source priorities based on suitable land use instead of political agendas. There are ample opprotunities for rapeseed (producing roughly 11x more energy than corn) and wind energy (having little visual impact upon the landscape if land is evaluated and identified based on community and environmental values).

The flexible system of the future can start with smart Marcellus planning, development and reinvestment. If we plan a better today, we can create a sustainable tomorrow.



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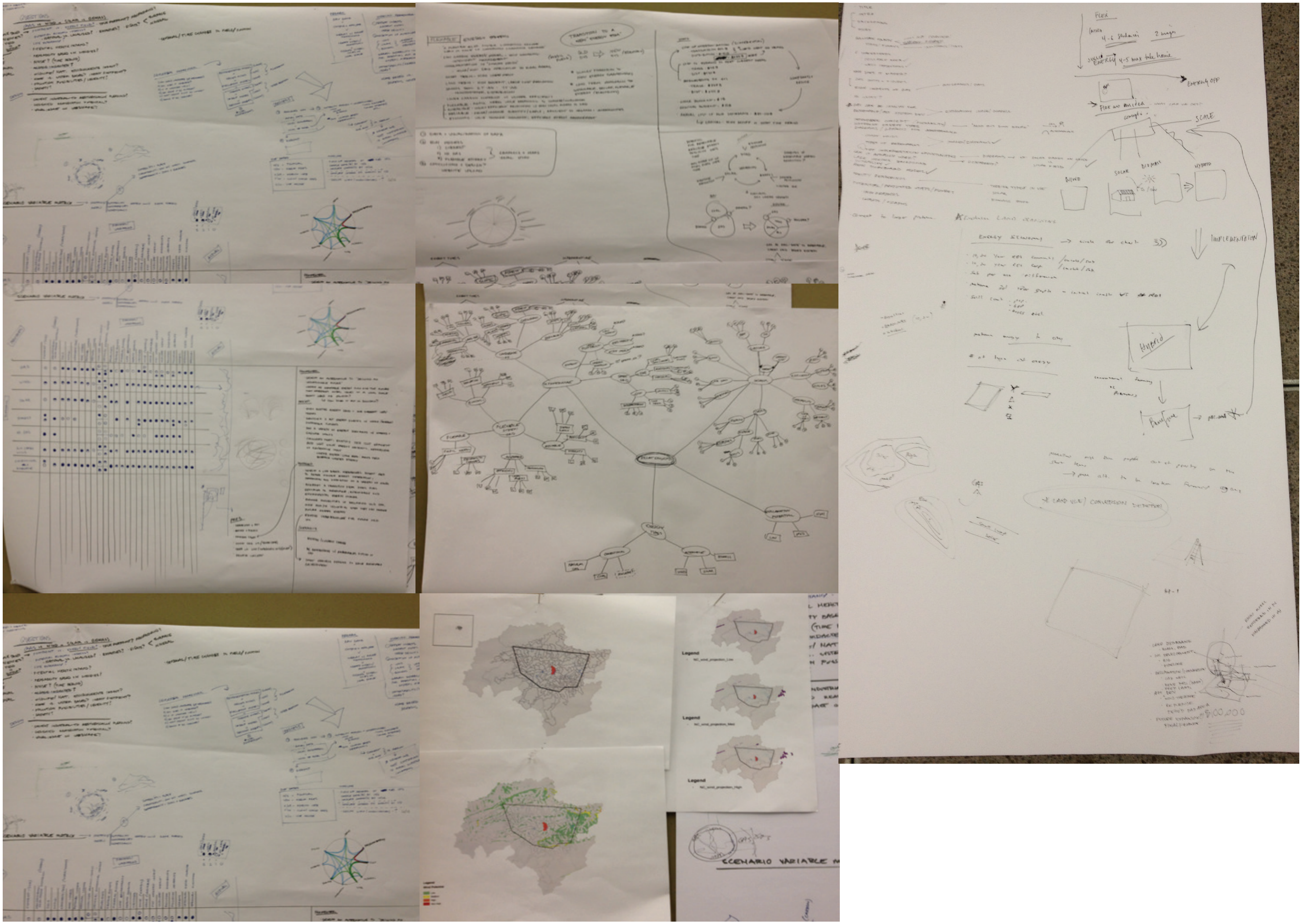
TABLES

8 Watersheds	Acres Available	Acres Needed/Unit	Number of Units	Capacity Used	kWh/Year/Unit	Annual kWh	Production Cost/kWh	Market Value ($)/kWh	Initial Investment/Unit	Total Investment	Gross Annual Earnings	Gross Annual Royalties (12.5%)	Net Earnings (10 Years)	Net Earnings (20 years)	Royalty Based Net Earnings (10 Years)	Royalty Based Net Earnings (20 Years)	Initial Investment Subsidy	Subsidised Total Investment	kWh Subsidy	Subsidised Gross Annual Earnings	Subsidised Gross Annual Royalties (12.5%)	Subsidized Net Earnings (10 Years)	Subsidised Net Earnings (20 years)	Subsidised Royalty Based Net Earnings (10 Years)	Subsidised Royalty Based Net Earnings (20 Years)
Natural Gas																									
Horizontal Deep Well	1112463.89	2010	553.4646219	100%	225360000	1.24729E+11	$ 0.04	$ 0.13	$ 7,600,000.00	$ 4,206,331,126.37	$ 11,225,590,847.03	$ 1,403,198,855.88	$ 108,049,577,343.96	$ 220,305,485,814.29	$ 94,017,588,785.17	$ 192,241,508,696.71		$ 4,206,331,126.37	$ -	$ 11,225,590,847.03	$ 1,403,198,855.88	$ 119,275,168,190.99	$ 332,561,394,284.62	$ 105,243,179,632.20	$ 304,497,417,167.04
Biomass																									
Rapeseed	864244.58	1	864244.58	100%	4111.4	3553255166	$ 0.05	$ 0.13	$ 473.16	$ 408,925,965.47	$ 277,153,902.96	$ 34,644,237.87	$ 2,362,613,064.17	$ 5,134,152,093.82	$ 2,016,170,685.47	$ 4,441,267,336.41		$ 408,925,965.47	$ 0.011	$ 316,239,709.79	$ 39,529,963.72	$ 2,678,852,773.97	$ 8,296,549,191.75	$ 2,283,553,136.72	$ 7,505,949,917.26
