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# Abstract

Rare earth minerals and metals will become a key commodity for the energy transition. Hence, benchmarking energy technologies based on the real costs and pollution associated with the mining, building, and recycling renewable energy technologies can give us the true implications the energy transition will have on our societies. The results from the energy model presented on this paper show renewable energy technologies a strong supporter of the energy supply but a weak stand-alone provider. Furthermore, high upfront costs and Global Warming Potential, GWP figures may have negative implications to the Human Development Indicators. Finally, the energy transition may induce elevated prices of rare earth minerals and metals, as these resources are heavily relied upon the production of renewable energy technologies.



Keywords: Energy system model, Global Warming Potential, Capacity factor, Life-cycle cost and GWP allocation, Rare-earth minerals, Human Development Index


- *Dedicated To My Family*

# Content:

# Modeling the Energy Transition and analyzing its implications: A raw material approach

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# 1. Introduction

Amid the 2022 energy crisis caused by the war in Ukraine and climate change protests, governments are now investing in the energy transition in the hopes of higher energy security and a sustainable future. As of 2021, 44 countries and the European Union have pledged to net-zero-by-2050 policies. Altogether accounting for 70% of the total global emissions. –(IEA) Out of all the countries ten of them have made the net-zero-by-2050 aspirations a legal obligation and another eight are in the process of doing so. In year 2021 Coal, Natural Gas, and Oil accounted for 62% of the total world energy production. –(IEA) Such fuels and technologies are cheap, abundant, and have low investment and maintenance costs, as we will discuss below. Therefore, they guarantee a stable economy and affordable energy prices.

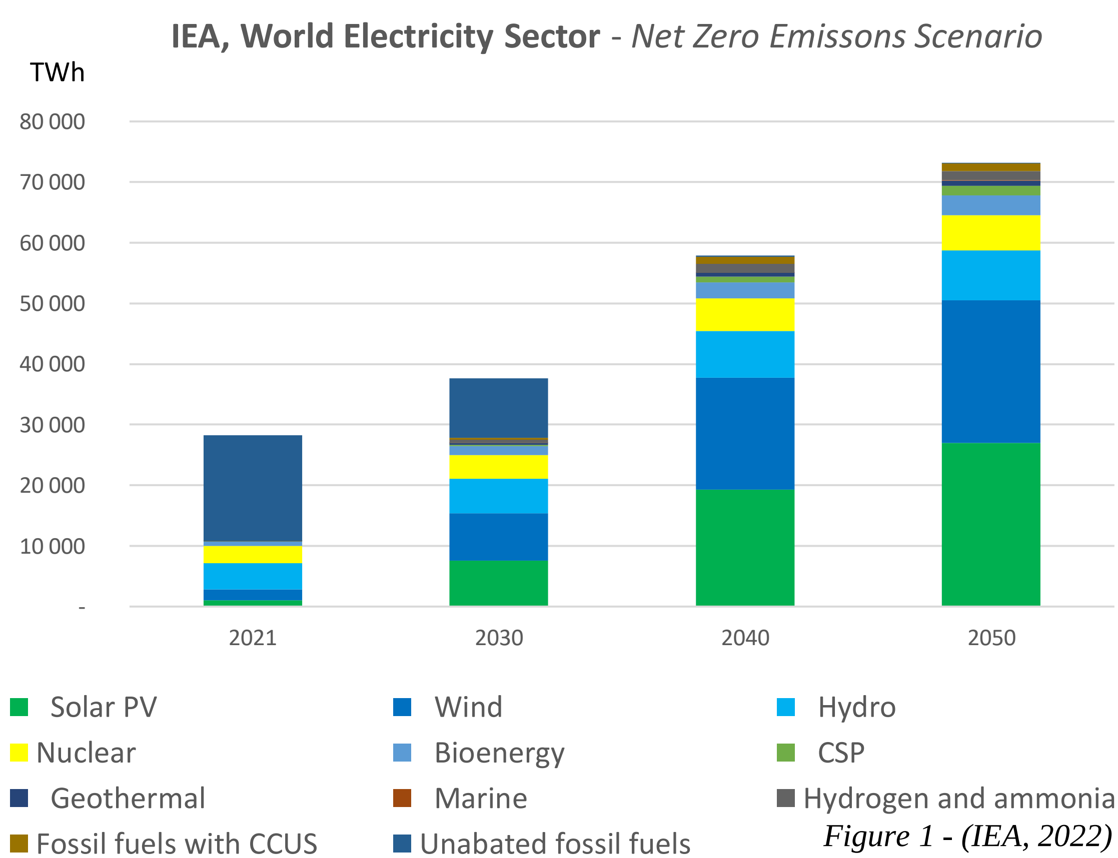


*Figure 1 - (IEA, 2022)*

The International Energy Agency net-zero-by-2050 report lays out a blueprint for each union member to follow and it serves as a reference for many others. What the report predicts is that by 2050 the world's 88% electricity needs will be met by renewable energy, mainly Solar PV, Windmills, and Hydro. Nuclear will account for 8% and the other 4% will be met by carbon capture coal and hydrogen. –(IEA)

Having seen the scale at which the IEA member countries and others are aspiring to expand renewables towards reaching the net-zero-by-2050 goals I raise the following questions:

1. How would the electric energy supply of a country look like constrained by the pollution and cost of each technology with emphasis to raw materials?
2. What are the implications of the transition on human development indicators and raw materials supply chains and prices?

In this paper, I propose building an energy system model for a country and map out how the energy supply would look like, based on cost, and pollution constraints. As a second part of the paper, I lay out the implications of the energy transition and analyze. The model requires a specific country as an example to increase the level of accuracy through official governmental data. The country of choice for this paper is Switzerland due to the data availability and the high-to-medium share of renewable energy resources like wind, sun, and precipitation.

## 2. Literature on Energy models and author contribution.

Energy Models can be separated into two main categories: bottom-up and top-down approaches:

- A bottom-up model collects highly detailed technical data from energy technologies mentioning; capacity factors, production functions/patterns, or economic such as life-cycle investing and maintenance costs. The end-use demand is taken as given. A bottom-up approach is a mathematical formulation in which a function computes a set of variables that minimize or maximize an objective function subject to a set of constraints. This approach aims to model an energy system or sector to understand how technological changes or advancements affect the energy supply structure. –(Herbst)
- A top-down approach collects high-level information on different activities not necessarily related directly to energy technologies or consumption, such as economic activity, trade activity, and food prices, and associates that data with the corresponding energy consumption or structure. This approach aims to understand the implications of an energy structure on wider economic factors. –(Herbst)

My model of choice is a bottom-up approach which gives the ability to understand the true capacity of a country to adopt the net-zero-by-2050 aspirations and later to quantify the final energy delivered to the end-use consumer. The model is easy to understand and is explained in plain English. As part of my contribution, I will analyze the potential effects my model's results will have on the human development indicators and risks related to supply chains and prices of raw materials needed on building the technologies.

# 3. Roadmap

In the first section of the paper, I introduce the subject of my paper, points 1, 2. In the second section after the introduction and the author's contribution, I lay out how the model has been constructed and all the relevant assumptions. Section 2 includes points 4, 5, and 6. In section 3 which includes points 7, 8, 9, I discuss and lay out the implications of the energy transition on the human development indicators and on the rare-earth metals and minerals. Point 10 are the concluding remarks of the paper. All the data and excel models used on this paper is are open source and can be downloaded via the GitHub link on the reference section.

# 4. Model

Switzerland is the country with the lowest carbon footprint among the IEA members. Their electricity sector is dominated by nuclear 30% and hydro 60% generation as of 2021-(IEA). Being a country, which has its domestic renewable energy technologies resources exploited to a large extent, makes Switzerland a great case study as it minimizes the chances of introducing new technologies that were not included in this study. Energy technologies that will be included in the Switzerland case study are Oil, Natural Gas, Biofuels, Waste, Nuclear, Hydro, Solar PV, and Windmills.

## 4.1 Constraints

- ***f Min*** represents the minimum amount in GW of a particular energy source that must be included in the model. For the net-zero-by-2050 scenario, I will assume the minimum is 0.
- ***f Max*** represents the maximum domestic capacity of a technology that can be deployed given in GW. In more concrete terms, the amount of hydropower

plants is constrained by the number of rivers and precipitations available within a country. – (Bieler)

- ***Cf,*** capacity factor represents the ratio between the energy produced and the total capacity of a particular energy technology installed. In other terms, this ratio gives the effectiveness at which a primary energy source gets converted into usable end-use energy. It accounts for both the effectiveness of a particular technology and the abundance of a primary resource. We would expect a higher capacity factor for Solar PV in Dubai than in London due to higher solar radiation. But the city of London may have installed more efficient panels which can even out the difference. Therefore, each calculation must be performed for every country individually. Given by (1):

$$\textbf{(1)}\ Cf = \frac{GWh}{(GW \times 8766h)}$$

- *GWh represents the end-use energy produced in one year and GW represents the maximum capacity of production at a given hour, multiplied by the total hours of one year.*

- ***Costs*** are categorized into investment; ***C inv*** and maintenance costs ***C main***. Being self-explanatory costs are expressed in millions of euros per GW capacity *M€ / GW*. – (Muyldermans)

- ***GWP*** stands for "Global Warming Potential" which expresses the potential for greenhouse gas emissions to trap heat in the atmosphere. It measures how much energy is trapped in the atmosphere due to one unit of a certain gas being released compared to the emission of one unit of carbon dioxide. Expressed as megatons of Co2, *Mt-Co2*. – (ScienceDirect)

## 4.2 Assumptions on constraints.

The assumption of this paper has been kept at a minimum to increase the accuracy of the results. Nonetheless, they can be crucial when dealing with ambiguity. The maximum capacity that can be installed for nuclear, fossil fuels, waste, and biofuels has been assumed to be the current capacity as of 2021. This assumption is backed by the Swiss government's decision on phasing out nuclear and fossil fuels. – (Swiss Confederate) For waste I assume there is a saturation since this is dependent on limited raw materials (waste). Biofuels I assume that there is a saturation as well due to a large amount of land and other resources it takes to produce them. Such resources are also limited by the demand for agriculture. On the other hand, the minimum amount for each energy source is 0. The point of the model is to create a pathway towards future investments. Considering current installed capacities for each technology as minimum values will not produce any results.

## 4.3 Variables

In this study, I have adopted a 12 typical days approach for a whole year based on the methodology of EnergyScope TD by –(Limpens). Each typical day represents a month, and every hour of that day is the average consumption or production of every day of that month. This methodology gives breaks down the supply function on monthly and hourly intervals also simplifying the model's output complexity. The variables optimized subject to the constraints are every hour of a typical day.  Figure 2 on the side represents the hourly consumption of three typical days of January, February, and March.

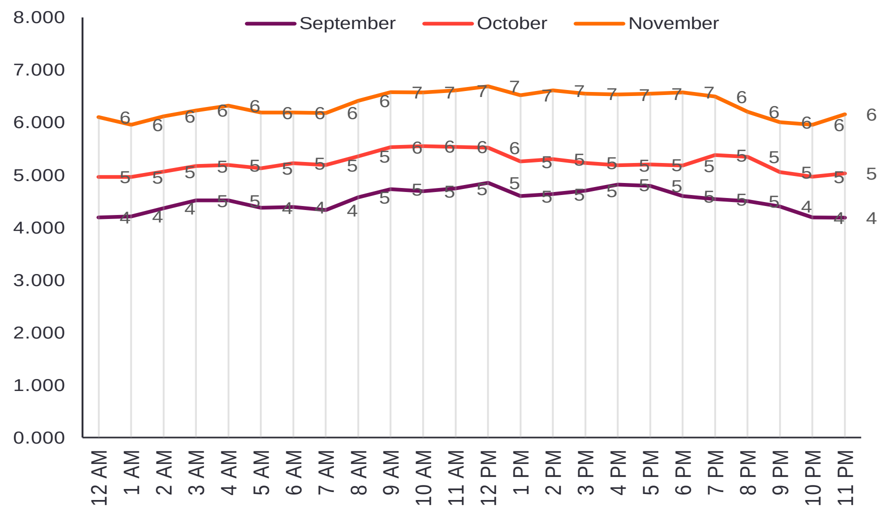


**Figure 2. Hourly GW consumption**

## 4.4 Activity Distribution Map

Activity maps for the demand side of the electricity sector capture how the demand changes from one hour to another and between months. It shows where the peaks are, lows, and everything in between for a whole year given in 12 typical days for each month. Activity maps for the demand side are straightforward to understand, however, that is not the case with the supply side of the electricity sector.

Energy technologies such as oil, gas, biofuels, waste, or nuclear plants are simple to model if we only are given the capacity of the plant. This is because the primary fuels to run these plants can be controlled by us. But in the case of renewable primary sources such as sun radiation, wind, and precipitations the data provided by the national weather stations can be ambiguous for the model to give precise solutions. I propose mapping the activity of each renewable energy source into an activity map to understand how annual production is distributed between a typical day of each month and hours.

The data needed to map solar PV and wind activity has been provided by the "Open-Source System Data" -(OPSD). They have a wide range of time-series data for every country in the EU. The hourly time-series data starts in 2014 with a capacity of 455 GW and ends at the end of 2019 at 620 GW. Since we want to map only the activity of production then we must adjust production to one specific capacity to later get the average of each hour. Production of both wind and solar are then adjusted to their first year on the time series production data according to formula **(2):**

$$\textbf{(2)}\ Adjusted\ capacity\ = (1 - \frac{(GW - GW\alpha)}{GW\alpha}) \times GWh$$

- ***GWα*** *represents the anchor value (the year 2014 capacity) for adjusting the rest of the production values.*

After adjusting each time series to a single capacity production, we can then take the average production of each hour for every day of the month. Every hour of each typical day is then divided by the total GWh production giving the production distribution. Tables 2 & 3 give how the production changes for each hour of the typical day/month.

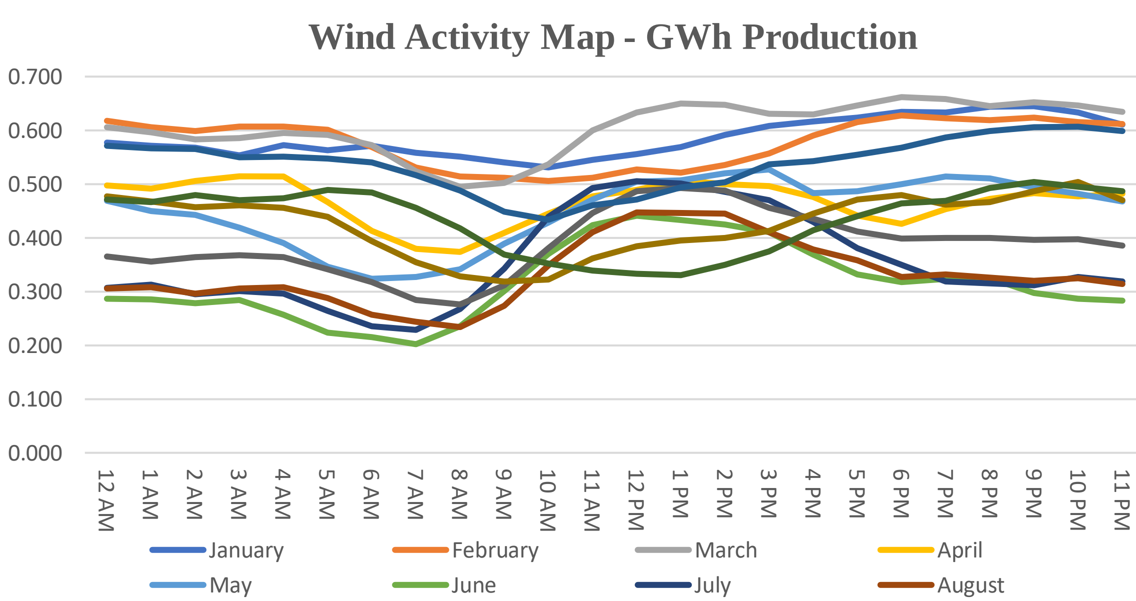


*Figure 3 - (Open Power System, 2023)*

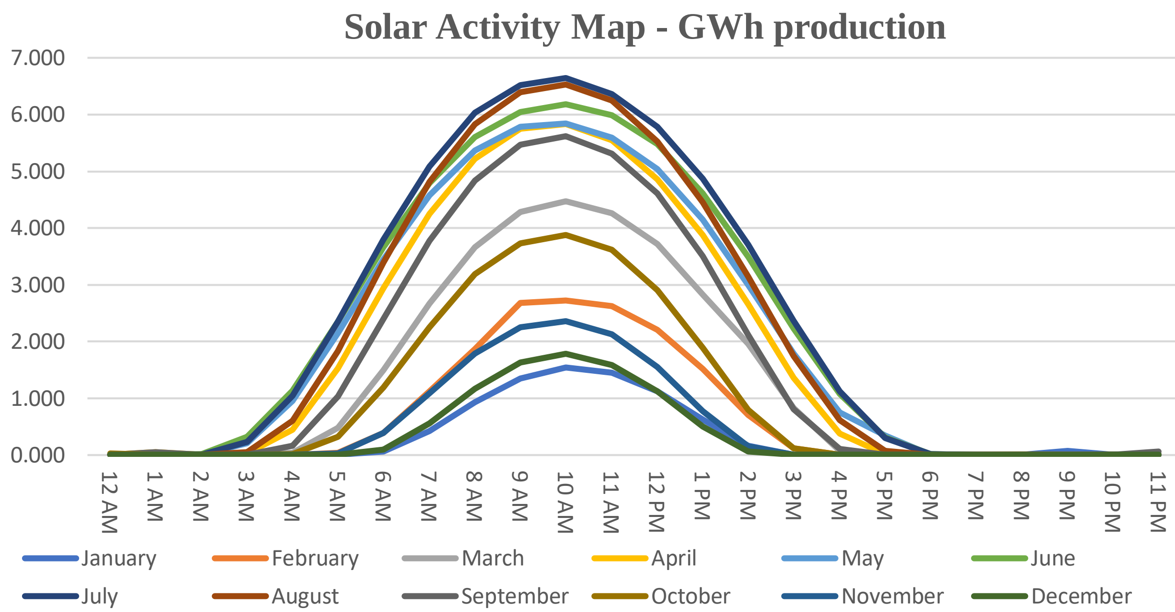


*Figure 4* - (Open Power System, 2023)

Monthly hydropower production data have been taken from official Swiss sources. – (Swiss confederation). The reason why in this study I consider hourly time-series for hydro production ambiguous is that dams serve as energy storage which can be deployed at any given time. In other words, if we get a large number of rainfall or other precipitation then the dam will use the collected water when it needs to during the month. This means that each typical day will have different values but each hour will have the same value within a day. For nuclear production, I use the same reasoning as hydro data.

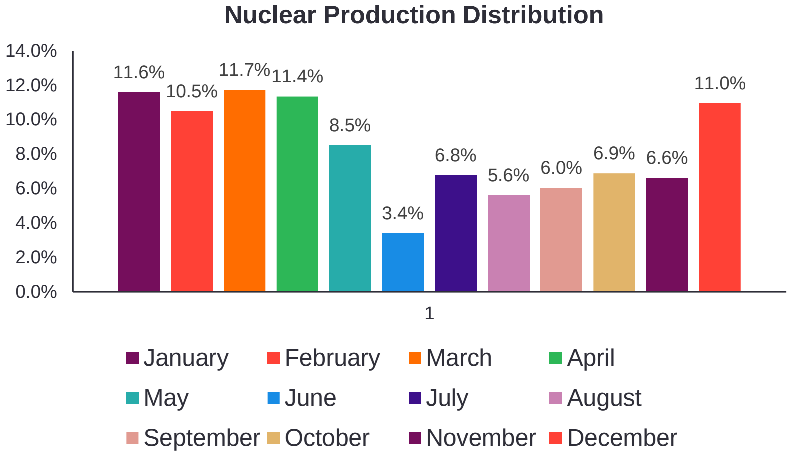


*Figure 5 – (Open Power System, 2023)*

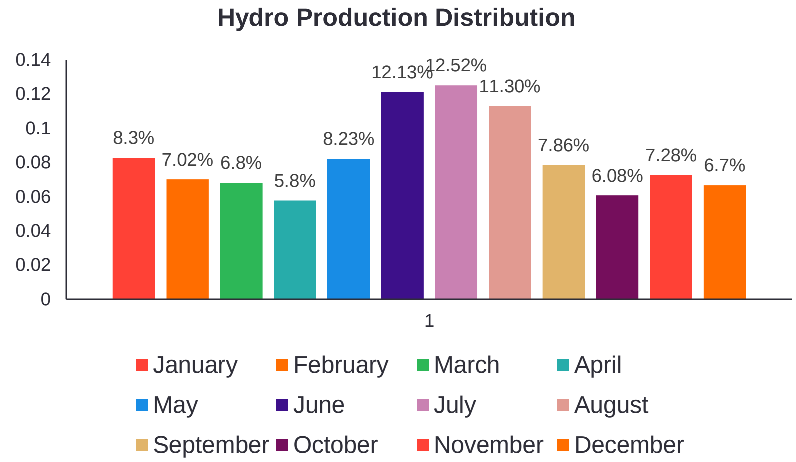


*Figure 6 – (Open Power System, 2023)*

For Waste, Natural Gas, and Oil there was no monthly electricity production data available due to the small share they carry. Therefore, I have included them in the model as constants for every hour of each typical day. A distribution map gives each hour a percentage value of total GWh production for the 12 typical day intervals. Such a distribution map can show us how a certain amount of GWh is expected to be distributed across 12 typical days and every hour of each day for some technologies.

## 4.5 Calculating the maximum GWh production for each technology

Although the maximum production data is provided by the Swiss sources in annual GWh production I have to convert it to the 12 typical day interval production we are considering. First I calculate the capacity that would be required to match the given production according to (3)

**(3)** $GW\alpha = \frac{GWh/Cf}{8766h}$

- 8766h represents the number of hours in one year.

After calculating the capacity of each energy source I convert this capacity into GWh production for the 12 typical days we have considered. Given by **(4)**:

$$\textbf{(4)} \qquad GWh = GW \times h \times Cf$$

- *To estimate the expected GWh production from a given available capacity, we have to multiply it by the running time of this capacity in total hours, and again multiply it with the capacity factor Cf, which accounts for the inefficiencies in either resources or and technological. In our model, I am considering only 12 typical days which account for 288 hours of running time. The capacity factor Cf for each technology is given in table 1 and it has been calculated from historical production data via formula (1).*

## 4.6 Solver

To solve the model I have used the MS Excel Solver. The Excel "Simplex LP" Solver is very easy to use and intuitive but very time-consuming. It can only calculate 200 variables at a time and my model consists of 2300 variables. To solve the model in Excel Solver I had to calculate each typical day separately. The values used for the calculation are summarized in *table 1*.

# 5. Life-cycle cost & GWP analysis and calculation

The GWP index and costs for each technology were given by the – (Muyldermans) in the form of GWP/GW and €M/GW capacity. In other words, it estimated how much 1 Gigawatt of each technology costs and its Global Warming Potential (GWP) value. The cost was separated into investment and maintenance. Furthermore, the costs and GWP values were given as a total for each technology's entire life cycle. When doing the analysis and calculation of costs and GWP the two key determinants were:

- Lifecycle of the technology.
- The efficiency of the technology to convert raw resources into energy.

Both points above will be factored into the final estimated values on points **5.1** and **5.2**.

## 5.1 Cost and GWP allocation

Cost and GWP allocation are done on a life-cycle basis. Because we are only considering a 12 typical day interval, I propose allocating a portion of the cost and GWP index as a percentage value of the 12 typical day interval to its entire life cycle. Given by **(5)**. Although the costs and GWP pollution are front heavy this solution can give us the real cost and GWP index because it accounts for the lifetime of each technology.

**(5)** $$\textit{Cost Allocation} = = \frac{12TD}{365 * X} \times \beta$$

- *12TD stands for 12 typical days*
- *X, represents the lifetime in years*
- *$\beta$, represents either total cost in €M/GW or GWP/GW index*

Furthermore, another question may arise whether we consider the investment cost as a lump sum and allocate the 12TD interval only to the maintenance costs or whether take the sum allocate the 12TD interval to the total cost. I propose the latter, that is because we have a few technologies that have high investment costs but also a longer life cycle. By summing investing and maintenance costs to later allocate the 12TD interval I can get a real cost per gigawatt.

## 5.2 Conversion of the cost and GWP from capacity (GW) to energy (GWh)

The cost, €M/GW and GWP, GWP/GW expresses each value in terms of capacity installed in Gigawatts GW. Converting them into energy delivered such as €M/GWh and GWP/GWh is very important, not only for estimating the hourly cost and pollution of the model but mainly to account for the efficiency of each technology to convert raw resources into energy. In concrete terms, one technology may have cheap costs but it's not efficient enough to convert raw resources such as wind, solar radiation, or precipitations into energy. The reasons can be either local or geographical.