Sunflower	864244.58	1	864244.58	100%	3302.6	2854254150	$ 0.05	$ 0.13	$ 396.91	$ 343,027,316.25	$ 222,631,823.69	$ 27,828,977.96	$ 1,883,290,920.68	$ 4,109,609,157.61	$ 1,605,001,141.06	$ 3,553,029,598.38		$ 343,027,316.25	$ 0.011	$ 254,028,619.34	$ 31,753,577.42	$ 2,137,319,540.02	$ 6,649,895,351.03	$ 1,819,783,765.84	$ 6,014,823,802.67
Pumpkin Seed	864244.58	1	864244.58	100%	1853.5	1601877329	$ 0.05	$ 0.13	$ 1,785.00	$ 1,542,676,575.30	$ 124,946,431.66	$ 15,618,303.96	$ (293,212,258.66)	$ 956,252,057.99	$ (449,395,298.24)	$ 643,885,978.83		$ 1,542,676,575.30	$ 0.011	$ 142,567,082.28	$ 17,820,885.29	$ (150,645,176.37)	$ 2,381,922,880.82	$ (328,854,029.23)	$ 2,025,505,175.11
Flaxseed	864244.58	1	864244.58	100%	1651.3	1427127075	$ 0.05	$ 0.13	$ 336.59	$ 290,896,083.18	$ 111,315,911.85	$ 13,914,488.98	$ 822,263,035.28	$ 1,935,422,153.75	$ 683,118,145.47	$ 1,657,132,374.13		$ 290,896,083.18	$ 0.011	$ 127,014,309.67	$ 15,876,788.71	$ 949,277,344.95	$ 3,205,565,250.46	$ 790,509,457.86	$ 2,888,029,476.28
Soybeans	864244.58	1	864244.58	100%	1550.2	1339751948	$ 0.05	$ 0.13	$ 349.63	$ 302,165,832.51	$ 104,500,651.94	$ 13,062,581.49	$ 742,840,686.87	$ 1,787,847,206.24	$ 612,214,871.95	$ 1,526,595,576.40		$ 302,165,832.51	$ 0.011	$ 119,237,923.36	$ 14,904,740.42	$ 862,078,610.23	$ 2,980,226,439.89	$ 713,031,206.03	$ 2,682,131,631.48
Oats	864244.58	1	864244.58	100%	741.4	640750931.6	$ 0.05	$ 0.13	$ 336.88	$ 291,146,714.11	$ 49,978,572.67	$ 6,247,321.58	$ 208,639,012.55	$ 708,424,739.20	$ 146,165,796.71	$ 583,478,307.54		$ 291,146,714.11	$ 0.011	$ 57,026,832.91	$ 7,128,354.11	$ 265,665,845.46	$ 1,278,693,068.34	$ 194,382,304.32	$ 1,136,125,986.06
Corn	864244.58	1	864244.58	100%	606.6	524250762.2	$ 0.05	$ 0.13	$ 536.41	$ 463,589,435.16	$ 40,891,559.45	$ 5,111,444.93	$ (54,673,840.62)	$ 354,241,753.92	$ (105,788,289.94)	$ 252,012,855.28		$ 463,589,435.16	$ 0.011	$ 46,658,317.84	$ 5,832,289.73	$ (8,015,522.78)	$ 820,824,932.30	$ (66,338,420.08)	$ 704,179,137.71
Wind																									
2.5 MW	272177.03	22	12371.68318	30%	6570000	81281958505	$ 0.05	$ 0.13	$ 1,980,000.00	$ 24,495,932,700.00	$ 6,502,556,680.36	$ 812,819,585.05	$ 40,529,634,103.64	$ 105,555,200,907.27	$ 32,401,438,253.18	$ 89,298,809,206.36	25%	$ 18,371,949,525.00	$ 0.022	$ 8,290,759,767.46	$ 1,036,344,970.93	$ 54,944,377,046.10	$ 194,586,781,756.91	$ 44,580,927,336.77	$ 173,859,882,338.25