I propose calculating the total cost of the installed capacity and then dividing that total cost by the amount of GWh produced during the 12 typical day interval. Illustrated into **(6):**

$$\textbf{(6)} \qquad \beta/GWh = \frac{GW*\beta}{GWh}$$

- *C represents the allocated cost during the 12TD interval.*
- *GWh represents the total amount of energy delivered for end-use.*
- *β represents either allocated cost, €M/GW, or GWP index, GWP/GW.*

Furthermore, we know from **(4)** that $GWh = GW \times h \times Cf$ hence:

$\beta/GWh = \frac{GW*\beta}{GW\times h\times Cf}$ After doing the algebraic simplification of the formula above I arrive at:

$$\textbf{(7)} \qquad \beta /GWh = \frac{\beta}{Cf*h}$$

- *In our case, the 12 typical days account for 288 hours, hence, h = 288.*

Number **(7)** shows us that both values €M/GWh and GWP/GWh are dependent on constants. Such calculation can capture the efficiency of an energy technology via the Capacity Factor C*f*. We can now say that our final values of €M/GWh and GWP/GWh account for the lifecycle and the efficiency of each technology.

*Table 1.*

| *Electricity Sector* | f min [GW] | f max [GW] | Costs: C inv M€/ GW | Costs: C main M€/GW | Costs: Total | GWP/GWh | GWP Alocation | €M/GWh | Cf capacity Factor | GWP ktCO2/GW | Lifetime | Current Installed Capacity [GW] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Coal** | 0 | *0* | € - | € - | € - | 0.400 | - | € - | **0** | - | 0 | 0 |
| **Oil** | 0 | *18* | € 55 | € 1 | € 56 | 0.315 | - | 0.0007 | **0.513** | - | 17 | 0.004 |
| **Natural Gas** | 0 | *535* | € 1,408 | € 91 | € 1,499 | 0.260 | - | 0.0231 | **0.211** | - | 35 | 0.289 |
| **Biofuels** | 0 | *693* | € 1,374 | € 112 | € 1,486 | 0.033 | - | 0.0375 | **0.452** | - | 10 | 0.1748 |
| **Waste** | 0 | *2081* | € 2,928 | € 108 | € 3,036 | 0.150 | - | 0.0204 | **0.585** | - | 29 | 0.406 |
| **Nuclear** | 0 | 19364 | € 4,846 | € 102 | € 4,948 | 0.002 | 0.3671 | 0.0128 | **0.736** | 670 | 60 | 3 |
| **Hydro** | 0 | 49395 | € 5,000 | € 50 | € 5,050 | 0.027 | 2.2533 | 0.0484 | **0.291** | 2810 | 41 | 15.66 |
| **Solar PV** | 0 | 12000 | € 870 | € 10 | € 880 | 0.054 | 1.4584 | 0.0427 | **0.094** | 1109 | 25 | 3.482 |
| **Wind** | 0 | 4000 | € 1,040 | € 3 | € 1,043 | 0.017 | 0.9156 | 0.0316 | **0.188** | 557 | 20 | 0.0884 |

# 6. Constraint Calculations

The inputs that I have calculated are, *Capacity Factor Cf, GWP/GWh, and €M/GWh*. In the following paragraphs, I will do a summarization of these results.

## 6.1 Capacity Factor

In terms of efficiency in converting raw resources such as solar radiation, uranium, or oil into energy. On average fossil fuels have the higher scores due to their energy-dense structure. Nonetheless, my results give nuclear power plants the highest score of 73.6%, highest score from fossil fuels by a large margin. This explains the high energy density of Uranium as a material. Second comes waste followed by oil, biofuels, and natural gas at 58.5%, 51.3%, 45.2%, and 21.1% respectively. Renewable energy scores are led by hydropower plants at 29.0%, wind at 18.8%, and solar at 9.4%. These values not only they describe the efficiency of the technologies we are considering but also, they capture the geographical location of where these technologies are installed. For solar we would expect to see a higher score in a country with more solar radiation.

## 6.2 Cost; €M / GWh

In terms of cost, the GWh fossil fuels lead the way with Oil at €734 per GWh. The second cheapest comes Nuclear at €12,785. That is followed by Waste at €20,439, Natural Gas at €23,144, Wind at €31,592, Biofuels at €37,508, Solar at €42,718, and the most expensive Hydro at €48,381. The cost per GW capacity of Hydro and Nuclear are quite similar at €M 5,050 and €M 4,948 per GW capacity but the reason why my methodology makes hydro a lot more expensive is the short lifecycle of 41 years compared to 60 for Nuclear and lower capacity factor as discussed on point 5.1.

### 6.3 GWP; GWP/GWh

GWP scores will be given in MWh to make them easier to grasp. Nuclear is the least pollutant with a score of 1.7/MWh. After that comes Wind, Hydro, Biofuels, and Solar with scores of 16.9/MWh, 26.9/MWh, 33.0/MWh, and 53.8/MWh, respectively. Then, fossil fuel scores are in the hundreds of units. Waste, Natural gas, Oil, and Coal have their scores at 150/MWh, 260/MWh, 315/MWh, and 400/MWh, respectively.

## 7. Cost and GWP minimization scenario results

Tables 2 and 3 summarize the results of the two scenarios. In the first scenario, we minimize Cost and in the second scenario, we minimize GWP.

### 7.1 Cost minimization scenario

In the cost minimization scenario, we see nuclear capacity at full utilization

*Table 2*

| GWP Min | GWh | %GWh | Utilization | GWP | Cost per GW |
|---|---|---|---|---|---|
| **Biofuels** | **-** | **0.0%** | **0.0%** | **-** | **-** |
| Wind | 131.4 | 9.1% | 100.0% | 2.2 | 4.2 |
| Solar | - | 0.0% | 0.0% | - | - |
| Hydro | 680.9 | 47.0% | 42.0% | 18.3 | 32.9 |
| Nuclear | 636.2 | 43.9% | 100.0% | 1.1 | 8.1 |
| Waste | - | 0.0% | 0.0% | - | - |
| Natural Gas | - | 0.0% | 0.0% | - | - |
| Oil | - | 0.0% | 0.0% | - | - |
| **Total:** | **1448.5** | | | **21.6** | **€ 45.23** |

accounting for 43.9% of the electricity supply. Hydro accounts for 25.9% of the supply followed by Solar and Wind at 13.5% and 9.1% respectively. Then, at a smaller percentage come Waste, Biofuels, and Natural Gas at 4.7%, 1.6%, and 1.2%, respectively. All the energy

sources are utilized because Hydro being the most expensive has also a large capacity. Therefore, to minimize the cost you must substitute Hydropower with alternative sources such as fossil fuels which have smaller capacities of production. Hence, we see a diverse energy supply. The GWP for this scenario sits at 39.7 and the total cost of running the system generated is €41.5 million.

## 7.2 GWP minimization scenario

*Table 3*

| Cost Min | GWh | %GWh | Utilization | GWP/GWh | €m/GWh |
|---|---|---|---|---|---|
| **Oil** | **0.6** | **0.0%** | **100.0%** | **0.2** | **0.0** |
| Solar | 195.9 | 13.5% | 49.7% | 10.5 | 8.4 |
| Wind | 131.4 | 9.1% | 100.0% | 2.2 | 4.2 |
| Biofuels | 22.8 | 1.6% | 100.0% | 0.8 | 0.9 |
| Natural Gas | 17.6 | 1.2% | 100.0% | 4.6 | 0.4 |
| Waste | 68.4 | 4.7% | 100.0% | 10.3 | 1.4 |
| Nuclear | 636.2 | 43.9% | 100.0% | 1.1 | 8.1 |
| Hydro | 375.7 | 25.9% | 23.2% | 10.1 | 18.2 |
| **Total:** | **1,448.5** | | | **39.7** | **€ 41.5** |

On the Global Warming Potential index minimization, we notice fewer energy sources being utilized. This is because Hydro and Nuclear are capable of large capacities accounting for 43.9% and 47% of the energy supply. The wind is the third and last source accounting for 9.1% of the energy supply. Utilization for Nuclear, Hydro, and Wind is at 100%, 42%, and 100% respectively. The GWP index for this scenario sits at 21.6 which is half of the cost min scenario and the cost of running the system is slightly higher at €45.2 million. The reason why we see a smaller difference in costs between the scenarios is that the cheapest technologies available have very limited capacity. Point out, Nuclear is a key player in both cost and GWP but the Swiss government's decision to phase out nuclear and other non-renewable technologies will further increase costs. The costs that are included in this model constitute the construction and maintenance costs which are the investment we must make to extract the energy we are aiming for. Higher costs for the same amount of energy delivered means we will have less net energy available to us. The relationship between energy delivered and energy invested is captured by the Energy Return on Investment (EROI) ratio. The literature on this metric is vast.

## 8. Energy consumption on the human development indicators

On a published paper titled "Energy, EROI, and quality of life" the author, Lambert does an extensive research and analysis on how energy consumption correlates with quality-of-life indicators. Given the rising costs of drilling for oil the author analyses the EROI at a societal level and energy-per-capita and finally composes a new energy index. The author also explains how the price of a fuel is determined by its embodied energy or by the energy required to bring the raw material to its final consumption stage. Their new index "LEI" which combines, the energy intensity of a GDP unit, energy consumption per capita, and Gini-index is found to be correlated with quality-of-life indicators. I want to take this research further by testing for causality of energy consumption on human development indicators.

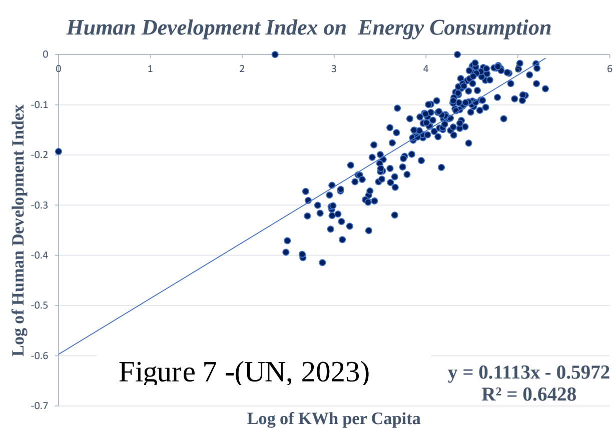

Figure 7 -(UN, 2023)

The human development index (HDI) was developed and calculated by the "United Nations" as part of its development program. It was first introduced in 1990, and its goal is to emphasize people and their capacity only and not include the economic indicators alone.

– (UNDP) The human development office computes the index for about 190 countries, and it uses the following indicators:

1. Life expectancy at birth
2. Expected years of schooling
3. Mean years of schooling
4. Gross national income per capita (PPP $)

The human development index is the geometric mean of its indicators which alone are highly correlated with the energy consumption levels for the sample of 182 countries I have included in my study. On the right, I have presented the graphs and the regression line equations of energy per capita and the HDI index followed by its composite indicators. The energy per capita is given in KWh and it includes every energy sector such as electricity, industry, transportation, and more, provided by "Our World in Data" – (Our World in Data)

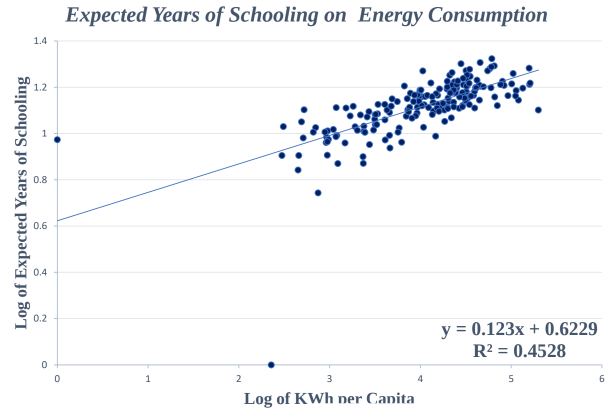


Figure 8 -(UN, 2023)

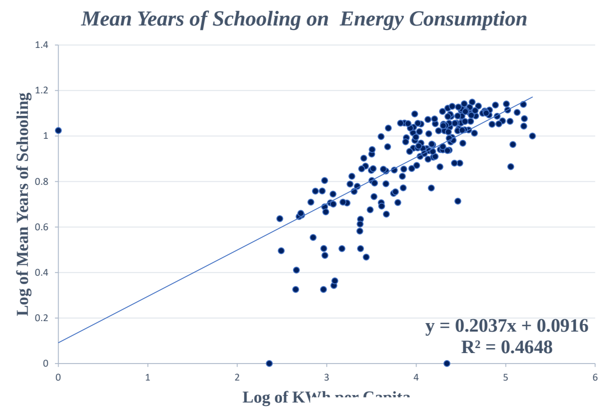


Figure 9 -(UN, 2023)

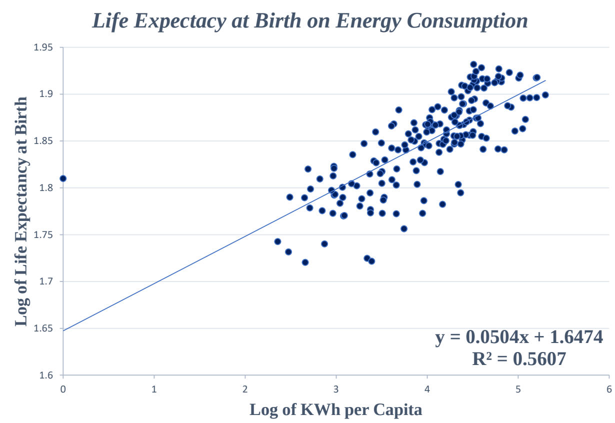


Figure 10 -(UN, 2023)

It is common to think that the correlation is biased due to the economic development affecting positively the HDI indicators and energy consumption. But my hypothesis suggests that energy consumption precedes economic development and ultimately human development. To test this hypothesis, I propose performing an instrumental variable analysis on the Human Development Index as the dependent variable and testing for endogeneity on the energy consumption variable. I cannot perform an endogeneity test on energy consumption with the index itself as dependent on its statistical stationery. The only values the index can take are between 0 and 1. Hence I will only perform tests on its indicators.

The instrumental variable that I propose is the difference between the average minimum and maximum temperature for each country, calling it temperature variation. The data minimum and maximum average temperature were provided by the World Bank at their "Climate Change Knowledge" database portal. – (World Bank)

The reasoning behind this instrumental variable is that countries with a large difference in the temperature range consume more energy than other counties with a smaller range, no matter the actual temperature values. Explained in another way, such countries would be the ones with extreme winters and summers, and their inhabitants would require a large amount of energy for both heating in the winter and cooling in the summer. The temperature range proves to be significant at the 95% confidence interval with a coefficient of 0.75 and an r-squared value of 18.5%. A such instrumental variable is correlated with the outcome/dependent but does not have a causal effect on the outcome due to its randomness.

To further strengthen my model, I choose to control for some economic development indicators that drive both energy consumption and human development. Such control indicators are GDP/capita and gross national income. GDP/capita is an economic indicator driven by energy consumption and has a positive effect on human development indicators. Gross national income accounts for wealthy countries that can afford to consume large amounts of energy and invest in improving human development indicators. In my hypothesis energy demand is infinite and it's only constrained by supply, hence demand/consumption equals supply. For running the instrumental variable regression, I have used the Two-stage least squares (2SLS) method. The structural equation:

After using the instrument to predict the energy consumption KWh/Capita the equation is as (8):

$$\textbf{(8)}\ log(HDI\ Indicators) = \beta 0 + \beta 1\ log\frac{K\widehat{W}h}{Capita} + \beta kXk + \varepsilon$$

- $\frac{K\widehat{W}h}{Capita}$ represents the predicted energy consumption based on the "Temperature_Variation" instrument.
- k stands for: National Income, GDP per capita

After running the regression and testing for endogeneity, results show evidence of exogeneity of the KWh/Capita variable for all three indicators tested. Below you will find a summary table of the results.

*Table 4*

| Indicators | Durbin Score | Wu-Hausman Score | Min Eigenvalue | Coef. |
|---|---|---|---|---|
| **Life Expectancy at birth** | **0.72** | **0.73** | **8.73** | **0.034** |
| **Expected Years of Schooling** | **0.87** | **0.88** | **8.46** | **0.053** |
| **Mean Years of Schooling** | **0.77** | **0.77** | **8.46** | **0.149** |

Furthermore, by testing for weak instruments, the minimum eigenvalue showed above we can reject the null hypothesis that our instruments are weak at the 90% confidence interval. The strongest coefficient is the one between energy consumption and mean_years_of_schooling followed second by expected years_of_schooling and life_expectancy_at_birth.

## 9. Raw Material Prices and Production implications

Green energy technologies, such as Solar, and off/on-shore wind power, can improve energy security by capitalizing on a country's natural resources. However green energy technologies are highly dependent on the raw materials needed to build them. The net weight of raw materials per MW of green tech is substantially higher. Moreover, a large portion of these materials consists of rare earth metals and minerals. The figure 11, below shows a contrast between the nonrenewable and the green technologies in terms of amounts needed and type of materials.

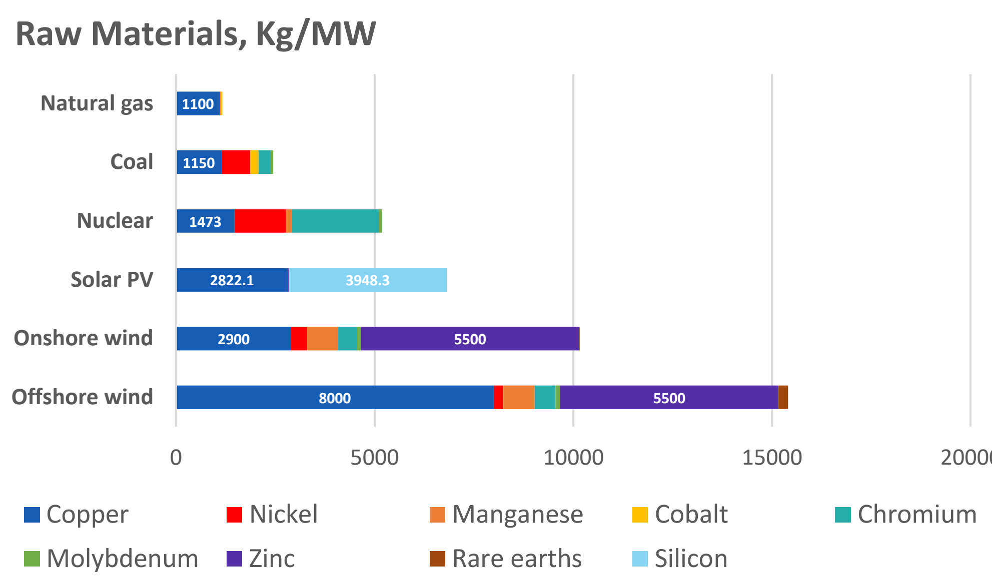


Figure 11 – (IEA, Critical Minerals, 2021)

Referring to figure 1, the international energy agency (IEA) has estimated that by 2050, around 70% of the total world's electricity will be produced by wind, solar, and hydro. These goals demand a substantial number of raw materials and rare earth minerals to build the technologies and infrastructure, far beyond the current production levels.

A transition may induce a shock in material prices because of a shortfall in supply. The supply chains of the raw materials will also be a crucial factor in the energy transition, particularly after we witnessed the 2022 energy crisis, triggered by a disruption in a heavily reliant Russian supply chain. Such disruption caused elevated energy prices and high inflation. In the case of raw materials for the energy transition, China holds a more dominant position than Russia did with natural gas. Another aspect as important as the others are the role that these materials play in non-energy-related industries.

As such, I lay out three main raw material risks that the energy transition will encounter. Those are:

1. Positive Demand shock, caused by rapid investing in green technologies
2. Positive non-energy industrial shock, caused by an expanding business cycle
3. Positive raw materials supply shock, caused by countries investing in production and new supply chains.

Demand shocks can be captured by the price of the raw materials. Non-energy industrial shocks can be captured by industrial production indexes, more on the index chosen below. Lastly, a supply shock is captured by the production figures of the respective raw material. To understand the implications of these shocks I propose constructing a Vector Autoregressive model with price, production of the respective metal, and industrial production as endogenous variables. The three shocks I laid out above will be treated as exogenous.

## 9.1 Expected shock responses

*Table 5*

| | Price of Raw Material | Production of Raw Materials | Industrial Production |
|---|---|---|---|
| Demand Shocks | + | + | 0 |
| Supply Shock | - | + | 0 |
| Industrial Shocks | + | + | + |

## 9.2 Metal & Mineral Data

The data for the metal price and production has been provided by the United States Geological Survey (USGS). For most of the metals, the time series annual data for price and production can go back to 1900 and as recently as 2019. Industrial production has been provided by the Federal reserve bank of ST. Louis statistics (FRED). It measures the real output of all relevant establishments located in the United States, regardless of their ownership.

## 9.3 Metal Selection

For the metal selection, I propose building a risk score index consisting of supply chain risk, end-of-life recycling score, and the percent demand growth of the respective metal from current production levels. The total risk score is calculated as the geometric mean of the three indicators. More on the indicators:

1. The supply chain risk score is the weighted average of each country's government stability index based on the contribution they have to the total supply of the respective metal. Data for the supply chains are provided by the United States Geological Survey (USGS). The government risk score values vary between 0-100 and have been provided by World Bank. (World Bank)
2. End of Life (EoL) recycling rates were taken from the United Nations Environment Program Report (UNEP). End of Life recycle rates describe the amount that is recycled/retained. I have converted the rate as a risk score by capturing the amount lost that is; 1-EoL%.

3. The % growth from current levels of production has been provided by the World Bank in its "Minerals for Climate Action" report.

Below you will find the table for each metal included in the study case: A key fact to point out is the high supply chain risk score each metal has. This is due to the large quantity of each metal that China is supplying being a country rich in resources and highly unstable politics.

*Table 6*

| Metal: | Supply Chain Risk: | Recycling Risk Score: | % Growth Amount Requirements: | Risk Score: |
|---|---|---|---|---|
| Lithium | 85.77 | 99 | 488 | 2.18086 |
| Indium | 67.06 | 99 | 231 | 2.05001 |
| Graphite | 37.74 | 100 | 494 | 2.04043 |
| Vanadium | 66.21 | 99 | 189 | 2.02244 |
| Cobalt | 85.70 | 32 | 460 | 1.97870 |
| Zinc | 83.26 | 58.5 | 98 | 1.89059 |
| Nickel | 86.72 | 41 | 99 | 1.83948 |
| Silver | 75.86 | 41 | 56 | 1.74453 |
| Neodysium | 47.79 | 99 | 37 | 1.73862 |
| Lead | 87.84 | 28 | 18 | 1.52455 |
| Molybdenum | 53.76 | 70 | 11 | 1.49257 |
| Titanium | 53.71 | 9 | 64 | 1.43934 |
| Aluminium | 51.50 | 43 | 9 | 1.38604 |
| Copper | 65.97 | 52 | 7 | 1.38180 |
| Manganese | 88.42 | 47 | 4 | 1.25137 |
| Iron Ore | 69.84 | 28.25 | 2 | 0.93044 |
| Chromium | 47.04 | 10 | 2 | 0.79552 |

The chosen metals for the study are Vanadium, Indium, Zinc, and Rare Earth. The selection has been made based on the highest risk scores, data availability, and model stability. Rare Earth has not been included in the risk score table due to the lack of indicator data but knowing the importance of Rare Earth minerals I have decided to include it in the VAR model.

## 9.4 VAR diagnostics

The diagnostics of the stability of the VAR model include eigenvalue stability condition and testing of autocorrelation via the langrage-multiplier test. The results for all VAR models are stable with all eigenvalues lying within the unit circle. Lastly, there is no evidence of autocorrelation at the selected lag.

## 9.5 Causality Testing

To further understand the relationship of the shock I propose testing for causality via the Granger causality test. The results show that all metals and minerals included are endogenous and do not show a causal relationship with one-another. Only Vanadium results, show evidence of the causality of Price on Production. Such results of causality testing show that price, production, and economic activity are driven by other factors that are not included in the model. An exogenous shock such as a demand and production shock driven by changes in policies may cause economic instability due to unpredictable price and production volatility.

## 9.6 Impulse response function results

Overall, in terms of response dynamics for each shock, each VAR model is similar.


Figure 12 – Impulse Response Functions, Indium

Considering that each of our shocks is exogenous, our response function is solely induced by the shock we are testing for. A key result to point out is the low-price elasticity of supply when testing for a demand shock on production. The consistency of the supply elasticity results is maintained when examining the effect of a positive shock in aggregate demand on price and production. The results show a price level increase that surpasses the increase in production levels.

## 9.7 Price Elasticity of Supply

The table below summarizes the responses of price and production to a positive Price/Demand shock. Note that price and production responses are separate functions from one another and that they describe how would price and production respond to a one-unit positive shock in price.