50 KW	378493.71	11	34408.51909	30%	131400	4521279409	$ 0.05	$ 0.13	$ 99,000.00	$ 3,406,443,390.00	$ 361,702,352.68	$ 45,212,794.09	$ 210,580,136.84	$ 3,827,603,663.67	$ (241,547,804.02)	$ 2,923,347,781.96	30%	$ 2,384,510,373.00	$ 0.022	$ 461,170,499.67	$ 57,646,312.46	$ 1,693,683,653.51	$ 9,461,241,677.39	$ 1,117,220,528.92	$ 8,308,315,428.21
10 KW	195662.78	0.5	391325.56	30%	26280	10284035717	$ 0.05	$ 0.13	$ 19,800.00	$ 7,748,246,088.00	$ 822,722,857.34	$ 102,840,357.17	$ 478,982,485.44	$ 8,706,211,058.88	$ (549,421,086.24)	$ 6,649,403,915.52	30%	$ 5,423,772,261.60	$ 0.022	$ 1,048,971,643.11	$ 131,121,455.39	$ 3,852,427,954.95	$ 21,520,401,316.42	$ 2,541,213,401.06	$ 18,897,972,208.63
Solar																									
1KW PV Cell	934622.94	0.0038	245953405.3	20%	1752	4.3091E+11	$ 0.11	$ 0.13	$ 3,840.00	$ 944,461,076,210.53	$ 8,618,207,320.42	$ 1,077,275,915.05	$ (858,279,003,006.32)	$ (772,096,929,802.11)	$ (869,051,762,156.84)	$ (793,642,448,103.16)	30%	$ 661,122,753,347.37	$ 0.022	$ 18,098,235,372.88	$ 2,262,279,421.61	$ (556,842,444,770.27)	$ (307,776,253,210.11)	$ (579,465,238,986.38)	$ (353,021,841,642.32)

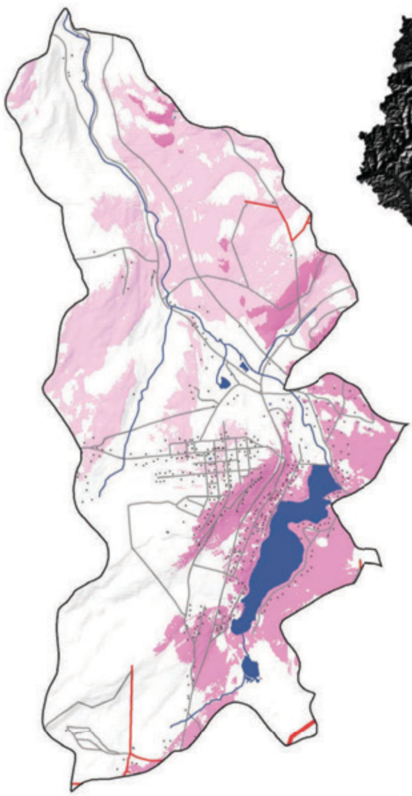
Sullivan County	Acres Available	Acres Needed/Unit	Number of Units	Capacity Used	kWh/Year/Unit	Annual kWh	Production Cost/kWh	Market Value ($)/kWh	Initial Investment/Unit	Total Investment	Gross Annual Earnings	Gross Annual Royalties (12.5%)	Net Earnings (10 Years)	Net Earnings (20 years)	Royalty Based Net Earnings (10 Years)	Royalty Based Net Earnings (20 Years)	Initial Investment Subsidy	Subsidised Total Investment	kWh Subsidy	Subsidised Gross Annual Earnings	Subsidised Gross Annual Royalties (12.5%)	Subsidized Net Earnings (10 Years)	Subsidised Net Earnings (20 years)	Subsidised Royalty Based Net Earnings (10 Years)	Subsidised Royalty Based Net Earnings (20 Years)
Natural Gas																									
Horizontal Deep Well	289380.57	2010	143.9704328	100%	225360000	32445176744	$ 0.04	$ 0.13	$ 7,600,000.00	$ 1,094,175,289.55	$ 2,920,065,906.95	$ 365,008,238.37	$ 28,106,483,779.94	$ 57,307,142,849.43	$ 24,456,401,396.25	$ 50,006,978,082.06		$ 1,094,175,289.55	$ -	$ 2,920,065,906.95	$ 365,008,238.37	$ 31,026,549,686.89	$ 86,507,801,918.93	$ 27,376,467,303.20	$ 79,207,637,151.55