*Table 7.*

| Period: | IndiumPP | IndiumPQ | RarePP | RarePQ | VanadiumPP | VanadiumPQ | ZincPP | ZincPQ |
|---|---|---|---|---|---|---|---|---|
| | Price Shock on Price (P) & Production (Q) | | | | | | | |
| 1 | 100.0% | 5.1% | 100.0% | 1.6% | 100.0% | 11.5% | 100.0% | 0.9% |
| 2 | 96.5% | 6.3% | 93.4% | 2.0% | 88.4% | 11.7% | 94.7% | 4.1% |
| 3 | 95.9% | 9.9% | 89.8% | 1.6% | 86.6% | 11.8% | 94.6% | 4.3% |
| 4 | 95.6% | 9.8% | 84.6% | 1.5% | 83.9% | 11.8% | 94.5% | 4.5% |
| 5 | 95.1% | 9.8% | 83.9% | 2.3% | 83.7% | 11.8% | 94.4% | 4.5% |
| 6 | 94.9% | 9.9% | 83.7% | 2.9% | 83.5% | 11.9% | 94.4% | 4.5% |
| 7 | 94.9% | 9.9% | 83.7% | 2.9% | 83.3% | 11.9% | 94.4% | 4.5% |
| 8 | 94.9% | 9.9% | 83.6% | 2.9% | 83.3% | 11.9% | 94.4% | 4.5% |

The responses of price on price show a slight decrease from the initial shock in period 1. As per production, it raises only by a small portion to the one unit increase in price. The response of production on a shock on price estimates for us the price elasticity of supply. These estimations are low and are also reflected in the elevated prices in all periods.

## 9.8 Alternative aggregate demand indicator

Using an alternative aggregate demand indicator such as Industrial Production we obtain similar results and a more obvious lag in production response is introduced. Between the two different aggregate demand indicators, the results stay consistent except for zinc which increases the amount produced.

*Table 8.*

| Period: | IndiumPP | IndiumPQ | VanadiumPP | VanadiumPQ | RarePP | RarePQ | ZincPP | ZincPQ |
|---|---|---|---|---|---|---|---|---|
| | Price Shock on Price (P) & Production (Q) | | | | | | | |
| 1 | 100.0% | 5.8% | 100.0% | 0.0% | 100.0% | 0.2% | 100.0% | 11.7% |
| 2 | 98.3% | 7.1% | 99.7% | 0.0% | 99.9% | 1.6% | 98.9% | 12.7% |
| 3 | 90.9% | 10.4% | 99.0% | 15.8% | 95.4% | 1.5% | 98.9% | 13.2% |
| 4 | 90.2% | 10.4% | 98.5% | 16.1% | 93.8% | 3.8% | 97.8% | 14.1% |
| 5 | 89.7% | 10.3% | 98.3% | 16.0% | 93.7% | 4.5% | 97.7% | 14.2% |
| 6 | 89.3% | 10.4% | 98.3% | 16.0% | 92.3% | 4.7% | 97.6% | 14.3% |
| 7 | 89.3% | 10.4% | 98.3% | 16.2% | 92.0% | 5.1% | 97.6% | 14.3% |
| 8 | 89.3% | 10.4% | 98.3% | 16.2% | 92.0% | 5.4% | 97.6% | 14.3% |

# 10.Conclusion

Rare earth minerals and metals will become a key commodity for the energy transition. Hence, benchmarking these technologies based on the costs and pollution associated with the mining, building, and recycling renewable energy technologies can give us the true implications the energy transition will have on our societies.

Based on the model results, the renewable energy technologies show to be a strong energy provider for Switzerland in the long term. However, the high upfront costs per GW capacity, and the supply functions/patterns of renewable energy will require strong strategic investments towards rare-earth minerals supply-chains, and an overall update of the electricity grid. Furthermore, the Global Warming Potential (GWP) figures show that renewable energy pollution are front heavy, and we may risk reallocating the mining, building, and recycling pollution to other countries. Other risks as lower energy return on investment may have negative implication on the human development factors. Finally, elevated prices and supply shortfalls of rare earth minerals and metals show to be bottlenecks to the energy transition based on the IEA 2040 scenario.

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# Appendix

## *Activity Distribution Map 1*

| WIND Activity Distribution MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.439% | 0.471% | 0.461% | 0.379% | 0.357% | 0.218% | 0.233% | 0.232% | 0.278% | 0.363% | 0.435% | 0.358% |
| 1 AM | 0.434% | 0.461% | 0.453% | 0.374% | 0.342% | 0.218% | 0.238% | 0.234% | 0.270% | 0.356% | 0.431% | 0.355% |
| 2 AM | 0.432% | 0.455% | 0.444% | 0.385% | 0.337% | 0.212% | 0.225% | 0.225% | 0.277% | 0.348% | 0.430% | 0.365% |
| 3 AM | 0.421% | 0.462% | 0.446% | 0.392% | 0.319% | 0.216% | 0.229% | 0.233% | 0.280% | 0.351% | 0.419% | 0.358% |
| 4 AM | 0.435% | 0.462% | 0.453% | 0.391% | 0.297% | 0.196% | 0.225% | 0.235% | 0.277% | 0.347% | 0.419% | 0.361% |
| 5 AM | 0.428% | 0.457% | 0.450% | 0.355% | 0.264% | 0.170% | 0.201% | 0.220% | 0.260% | 0.334% | 0.416% | 0.372% |
| 6 AM | 0.435% | 0.433% | 0.435% | 0.314% | 0.246% | 0.164% | 0.179% | 0.196% | 0.242% | 0.300% | 0.411% | 0.369% |
| 7 AM | 0.425% | 0.404% | 0.399% | 0.289% | 0.249% | 0.154% | 0.174% | 0.186% | 0.217% | 0.270% | 0.393% | 0.346% |
| 8 AM | 0.419% | 0.391% | 0.377% | 0.284% | 0.260% | 0.179% | 0.204% | 0.178% | 0.210% | 0.250% | 0.371% | 0.318% |
| 9 AM | 0.411% | 0.389% | 0.382% | 0.312% | 0.296% | 0.229% | 0.261% | 0.208% | 0.237% | 0.243% | 0.341% | 0.281% |
| 10 AM | 0.404% | 0.385% | 0.409% | 0.339% | 0.326% | 0.282% | 0.334% | 0.265% | 0.290% | 0.246% | 0.330% | 0.268% |
| 11 AM | 0.414% | 0.390% | 0.457% | 0.363% | 0.358% | 0.322% | 0.375% | 0.312% | 0.340% | 0.275% | 0.351% | 0.258% |
| 12 PM | 0.423% | 0.401% | 0.482% | 0.372% | 0.384% | 0.336% | 0.385% | 0.340% | 0.371% | 0.293% | 0.359% | 0.253% |
| 1 PM | 0.433% | 0.397% | 0.495% | 0.386% | 0.385% | 0.330% | 0.381% | 0.340% | 0.375% | 0.301% | 0.375% | 0.252% |
| 2 PM | 0.450% | 0.408% | 0.493% | 0.381% | 0.396% | 0.323% | 0.370% | 0.339% | 0.372% | 0.304% | 0.383% | 0.266% |
| 3 PM | 0.463% | 0.424% | 0.480% | 0.378% | 0.401% | 0.312% | 0.358% | 0.312% | 0.347% | 0.314% | 0.409% | 0.285% |
| 4 PM | 0.470% | 0.449% | 0.479% | 0.362% | 0.368% | 0.281% | 0.327% | 0.288% | 0.331% | 0.339% | 0.413% | 0.316% |
| 5 PM | 0.475% | 0.469% | 0.492% | 0.336% | 0.370% | 0.252% | 0.290% | 0.273% | 0.313% | 0.359% | 0.422% | 0.335% |
| 6 PM | 0.482% | 0.478% | 0.504% | 0.324% | 0.381% | 0.242% | 0.266% | 0.249% | 0.304% | 0.365% | 0.432% | 0.353% |
| 7 PM | 0.482% | 0.473% | 0.501% | 0.345% | 0.391% | 0.246% | 0.243% | 0.253% | 0.304% | 0.351% | 0.446% | 0.357% |
| 8 PM | 0.490% | 0.471% | 0.491% | 0.360% | 0.388% | 0.247% | 0.240% | 0.248% | 0.304% | 0.355% | 0.455% | 0.375% |
| 9 PM | 0.491% | 0.474% | 0.497% | 0.368% | 0.376% | 0.226% | 0.237% | 0.243% | 0.301% | 0.371% | 0.461% | 0.383% |
| 10 PM | 0.482% | 0.469% | 0.492% | 0.364% | 0.367% | 0.218% | 0.249% | 0.247% | 0.302% | 0.383% | 0.462% | 0.376% |
| 11 PM | 0.464% | 0.466% | 0.483% | 0.367% | 0.356% | 0.216% | 0.242% | 0.239% | 0.293% | 0.357% | 0.456% | 0.370% |

## *Activity Distribution Map 2*

| SOLAR Activity Distribution MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.0007% | 0.0005% | 0.0008% | 0.0007% | 0.0007% | 0.0008% | 0.0011% | 0.0010% | 0.0008% | 0.0066% | 0.0009% | 0.0010% |
| 1 AM | 0.0007% | 0.0005% | 0.0008% | 0.0144% | 0.0007% | 0.0008% | 0.0011% | 0.0009% | 0.0116% | 0.0009% | 0.0009% | 0.0010% |
| 2 AM | 0.0006% | 0.0005% | 0.0009% | 0.0007% | 0.0016% | 0.0041% | 0.0019% | 0.0009% | 0.0008% | 0.0009% | 0.0009% | 0.0010% |
| 3 AM | 0.0007% | 0.0005% | 0.0009% | 0.0065% | 0.0525% | 0.0814% | 0.0575% | 0.0130% | 0.0009% | 0.0008% | 0.0008% | 0.0010% |
| 4 AM | 0.0006% | 0.0005% | 0.0100% | 0.1135% | 0.2432% | 0.2874% | 0.2645% | 0.1531% | 0.0414% | 0.0031% | 0.0008% | 0.0010% |
| 5 AM | 0.0007% | 0.0090% | 0.1219% | 0.3871% | 0.5454% | 0.5963% | 0.5959% | 0.4660% | 0.2615% | 0.0812% | 0.0073% | 0.0010% |
| 6 AM | 0.0170% | 0.0994% | 0.3808% | 0.7458% | 0.8742% | 0.9295% | 0.9627% | 0.8618% | 0.6083% | 0.3027% | 0.0983% | 0.0245% |
| 7 AM | 0.1064% | 0.2845% | 0.6773% | 1.0774% | 1.1605% | 1.2153% | 1.2885% | 1.2204% | 0.9566% | 0.5720% | 0.2750% | 0.1424% |
| 8 AM | 0.2352% | 0.4741% | 0.9294% | 1.3241% | 1.3603% | 1.4212% | 1.5289% | 1.4787% | 1.2272% | 0.8085% | 0.4525% | 0.2958% |
| 9 AM | 0.3431% | 0.6801% | 1.0856% | 1.4575% | 1.4672% | 1.5328% | 1.6531% | 1.6210% | 1.3867% | 0.9449% | 0.5709% | 0.4126% |
| 10 AM | 0.3915% | 0.6909% | 1.1344% | 1.4795% | 1.4820% | 1.5681% | 1.6852% | 1.6562% | 1.4251% | 0.9838% | 0.5985% | 0.4528% |
| 11 AM | 0.3675% | 0.6670% | 1.0800% | 1.4068% | 1.4175% | 1.5187% | 1.6133% | 1.5843% | 1.3476% | 0.9167% | 0.5393% | 0.4027% |
| 12 PM | 0.2837% | 0.5592% | 0.9423% | 1.2335% | 1.2770% | 1.3894% | 1.4664% | 1.4027% | 1.1696% | 0.7384% | 0.3929% | 0.2841% |
| 1 PM | 0.1592% | 0.3849% | 0.7166% | 0.9848% | 1.0512% | 1.1690% | 1.2363% | 1.1302% | 0.8886% | 0.4793% | 0.1977% | 0.1288% |
| 2 PM | 0.0412% | 0.1796% | 0.4964% | 0.6735% | 0.7616% | 0.8872% | 0.9396% | 0.7977% | 0.5368% | 0.2025% | 0.0392% | 0.0172% |
| 3 PM | 0.0016% | 0.0315% | 0.2118% | 0.3439% | 0.4526% | 0.5665% | 0.5996% | 0.4436% | 0.2044% | 0.0301% | 0.0015% | 0.0011% |
| 4 PM | 0.0008% | 0.0007% | 0.0174% | 0.0950% | 0.1902% | 0.2737% | 0.2856% | 0.1560% | 0.0263% | 0.0012% | 0.0011% | 0.0011% |
| 5 PM | 0.0007% | 0.0006% | 0.0008% | 0.0045% | 0.0877% | 0.0800% | 0.0770% | 0.0178% | 0.0008% | 0.0009% | 0.0010% | 0.0011% |
| 6 PM | 0.0007% | 0.0005% | 0.0007% | 0.0005% | 0.0008% | 0.0042% | 0.0034% | 0.0008% | 0.0007% | 0.0009% | 0.0009% | 0.0010% |
| 7 PM | 0.0007% | 0.0005% | 0.0007% | 0.0005% | 0.0005% | 0.0006% | 0.0009% | 0.0008% | 0.0007% | 0.0008% | 0.0008% | 0.0010% |
| 8 PM | 0.0007% | 0.0005% | 0.0007% | 0.0006% | 0.0006% | 0.0007% | 0.0011% | 0.0009% | 0.0007% | 0.0009% | 0.0008% | 0.0010% |
| 9 PM | 0.0183% | 0.0005% | 0.0007% | 0.0006% | 0.0007% | 0.0008% | 0.0011% | 0.0010% | 0.0008% | 0.0009% | 0.0008% | 0.0009% |
| 10 PM | 0.0006% | 0.0005% | 0.0008% | 0.0007% | 0.0007% | 0.0008% | 0.0012% | 0.0009% | 0.0008% | 0.0009% | 0.0008% | 0.0010% |
| 11 PM | 0.0006% | 0.0005% | 0.0008% | 0.0007% | 0.0007% | 0.0008% | 0.0012% | 0.0009% | 0.0170% | 0.0009% | 0.0008% | 0.0010% |