Biomass																									
Rapeseed	219645.1	1	219645.1	100%	4111.4	903048864.1	$ 0.05	$ 0.13	$ 473.16	$ 103,927,275.52	$ 70,437,811.40	$ 8,804,726.43	$ 600,450,838.51	$ 1,304,828,952.54	$ 512,403,574.26	$ 1,128,734,424.04		$ 103,927,275.52	$ 0.011	$ 80,371,348.91	$ 10,046,418.61	$ 680,822,187.42	$ 2,108,542,441.63	$ 580,358,001.29	$ 1,907,614,069.36
Sunflower	219645.1	1	219645.1	100%	3302.6	725399907.3	$ 0.05	$ 0.13	$ 396.91	$ 87,179,336.64	$ 56,581,192.77	$ 7,072,649.10	$ 478,632,591.02	$ 1,044,444,518.68	$ 407,906,100.06	$ 902,991,536.77		$ 87,179,336.64	$ 0.011	$ 64,560,591.75	$ 8,070,073.97	$ 543,193,182.77	$ 1,690,050,436.15	$ 462,492,443.09	$ 1,528,648,956.78
Pumpkin Seed	219645.1	1	219645.1	100%	1853.5	407112192.9	$ 0.05	$ 0.13	$ 1,785.00	$ 392,066,503.50	$ 31,754,751.04	$ 3,969,343.88	$ (74,518,993.08)	$ 243,028,517.35	$ (114,212,431.88)	$ 163,641,639.74		$ 392,066,503.50	$ 0.011	$ 36,232,985.16	$ 4,529,123.15	$ (38,286,007.91)	$ 605,358,368.98	$ (83,577,239.37)	$ 514,775,906.07
Flaxseed	219645.1	1	219645.1	100%	1651.3	362699953.6	$ 0.05	$ 0.13	$ 336.59	$ 73,930,344.21	$ 28,290,596.38	$ 3,536,324.55	$ 208,975,619.62	$ 491,881,583.45	$ 173,612,374.14	$ 421,155,092.50		$ 73,930,344.21	$ 0.011	$ 32,280,295.87	$ 4,035,036.98	$ 241,255,915.50	$ 814,684,542.18	$ 200,905,545.65	$ 733,983,802.50
Soybeans	219645.1	1	219645.1	100%	1550.2	340493834	$ 0.05	$ 0.13	$ 349.63	$ 76,794,516.31	$ 26,558,519.05	$ 3,319,814.88	$ 188,790,674.22	$ 454,375,864.76	$ 155,592,525.41	$ 387,979,567.12		$ 76,794,516.31	$ 0.011	$ 30,303,951.23	$ 3,787,993.90	$ 219,094,625.45	$ 757,415,377.04	$ 181,214,686.42	$ 681,655,498.97
Oats	219645.1	1	219645.1	100%	741.4	162844877.1	$ 0.05	$ 0.13	$ 336.88	$ 73,994,041.29	$ 12,701,900.42	$ 1,587,737.55	$ 53,024,962.88	$ 180,043,967.05	$ 37,147,587.36	$ 148,289,216.01		$ 73,994,041.29	$ 0.011	$ 14,493,194.07	$ 1,811,649.26	$ 67,518,156.95	$ 324,975,907.71	$ 49,401,664.36	$ 288,742,922.54
Corn	219645.1	1	219645.1	100%	606.6	133236717.7	$ 0.05	$ 0.13	$ 536.41	$ 117,819,828.09	$ 10,392,463.98	$ 1,299,058.00	$ (13,895,188.32)	$ 90,029,451.46	$ (26,885,768.29)	$ 64,048,291.51		$ 117,819,828.09	$ 0.011	$ 11,858,067.87	$ 1,482,258.48	$ (2,037,120.44)	$ 208,610,130.18	$ (16,859,705.28)	$ 178,964,960.50
Wind																									
2.5 MW	88077.11	22	4003.505	30%	6570000	26303027850	$ 0.05	$ 0.13	$ 1,980,000.00	$ 7,926,939,900.00	$ 2,104,242,228.00	$ 263,030,278.50	$ 13,115,482,380.00	$ 34,157,904,660.00	$ 10,485,179,595.00	$ 28,897,299,090.00	25%	$ 5,945,204,925.00	$ 0.022	$ 2,682,908,840.70	$ 335,363,605.09	$ 17,780,126,195.70	$ 62,968,728,042.00	$ 14,426,490,144.83	$ 56,261,455,940.25
50 KW	84088.27	11	7644.388182	30%	131400	1004472607	$ 0.05	$ 0.13	$ 99,000.00	$ 756,794,430.00	$ 80,357,808.57	$ 10,044,726.07	$ 46,783,655.67	$ 850,361,741.35	$ (53,663,605.04)	$ 649,467,219.93	30%	$ 529,756,101.00	$ 0.022	$ 102,456,205.92	$ 12,807,025.74	$ 376,278,190.60	$ 2,101,962,129.58	$ 248,207,933.19	$ 1,845,821,614.77
10 KW	46493.99	0.5	92987.98	30%	26280	2443724114	$ 0.05	$ 0.13	$ 19,800.00	$ 1,841,162,004.00	$ 195,497,929.15	$ 24,437,241.14	$ 113,817,287.52	$ 2,068,796,579.04	$ (130,555,123.92)	$ 1,580,051,756.16	30%	$ 1,288,813,402.80	$ 0.022	$ 249,259,859.67	$ 31,157,482.46	$ 915,425,748.39	$ 5,113,743,776.93	$ 603,850,923.80	$ 4,490,594,127.76
Solar																									
1KW PV Cell	232612.63	0.0038	61213850	20%	1752	1.07247E+11	$ 0.11	$ 0.13	$ 3,840.00	$ 235,061,184,000.00	$ 2,144,933,304.00	$ 268,116,663.00	$ (213,611,850,960.00)	$ (192,162,517,920.00)	$ (216,293,017,590.00)	$ (197,524,851,180.00)	30%	$ 164,542,828,800.00	$ 0.022	$ 4,504,359,938.40	$ 563,044,992.30	$ (138,589,135,821.60)	$ (76,600,563,336.00)	$ (144,219,585,744.60)	$ (87,861,463,182.00)

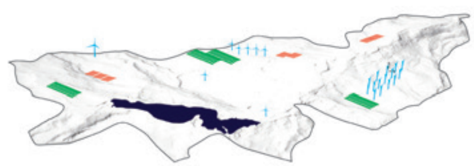
Lake Mokoma	Acres Available	Acres Needed/Unit	Number of Units	Capacity Used	kWh/Year/Unit	Annual kWh	Production Cost/kWh	Market Value ($)/kWh	Initial Investment/Unit	Total Investment	Gross Annual Earnings	Gross Annual Royalties (12.5%)	Net Earnings (10 Years)	Net Earnings (20 years)	Royalty Based Net Earnings (10 Years)	Royalty Based Net Earnings (20 Years)	Initial Investment Subsidy	Subsidised Total Investment	kWh Subsidy	Subsidised Gross Annual Earnings	Subsidised Gross Annual Royalties (12.5%)	Subsidized Net Earnings (10 Years)	Subsidised Net Earnings (20 years)	Subsidised Royalty Based Net Earnings (10 Years)	Subsidised Royalty Based Net Earnings (20 Years)