## *Activity Distribution Map 3*

| Hydro Power Map Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydro | January | February | March | April | May | June | July | August | September | October | November | December |
| | 8.29% | 7.02% | 6.83% | 5.79% | 8.23% | 12.13% | 12.52% | 11.30% | 7.86% | 6.08% | 7.28% | 6.68% |

## *Activity Distribution Map 4*

| Nuclear Activity Distribution MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuclear | January | February | March | April | May | June | July | August | September | October | November | December |
| | 11.6% | 10.5% | 11.7% | 11.4% | 8.5% | 3.4% | 6.8% | 5.6% | 6.0% | 6.9% | 6.6% | 11.0% |

# 0.1 Cost Minimization Results

*Table 0.1.1 Oil Utilization*

| Oil GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 1 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 2 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 3 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 4 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 5 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 6 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 7 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 8 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 9 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 10 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 11 AM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 12 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 1 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 2 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 3 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 4 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 5 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 6 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 7 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 8 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 9 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 10 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |
| 11 PM | 0.002053388 | 0.002053388 | 0.0020534 | 0.00205 | 0.002053 | 0.00205 | 0.0020534 | 0.00205339 | 0.002053388 | 0.002053388 | 0.002053388 | 0.002053388 |

*Table 0.1.2 Solar Utilization*

| SOLAR GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.002574805 | 0.00198231 | 0.0030317 | 0.00275 | 0.002932 | 0.00307 | 0.004487 | 0.00374556 | 0.003261989 | 0.025957716 | 0.003394295 | 0.00387652 |
| 1 AM | 0.002600877 | 0.001949186 | 0.0031741 | 0.05673 | 0.002861 | 0.00297 | 0.0044825 | 0.00353444 | 0.045778358 | 0.003465028 | 0.003472975 | 0.003915915 |
| 2 AM | 0.002553787 | 0.001927434 | 0.0033619 | 0.00281 | 0.006219 | 0.01598 | 0.0074496 | 0.00338326 | 0.003105849 | 0.003390287 | 0.003446834 | 0.003851401 |
| 3 AM | 0.002571833 | 0.001930693 | 0.0035666 | 0.02581 | 0.206917 | 0.32106 | 0.2266455 | 0.05121798 | 0.003493077 | 0.003320203 | 0.003325519 | 0.00383515 |
| 4 AM | 0.002512748 | 0.00189044 | 0.0396091 | 0.44759 | 0.958805 | 1.13321 | 1.0427982 | 0.60344298 | 0.163088033 | 0.012361096 | 0.003267257 | 0.003846879 |
| 5 AM | 0.00286358 | 0.035396476 | 0.4807647 | 1.12775 | 1.356289 | 2.26605 | 1.0849331 | 1.42809548 | 1.030866425 | 0.320030747 | 0.028959634 | 0.004009046 |
| 6 AM | 0.066864906 | 0.391845103 | 1.2216035 | 1.15666 | 1.278071 | 2.1443 | 1.1028304 | 1.42611558 | 2.092467108 | 1.193380561 | 0.387523308 | 0.096606572 |
| 7 AM | 0.419538113 | 1.12169212 | 1.4015119 | 1.28088 | 1.279372 | 2.18451 | 1.0588003 | 1.56308934 | 2.066785346 | 2.255038269 | 1.084160785 | 0.561336815 |
| 8 AM | 0.927402398 | 1.869037179 | 1.5523634 | 1.33512 | 1.344119 | 2.30733 | 1.2418796 | 1.76283593 | 2.318068134 | 2.817169697 | 1.783977258 | 1.166080307 |
| 9 AM | 1.352862309 | 2.13793912 | 1.6254594 | 1.25805 | 1.350782 | 2.34156 | 1.343276 | 1.86740499 | 2.435960581 | 3.005850772 | 2.250814842 | 1.626677279 |
| 10 AM | 1.543445759 | 2.069325905 | 1.4478059 | 1.05612 | 1.308389 | 2.22611 | 1.2848038 | 1.77892551 | 2.327623732 | 3.019836309 | 2.359481218 | 1.785027005 |
| 11 AM | 1.448805718 | 2.012350872 | 1.3893445 | 0.99141 | 1.391491 | 2.27285 | 1.3843595 | 1.79632076 | 2.315866465 | 2.966350079 | 2.126075691 | 1.587575394 |
| 12 PM | 1.118458155 | 2.052497179 | 1.4700465 | 1.01272 | 1.466545 | 2.36677 | 1.4448963 | 1.83623585 | 2.381869025 | 2.911340588 | 1.548956199 | 1.11987451 |
| 1 PM | 0.627553069 | 1.517537563 | 1.3165983 | 0.83732 | 1.333489 | 2.19645 | 1.2264296 | 1.68046119 | 2.123638582 | 1.889501113 | 0.779287257 | 0.507975296 |
| 2 PM | 0.162608181 | 0.708110567 | 1.3070239 | 0.93605 | 1.463404 | 2.35104 | 1.3810539 | 1.8391019 | 2.116181141 | 0.798546382 | 0.154593026 | 0.06799186 |
| 3 PM | 0.00645051 | 0.124263098 | 0.8349498 | 0.94366 | 1.549896 | 2.23357 | 1.4072702 | 1.74892699 | 0.805842158 | 0.118792795 | 0.005790521 | 0.004424831 |
| 4 PM | 0.002976595 | 0.002810638 | 0.0685796 | 0.37466 | 0.74994 | 1.07908 | 1.1261652 | 0.61520872 | 0.103556561 | 0.004751261 | 0.004193407 | 0.004424745 |
| 5 PM | 0.002824446 | 0.002276263 | 0.0030277 | 0.01775 | 0.345602 | 0.31543 | 0.3034829 | 0.07033836 | 0.003176976 | 0.00361697 | 0.003846706 | 0.004281541 |
| 6 PM | 0.002716764 | 0.00215284 | 0.0027497 | 0.00207 | 0.002973 | 0.01662 | 0.0133294 | 0.00333757 | 0.002837527 | 0.003405595 | 0.003635294 | 0.004108511 |
| 7 PM | 0.002684897 | 0.002063175 | 0.0026268 | 0.00206 | 0.001907 | 0.00238 | 0.00374 | 0.00335058 | 0.002750516 | 0.003347435 | 0.003325189 | 0.003989581 |
| 8 PM | 0.002663034 | 0.002022047 | 0.0027044 | 0.00224 | 0.002202 | 0.00273 | 0.0041831 | 0.00359006 | 0.002953456 | 0.003423455 | 0.003187968 | 0.003765927 |
| 9 PM | 0.072296565 | 0.002004703 | 0.0028619 | 0.0025 | 0.002708 | 0.0031 | 0.0045317 | 0.00377418 | 0.003165868 | 0.003593663 | 0.003194999 | 0.003685885 |
| 10 PM | 0.002533709 | 0.001946661 | 0.0029763 | 0.00264 | 0.002898 | 0.0031 | 0.0045997 | 0.00373328 | 0.003245157 | 0.003684267 | 0.003231102 | 0.003749182 |
| 11 PM | 0.002544267 | 0.001910278 | 0.0029942 | 0.00274 | 0.002886 | 0.00307 | 0.0045914 | 0.00373281 | 0.067132002 | 0.00371617 | 0.003344379 | 0.003774478 |

*Table 0.1.3 Wind Utilization*

| WIND GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.576821029 | 0.618341422 | 0.6059015 | 0.49785 | 0.468764 | 0.28652 | 0.3065133 | 0.30529292 | 0.365509635 | 0.477571338 | 0.571125557 | 0.470838712 |
| 1 AM | 0.570797021 | 0.606407401 | 0.5958504 | 0.49093 | 0.449978 | 0.28599 | 0.3127464 | 0.30811837 | 0.355457463 | 0.468239125 | 0.566655885 | 0.466726291 |
| 2 AM | 0.567201499 | 0.598272446 | 0.5834811 | 0.50597 | 0.443033 | 0.27842 | 0.2953607 | 0.29603583 | 0.363903994 | 0.457157376 | 0.565471981 | 0.479782423 |
| 3 AM | 0.553750401 | 0.606993333 | 0.5858461 | 0.5145 | 0.41887 | 0.28421 | 0.3006877 | 0.30621274 | 0.368258003 | 0.461122957 | 0.550112172 | 0.470125974 |
| 4 AM | 0.5720935 | 0.607316432 | 0.5949093 | 0.51397 | 0.390622 | 0.25743 | 0.2956617 | 0.30825187 | 0.364671014 | 0.455735132 | 0.550542301 | 0.473814329 |
| 5 AM | 0.562715093 | 0.600872864 | 0.5916107 | 0.46644 | 0.34675 | 0.22398 | 0.2642817 | 0.28848945 | 0.341856594 | 0.439033064 | 0.546918725 | 0.488780802 |
| 6 AM | 0.571405665 | 0.568497104 | 0.5720458 | 0.41317 | 0.323881 | 0.21497 | 0.2358247 | 0.25694907 | 0.317522821 | 0.394236132 | 0.540683949 | 0.48457386 |
| 7 AM | 0.558753065 | 0.53029384 | 0.5242151 | 0.37992 | 0.327768 | 0.20213 | 0.2287296 | 0.24426956 | 0.284736222 | 0.354370033 | 0.516659135 | 0.45529183 |
| 8 AM | 0.551195515 | 0.514479282 | 0.4949703 | 0.37384 | 0.341842 | 0.23516 | 0.2678976 | 0.23397743 | 0.276114886 | 0.328460755 | 0.487543584 | 0.417771675 |
| 9 AM | 0.539926705 | 0.51173545 | 0.5022126 | 0.40946 | 0.388575 | 0.30069 | 0.3428705 | 0.27388046 | 0.3113485 | 0.318697821 | 0.448321571 | 0.369182369 |
| 10 AM | 0.531079276 | 0.505814756 | 0.5372921 | 0.44542 | 0.428836 | 0.37037 | 0.438947 | 0.34889553 | 0.380867477 | 0.322645508 | 0.433744912 | 0.352682104 |
| 11 AM | 0.544632407 | 0.512045715 | 0.6000871 | 0.47739 | 0.470913 | 0.42363 | 0.4932367 | 0.41032245 | 0.446452214 | 0.361193934 | 0.460725553 | 0.338552012 |
| 12 PM | 0.556322547 | 0.526789414 | 0.6331153 | 0.48931 | 0.504448 | 0.44117 | 0.5053994 | 0.44731373 | 0.486912291 | 0.384656323 | 0.471745253 | 0.333078492 |
| 1 PM | 0.568495948 | 0.5217638 | 0.6500599 | 0.50669 | 0.506543 | 0.43312 | 0.5009339 | 0.4467325 | 0.492729657 | 0.395334509 | 0.49335977 | 0.330588763 |
| 2 PM | 0.591455913 | 0.535907618 | 0.6480172 | 0.50021 | 0.520695 | 0.42449 | 0.486037 | 0.44485884 | 0.488467969 | 0.399251105 | 0.50305184 | 0.349845969 |
| 3 PM | 0.607905563 | 0.556678595 | 0.6309995 | 0.49644 | 0.527179 | 0.41048 | 0.4706042 | 0.41001483 | 0.456297189 | 0.412837993 | 0.537080306 | 0.374818873 |
| 4 PM | 0.617055031 | 0.590207245 | 0.6296782 | 0.47632 | 0.483223 | 0.3693 | 0.4295899 | 0.37844348 | 0.435270559 | 0.445595538 | 0.543158766 | 0.414638694 |
| 5 PM | 0.624262825 | 0.615870467 | 0.6460385 | 0.44137 | 0.486773 | 0.33183 | 0.3808938 | 0.35818916 | 0.411273284 | 0.471814468 | 0.55504397 | 0.439916619 |
| 6 PM | 0.633929057 | 0.627748127 | 0.661849 | 0.42575 | 0.500106 | 0.31779 | 0.3494971 | 0.32758484 | 0.398890415 | 0.479304503 | 0.567621577 | 0.46364849 |
| 7 PM | 0.633728037 | 0.622014373 | 0.658654 | 0.45332 | 0.514289 | 0.32333 | 0.3192968 | 0.33230374 | 0.40016205 | 0.461785791 | 0.586533624 | 0.469126098 |
| 8 PM | 0.643825244 | 0.619244314 | 0.6455395 | 0.47292 | 0.510498 | 0.32423 | 0.3151729 | 0.3263508 | 0.399578884 | 0.466976276 | 0.598461317 | 0.492802789 |
| 9 PM | 0.644898875 | 0.623188467 | 0.6527681 | 0.48357 | 0.494419 | 0.29733 | 0.3111514 | 0.31971612 | 0.39575611 | 0.487047337 | 0.605501798 | 0.503946535 |
| 10 PM | 0.632803648 | 0.615869351 | 0.6462903 | 0.47774 | 0.482113 | 0.28687 | 0.3276402 | 0.32422943 | 0.397490397 | 0.503983167 | 0.606786415 | 0.494540589 |
| 11 PM | 0.610356894 | 0.612064705 | 0.634157 | 0.48244 | 0.467433 | 0.28346 | 0.3186217 | 0.31463122 | 0.38532115 | 0.469786118 | 0.598890397 | 0.486881163 |

*Table 0.1.4 Biofuels Utilization*

| Biofuels GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 1 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 2 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 3 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 4 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 5 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 6 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 7 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 8 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 9 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 10 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 11 AM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 12 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 1 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 2 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 3 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 4 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 5 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 6 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 7 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 8 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 9 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 10 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |
| 11 PM | 0.079055441 | 0.079055441 | 0.0790554 | 0.07906 | 0.079055 | 0.07906 | 0.0790554 | 0.07905544 | 0.079055441 | 0.079055441 | 0.079055441 | 0.079055441 |

*Table 0.1.5 Natural Gas Utilization*

| Natural Gas GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 1 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 2 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 3 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 4 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 5 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 6 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 7 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 8 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 9 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 10 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 11 AM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 12 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 1 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 2 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 3 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 4 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 5 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 6 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 7 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 8 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 9 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 10 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |
| 11 PM | 0.061031257 | 0.061031257 | 0.0610313 | 0.06103 | 0.061031 | 0.06103 | 0.0610313 | 0.06103126 | 0.061031257 | 0.061031257 | 0.061031257 | 0.061031257 |

*Table 0.1.6 Waste Utilization*

| Waste GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 1 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 2 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 3 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 4 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 5 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 6 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 7 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 8 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 9 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 10 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 11 AM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 12 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 1 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 2 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 3 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 4 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 5 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 6 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 7 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 8 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 9 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 10 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |
| 11 PM | 0.237394479 | 0.237394479 | 0.2373945 | 0.23739 | 0.237394 | 0.23739 | 0.2373945 | 0.23739448 | 0.237394479 | 0.237394479 | 0.237394479 | 0.237394479 |

*Table 0.1.7 Nuclear Utilization*

| Nuclear GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 1 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 2 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 3 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 4 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 5 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 6 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 7 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 8 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 9 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 10 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 11 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 12 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 1 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 2 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 3 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 4 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 5 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 6 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 7 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 8 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 9 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 10 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 11 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.00985 | 2.254528 | 0.89981 | 1.799617 | 1.48775964 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |

*Table 0.1.8 Hydro Powerplant Utilization*

| Hydro Power Map Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 2.07911466 | 1.651280923 | 1.0484641 | 0.71124 | 0.688876 | 1.74116 | 0.7263198 | 1.30838901 | 1.843993777 | 2.253462122 | 3.393552037 | 2.782493007 |
| 1 AM | 2.108078107 | 1.631501614 | 0.9639689 | 0.69912 | 0.835856 | 1.8269 | 0.8290299 | 1.51988102 | 1.828863186 | 2.282439592 | 3.249055204 | 2.631243601 |
| 2 AM | 2.198848023 | 1.760838242 | 1.0931478 | 0.92576 | 1.1391 | 2.0222 | 1.0227962 | 1.63255616 | 2.016600418 | 2.396132507 | 3.412022137 | 2.593790895 |
| 3 AM | 2.314607437 | 1.939853541 | 1.2110118 | 1.02969 | 1.133967 | 1.92764 | 0.9327516 | 1.63946737 | 2.161573844 | 2.50043041 | 3.540515028 | 2.702495416 |
| 4 AM | 2.376291882 | 1.961268847 | 1.1791288 | 0.71236 | 0.449203 | 1.22634 | 0.1769911 | 0.97980362 | 2.005489602 | 2.514095247 | 3.629085516 | 2.795983132 |
| 5 AM | 2.280847558 | 1.831741056 | 0.7015573 | 0 | 0 | 0 | 0 | 0 | 1.019535138 | 2.162066027 | 3.475771605 | 2.714684302 |
| 6 AM | 2.134173029 | 1.434204661 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.42864565 | 3.122577033 | 2.714660623 |
| 7 AM | 1.709474551 | 0.733816506 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.372145989 | 2.443852888 | 2.095207783 |
| 8 AM | 1.419324709 | 0.172829143 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.00593127 | 1.509208289 |
| 9 AM | 1.138644607 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.739829423 | 1.221490108 |
| 10 AM | 0.950956522 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.642725666 | 1.106837788 |
| 11 AM | 1.044337407 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.885481055 | 1.385391618 |
| 12 PM | 1.406043771 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.017288656 | 2.532226763 | 1.947302229 |
| 1 PM | 1.867582679 | 0.44842889 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.76470548 | 3.108296204 | 2.554226456 |
| 2 PM | 2.359840064 | 1.278175509 | 0 | 0 | 0 | 0 | 0 | 0 | 0.051995254 | 1.895341447 | 3.814581028 | 2.996601441 |
| 3 PM | 2.423716782 | 1.756082609 | 0.4193029 | 0 | 0 | 0.1463 | 0 | 0.15939035 | 1.455567793 | 2.491417202 | 3.870576938 | 3.004097512 |
| 4 PM | 2.350061098 | 1.798908916 | 1.1501529 | 0.60797 | 0.913232 | 1.28925 | 0.3861403 | 1.30687346 | 2.295979223 | 2.526779139 | 3.849327316 | 2.949774486 |
| 5 PM | 2.281064194 | 1.73848871 | 1.2527578 | 1.03711 | 1.296881 | 2.01741 | 1.1984364 | 1.83394479 | 2.398178054 | 2.516253142 | 3.852731898 | 2.895743304 |
| 6 PM | 2.309158769 | 1.713804672 | 1.1927195 | 1.14399 | 1.443112 | 2.24138 | 1.269946 | 1.76941333 | 2.217543881 | 2.489309301 | 3.864600652 | 2.872004515 |
| 7 PM | 2.341027501 | 1.955050889 | 1.379897 | 1.02603 | 1.137087 | 2.25003 | 1.2299383 | 1.62519199 | 2.155913523 | 2.707102555 | 3.769240872 | 2.749407754 |
| 8 PM | 2.032553442 | 1.742740598 | 1.3226058 | 0.83264 | 0.851308 | 2.17091 | 1.0816841 | 1.52528797 | 2.118426968 | 2.669892767 | 3.467349914 | 2.462200751 |
| 9 PM | 1.797540455 | 1.574383928 | 1.080928 | 0.81256 | 0.798959 | 2.06835 | 0.956168 | 1.46213159 | 2.022262753 | 2.355041649 | 3.257920037 | 2.376253087 |
| 10 PM | 1.791752513 | 1.465828944 | 0.9311838 | 0.75046 | 0.814312 | 2.00729 | 0.9139269 | 1.40122028 | 1.808583039 | 2.254641953 | 3.210285184 | 2.427110916 |
| 11 PM | 1.965656717 | 1.502242261 | 0.9868128 | 0.73433 | 0.748694 | 1.96164 | 0.8720913 | 1.36924844 | 1.752378877 | 2.348849716 | 3.415339598 | 2.578067843 |

# 0.2 GWP Minimization Results

*Table 0.2.1 Biofuels Utilization*

| Biofuels GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 0.2.2 Wind Utilization*

| WIND GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0.576821029 | 0.618341422 | 0.6059015 | 0.49784675 | 0.468764 | 0.28652218 | 0.30651325 | 0.3052929 | 0.365509635 | 0.477571338 | 0.571125557 | 0.470838712 |
| 1 AM | 0.570797021 | 0.606407401 | 0.5958504 | 0.49093321 | 0.4499783 | 0.28598609 | 0.3127464 | 0.3081184 | 0.355457463 | 0.468239125 | 0.566655885 | 0.466726291 |
| 2 AM | 0.567201499 | 0.598272446 | 0.5834811 | 0.50597042 | 0.4430329 | 0.27841896 | 0.29536069 | 0.2960358 | 0.363903994 | 0.457157376 | 0.565471981 | 0.479782423 |
| 3 AM | 0.553750401 | 0.606993333 | 0.5858461 | 0.51450219 | 0.4188704 | 0.28420787 | 0.30068773 | 0.3062127 | 0.368258003 | 0.461122957 | 0.550112172 | 0.470125974 |
| 4 AM | 0.5720935 | 0.607316432 | 0.5949093 | 0.51397345 | 0.390622 | 0.25743285 | 0.29566171 | 0.3082519 | 0.364671014 | 0.455735132 | 0.550542301 | 0.473814329 |
| 5 AM | 0.562715093 | 0.600872864 | 0.5916107 | 0.46643998 | 0.3467498 | 0.2239751 | 0.26428174 | 0.2884895 | 0.341856594 | 0.439033064 | 0.546918725 | 0.488780802 |
| 6 AM | 0.571405665 | 0.568497104 | 0.5720458 | 0.41316847 | 0.3238812 | 0.21496651 | 0.23582468 | 0.2569491 | 0.317522821 | 0.394236132 | 0.540683949 | 0.48457386 |
| 7 AM | 0.558753065 | 0.53029384 | 0.5242151 | 0.37991686 | 0.3277676 | 0.20212715 | 0.22872958 | 0.2442696 | 0.284736222 | 0.354370033 | 0.516659135 | 0.45529183 |
| 8 AM | 0.551195515 | 0.514479282 | 0.4949703 | 0.37384155 | 0.3418415 | 0.23516422 | 0.26789756 | 0.2339774 | 0.276114886 | 0.328460755 | 0.487543584 | 0.417771675 |
| 9 AM | 0.539926705 | 0.51173545 | 0.5022126 | 0.4094594 | 0.3885752 | 0.30068549 | 0.34287051 | 0.2738805 | 0.3113485 | 0.318697821 | 0.448321571 | 0.369182369 |
| 10 AM | 0.531079276 | 0.505814756 | 0.5372921 | 0.4454182 | 0.4288356 | 0.37036905 | 0.43894702 | 0.3488955 | 0.380867477 | 0.322645508 | 0.433744912 | 0.352682104 |
| 11 AM | 0.544632407 | 0.512045715 | 0.6000871 | 0.47739149 | 0.4709128 | 0.42362848 | 0.4932367 | 0.4103224 | 0.446452214 | 0.361193934 | 0.460725553 | 0.338552012 |
| 12 PM | 0.556322547 | 0.526789414 | 0.6331153 | 0.48930606 | 0.5044476 | 0.44117251 | 0.50539945 | 0.4473137 | 0.486912291 | 0.384656323 | 0.471745253 | 0.333078492 |
| 1 PM | 0.568495948 | 0.5217638 | 0.6500599 | 0.50668748 | 0.5065431 | 0.4331186 | 0.50093385 | 0.4467325 | 0.492729657 | 0.395334509 | 0.49335977 | 0.330588763 |
| 2 PM | 0.591455913 | 0.535907618 | 0.6480172 | 0.50020774 | 0.5206953 | 0.42449346 | 0.48603703 | 0.4448588 | 0.488467969 | 0.399251105 | 0.50305184 | 0.349845969 |
| 3 PM | 0.607905563 | 0.556678595 | 0.6309995 | 0.49644201 | 0.5271787 | 0.41048436 | 0.47060416 | 0.4100148 | 0.456297189 | 0.412837993 | 0.537080306 | 0.374818873 |
| 4 PM | 0.617055031 | 0.590207245 | 0.6296782 | 0.47631879 | 0.4832233 | 0.3692953 | 0.42958993 | 0.3784435 | 0.435270559 | 0.445595538 | 0.543158766 | 0.414638694 |
| 5 PM | 0.624262825 | 0.615870467 | 0.6460385 | 0.44136502 | 0.4867726 | 0.3318258 | 0.38089379 | 0.3581892 | 0.411273284 | 0.471814468 | 0.55504397 | 0.439916619 |
| 6 PM | 0.633929057 | 0.627748127 | 0.661849 | 0.42574818 | 0.5001059 | 0.31778995 | 0.34949707 | 0.3275848 | 0.398890415 | 0.479304503 | 0.567621577 | 0.46364849 |
| 7 PM | 0.633728037 | 0.622014373 | 0.658654 | 0.45332471 | 0.514289 | 0.32333389 | 0.31929682 | 0.3323037 | 0.40016205 | 0.461785791 | 0.586533624 | 0.469126098 |
| 8 PM | 0.643825244 | 0.619244314 | 0.6455395 | 0.47292391 | 0.5104981 | 0.32423244 | 0.31517286 | 0.3263508 | 0.399578884 | 0.466976276 | 0.598461317 | 0.492802789 |
| 9 PM | 0.644898875 | 0.623188467 | 0.6527681 | 0.48356751 | 0.4944195 | 0.29733048 | 0.31115144 | 0.3197161 | 0.39575611 | 0.487047337 | 0.605501798 | 0.503946535 |
| 10 PM | 0.632803648 | 0.615869351 | 0.6462903 | 0.47774188 | 0.4821131 | 0.28687467 | 0.32764018 | 0.3242294 | 0.397490397 | 0.503983167 | 0.606786415 | 0.494540589 |
| 11 PM | 0.610356894 | 0.612064705 | 0.634157 | 0.48244026 | 0.467433 | 0.28345934 | 0.31862168 | 0.3146312 | 0.38532115 | 0.469786118 | 0.598890397 | 0.486881163 |