Natural Gas																									
Horizontal Deep Well	3522.99	2010	1.752731343	100%	225360000	394995535.5	$ 0.04	$ 0.13	$ 7,600,000.00	$ 13,320,758.21	$ 35,549,598.20	$ 4,443,699.77	$ 342,175,223.76	$ 697,671,205.73	$ 297,738,226.01	$ 608,797,210.24		$ 13,320,758.21	$ -	$ 35,549,598.20	$ 4,443,699.77	$ 377,724,821.96	$ 1,053,167,187.70	$ 333,287,824.21	$ 964,293,192.21
Biomass																									
Rapeseed	2397.71	1	2397.71	100%	4111.4	9857944.894	$ 0.05	$ 0.13	$ 473.16	$ 1,134,500.46	$ 768,919.70	$ 96,114.96	$ 6,554,696.55	$ 14,243,893.57	$ 5,593,546.93	$ 12,321,594.32		$ 1,134,500.46	$ 0.011	$ 877,357.10	$ 109,669.64	$ 7,432,053.65	$ 23,017,464.53	$ 6,335,357.28	$ 20,824,071.79
Sunflower	2397.71	1	2397.71	100%	3302.6	7918677.046	$ 0.05	$ 0.13	$ 396.91	$ 951,675.08	$ 617,656.81	$ 77,207.10	$ 5,224,893.02	$ 11,401,461.12	$ 4,452,822.01	$ 9,857,319.09		$ 951,675.08	$ 0.011	$ 704,762.26	$ 88,095.28	$ 5,929,655.28	$ 18,449,083.69	$ 5,048,702.46	$ 16,687,178.04
Pumpkin Seed	2397.71	1	2397.71	100%	1853.5	4444155.485	$ 0.05	$ 0.13	$ 1,785.00	$ 4,279,912.35	$ 346,644.13	$ 43,330.52	$ (813,471.07)	$ 2,652,970.21	$ (1,246,776.23)	$ 1,786,359.89		$ 4,279,912.35	$ 0.011	$ 395,529.84	$ 49,441.23	$ (417,941.23)	$ 6,608,268.59	$ (912,353.53)	$ 5,619,443.99
Flaxseed	2397.71	1	2397.71	100%	1651.3	3959338.523	$ 0.05	$ 0.13	$ 336.59	$ 807,045.21	$ 308,828.40	$ 38,603.55	$ 2,281,238.84	$ 5,369,522.89	$ 1,895,203.33	$ 4,597,451.87		$ 807,045.21	$ 0.011	$ 352,381.13	$ 44,047.64	$ 2,633,619.97	$ 8,893,334.17	$ 2,193,143.56	$ 8,012,381.35
Soybeans	2397.71	1	2397.71	100%	1550.2	3716930.042	$ 0.05	$ 0.13	$ 349.63	$ 838,311.35	$ 289,920.54	$ 36,240.07	$ 2,060,894.09	$ 4,960,099.52	$ 1,698,493.41	$ 4,235,298.16		$ 838,311.35	$ 0.011	$ 330,806.77	$ 41,350.85	$ 2,391,700.86	$ 8,268,167.26	$ 1,978,192.39	$ 7,441,150.32
Oats	2397.71	1	2397.71	100%	741.4	1777662.194	$ 0.05	$ 0.13	$ 336.88	$ 807,740.54	$ 138,657.65	$ 17,332.21	$ 578,835.97	$ 1,965,412.48	$ 405,513.90	$ 1,618,768.35		$ 807,740.54	$ 0.011	$ 158,211.94	$ 19,776.49	$ 737,047.90	$ 3,547,531.83	$ 539,282.98	$ 3,152,001.99
Corn	2397.71	1	2397.71	100%	606.6	1454450.886	$ 0.05	$ 0.13	$ 536.41	$ 1,286,155.62	$ 113,447.17	$ 14,180.90	$ (151,683.93)	$ 982,787.76	$ (293,492.89)	$ 699,169.84		$ 1,286,155.62	$ 0.011	$ 129,446.13	$ 16,180.77	$ (22,237.80)	$ 2,277,249.05	$ (184,045.46)	$ 1,953,633.73
Wind																									
2.5 MW	405.69	22	18.44045455	30%	6570000	121153786.4	$ 0.05	$ 0.13	$ 1,980,000.00	$ 36,512,100.00	$ 9,692,302.91	$ 1,211,537.86	$ 60,410,929.09	$ 157,333,958.18	$ 48,295,550.45	$ 133,103,200.91	25%	$ 27,384,075.00	$ 0.022	$ 12,357,686.21	$ 1,544,710.78	$ 81,896,640.30	$ 290,038,845.27	$ 66,449,532.54	$ 259,144,629.75
50 KW	680.83	11	61.89363636	30%	131400	8132823.818	$ 0.05	$ 0.13	$ 99,000.00	$ 6,127,470.00	$ 650,625.91	$ 81,328.24	$ 378,789.05	$ 6,885,048.11	$ (434,493.33)	$ 5,258,483.35	30%	$ 4,289,229.00	$ 0.022	$ 829,548.03	$ 103,693.50	$ 3,046,578.08	$ 17,018,769.40	$ 2,009,643.05	$ 14,944,899.33
10 KW	360.91	0.5	721.82	30%	26280	18969429.6	$ 0.05	$ 0.13	$ 19,800.00	$ 14,292,036.00	$ 1,517,554.37	$ 189,694.30	$ 883,507.68	$ 16,059,051.36	$ (1,013,435.28)	$ 12,265,165.44	30%	$ 10,004,425.20	$ 0.022	$ 1,934,881.82	$ 241,860.23	$ 7,106,000.30	$ 39,695,480.35	$ 4,687,398.03	$ 34,858,275.80
Solar																									
1KW PV Cell	2577.19	0.0038	678207.8947	20%	1752	1188220232	$ 0.11	$ 0.13	$ 3,840.00	$ 2,604,318,315.79	$ 23,764,404.63	$ 2,970,550.58	$ (2,366,674,269.47)	$ (2,129,030,223.16)	$ (2,396,379,775.26)	$ (2,188,441,234.74)	30%	$ 1,823,022,821.05	$ 0.022	$ 49,905,249.73	$ 6,238,156.22	$ (1,535,473,525.01)	$ (848,682,231.16)	$ (1,597,855,087.17)	$ (973,445,355.47)

APPENDIX A - DESIGN PROCESS



APPENDIX B - SUITABILITY + IMPACTS





	FOOTPRINT (SITE)	MANUFACTURING FOOTPRINT	YIELD	OUTPUT	EFFICIENCY (SITE)	HOME LOSSES	REGULAR LOSSES	NATIONAL LOSSES	LOCAL ECONOMIC IMPACT (SHORT TERM)	LOCAL ECONOMIC IMPACT (LONG TERM)	NATIONAL ECONOMIC IMPACT (SHORT TERM)	NATIONAL ECONOMIC IMPACT (LONG TERM)	ROYALTIES	SURFACE RIGHTS	MINERAL RIGHTS
GAS	○	○	●	●	●	●	●	●	●	○	●	○	⊙	○	⊙
WIND	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	●	⊙	⊙	●	⊙	
SOLAR	○	⊙	⊙	⊙	⊙	●	⊙	○	○	●	⊙	⊙	●	⊙	
BIOMASS	●	●	○	○	○				○	●	○	○		●	
NO GAS	●	●							○	○	○	○	○	○	○
W + S + B	⊙	●	⊙	⊙	⊙	●	⊙	○	○	●	⊙	⊙	●	⊙	
CONVENTIONAL + ALTERNATIVE	⊙	⊙	●	●	●	●	●	●	⊙	⊙	⊙	⊙	●	⊙	⊙

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