*Table 0.2.3 Wind Utilization*

| SOLAR GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## *Table 0.2.4 Solar Utilization*

| SOLAR GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## *Table 0.2.5 Hydro Utilization*

| Hydro Power Map Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 2.46122403 | 2.032797798 | 1.4310304 | 1.09352451 | 1.0713429 | 2.12375949 | 1.11034141 | 1.6916691 | 2.226790332 | 2.658954404 | 3.776480898 | 3.165904093 |
| 1 AM | 2.490213549 | 2.012985365 | 1.3466776 | 1.13538333 | 1.2182515 | 2.20940262 | 1.21304699 | 1.90295 | 2.254176109 | 2.665439185 | 3.632062744 | 3.014694081 |
| 2 AM | 2.580936376 | 2.142300241 | 1.4760443 | 1.30810498 | 1.5248528 | 2.41771392 | 1.40978038 | 2.015474 | 2.399240833 | 2.779057359 | 3.795003536 | 2.977176862 |
| 3 AM | 2.696713835 | 2.321318799 | 1.5941129 | 1.43503475 | 1.7204184 | 2.62822683 | 1.53893171 | 2.0702199 | 2.544601486 | 2.883285178 | 3.923375112 | 3.085865131 |
| 4 AM | 2.758339195 | 2.342693853 | 1.5982725 | 1.53948684 | 1.7875422 | 2.73909156 | 1.59932379 | 1.9627812 | 2.548112201 | 2.905990908 | 4.011887338 | 3.179364576 |
| 5 AM | 2.663245703 | 2.246672097 | 1.5618566 | 1.50728875 | 1.7358238 | 2.64558488 | 1.46446769 | 1.80763 | 2.429936129 | 2.861631339 | 3.884265804 | 3.098227914 |
| 6 AM | 2.580572501 | 2.20558433 | 1.601138 | 1.53619143 | 1.6576058 | 2.52383342 | 1.482365 | 1.8056501 | 2.472001674 | 3.001560776 | 3.889634907 | 3.19080176 |
| 7 AM | 2.50854723 | 2.235043191 | 1.7810465 | 1.66041633 | 1.6589062 | 2.56404278 | 1.43833489 | 1.9426239 | 2.446319912 | 3.006718824 | 3.907548238 | 3.036079164 |
| 8 AM | 2.726261672 | 2.421400887 | 1.931898 | 1.71465101 | 1.7236538 | 2.68686088 | 1.62141416 | 2.1423705 | 2.697602699 | 3.196704262 | 4.169443094 | 3.054823161 |
| 9 AM | 2.871041482 | 2.517473685 | 2.004994 | 1.63758936 | 1.7303169 | 2.72109772 | 1.72281054 | 2.2469396 | 2.815495146 | 3.385385337 | 4.37017883 | 3.227701952 |
| 10 AM | 2.873936847 | 2.44886047 | 1.8273404 | 1.43564997 | 1.6879239 | 2.60564784 | 1.66433835 | 2.1584601 | 2.707158298 | 3.399370874 | 4.381741449 | 3.271399359 |
| 11 AM | 2.872677691 | 2.391885438 | 1.7688791 | 1.37093997 | 1.771026 | 2.65238396 | 1.76389406 | 2.1758553 | 2.695401031 | 3.345884644 | 4.391091311 | 3.352501578 |
| 12 PM | 2.904036492 | 2.432031745 | 1.8495811 | 1.39225603 | 1.8460795 | 2.74630059 | 1.8244309 | 2.2157704 | 2.76140359 | 3.308163809 | 4.460717527 | 3.446711305 |
| 1 PM | 2.874670314 | 2.345501018 | 1.6961329 | 1.21685777 | 1.7130236 | 2.57598451 | 1.60596413 | 2.0599958 | 2.503173148 | 3.033741158 | 4.267118027 | 3.441736317 |
| 2 PM | 2.90198281 | 2.365820641 | 1.6865585 | 1.31558507 | 1.8429388 | 2.73056974 | 1.76058842 | 2.2186365 | 2.54771096 | 3.073422394 | 4.34870862 | 3.444127867 |
| 3 PM | 2.809701858 | 2.259880272 | 1.6337873 | 1.32319253 | 1.9294306 | 2.75941281 | 1.78680477 | 2.2878519 | 2.640944516 | 2.989744563 | 4.255902024 | 3.388056908 |
| 4 PM | 2.732572258 | 2.181254119 | 1.598267 | 1.36216586 | 2.0427065 | 2.74786317 | 1.8918401 | 2.3016168 | 2.77907035 | 2.911064965 | 4.233055288 | 3.333733796 |
| 5 PM | 2.663423205 | 2.120299539 | 1.6353201 | 1.43439837 | 2.0220178 | 2.71237022 | 1.8814539 | 2.2838177 | 2.780889595 | 2.899404678 | 4.23611317 | 3.279559411 |
| 6 PM | 2.691410098 | 2.095492078 | 1.5750038 | 1.52559215 | 1.8256197 | 2.63753758 | 1.66280995 | 2.1522855 | 2.599915973 | 2.872249461 | 4.247770511 | 3.255647591 |
| 7 PM | 2.723246963 | 2.336648629 | 1.7620583 | 1.4076221 | 1.5185282 | 2.63193989 | 1.6132129 | 2.0080771 | 2.538198604 | 3.089984555 | 4.152100626 | 3.1329319 |
| 8 PM | 2.414751041 | 2.12429721 | 1.7048447 | 1.2144143 | 1.233045 | 2.55317244 | 1.46540175 | 1.9084126 | 2.50091499 | 3.052850788 | 3.850072447 | 2.845501244 |
| 9 PM | 2.249371585 | 1.955923197 | 1.4633245 | 1.19458981 | 1.1812018 | 2.45098864 | 1.3402342 | 1.8454403 | 2.404963186 | 2.738169878 | 3.640649601 | 2.759473537 |
| 10 PM | 2.173820787 | 1.84731017 | 1.3136947 | 1.13263524 | 1.1967443 | 2.38993217 | 1.29806117 | 1.7844881 | 2.191362762 | 2.637860786 | 3.593050852 | 2.810394663 |
| 11 PM | 2.347735549 | 1.883687104 | 1.3693415 | 1.11661023 | 1.1311151 | 2.34424527 | 1.25621733 | 1.7525158 | 2.199045444 | 2.732100451 | 3.798218542 | 2.961376887 |

## *Table 0.2.6 Nuclear Utilization*

| Nuclear GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 1 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 2 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 3 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 4 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 5 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 6 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 7 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 8 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 9 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 10 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 11 AM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 12 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 1 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 2 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 3 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 4 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 5 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 6 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 7 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 8 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 9 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 10 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |
| 11 PM | 3.071365339 | 2.783827177 | 3.1099899 | 3.0098522 | 2.2545281 | 0.89980848 | 1.79961695 | 1.4877596 | 1.600772154 | 1.826797176 | 1.75527027 | 2.908283993 |

*Table 0.2.7 Waste Utilization*

| Waste GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 0.2.8 Natural Gas Utilization*

| Natural Gas GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 0.2.9 Utilization*

| Oil GW MAP Switzerland | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 PM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 0.3 Demand Switzerland*

| | DEMAND in GWh | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Row Labels | January | February | March | April | May | June | July | August | September | October | November | December |
| 12 AM | 6.109 | 5.435 | 5.147 | 4.601 | 3.795 | 3.310 | 3.216 | 3.485 | 4.193 | 4.963 | 6.103 | 6.545 |
| 1 AM | 6.132 | 5.403 | 5.053 | 4.636 | 3.923 | 3.395 | 3.325 | 3.699 | 4.210 | 4.960 | 5.954 | 6.390 |
| 2 AM | 6.220 | 5.524 | 5.170 | 4.824 | 4.222 | 3.596 | 3.505 | 3.799 | 4.364 | 5.063 | 6.116 | 6.365 |
| 3 AM | 6.322 | 5.712 | 5.290 | 4.959 | 4.394 | 3.812 | 3.639 | 3.864 | 4.514 | 5.171 | 6.229 | 6.464 |
| 4 AM | 6.402 | 5.734 | 5.303 | 5.063 | 4.433 | 3.896 | 3.695 | 3.759 | 4.514 | 5.189 | 6.318 | 6.561 |
| 5 AM | 6.297 | 5.631 | 5.263 | 4.984 | 4.337 | 3.769 | 3.528 | 3.584 | 4.373 | 5.127 | 6.186 | 6.495 |
| 6 AM | 6.223 | 5.558 | 5.283 | 4.959 | 4.236 | 3.639 | 3.518 | 3.550 | 4.390 | 5.223 | 6.186 | 6.584 |
| 7 AM | 6.139 | 5.549 | 5.415 | 5.050 | 4.241 | 3.666 | 3.467 | 3.675 | 4.332 | 5.188 | 6.179 | 6.400 |
| 8 AM | 6.349 | 5.720 | 5.537 | 5.098 | 4.320 | 3.822 | 3.689 | 3.864 | 4.574 | 5.352 | 6.412 | 6.381 |
| 9 AM | 6.482 | 5.813 | 5.617 | 5.057 | 4.373 | 3.922 | 3.865 | 4.009 | 4.728 | 5.531 | 6.574 | 6.505 |
| 10 AM | 6.476 | 5.739 | 5.475 | 4.891 | 4.371 | 3.876 | 3.903 | 3.995 | 4.689 | 5.549 | 6.571 | 6.532 |
| 11 AM | 6.489 | 5.688 | 5.479 | 4.858 | 4.496 | 3.976 | 4.057 | 4.074 | 4.743 | 5.534 | 6.607 | 6.599 |
| 12 PM | 6.532 | 5.743 | 5.593 | 4.891 | 4.605 | 4.087 | 4.129 | 4.151 | 4.849 | 5.520 | 6.688 | 6.688 |
| 1 PM | 6.515 | 5.651 | 5.456 | 4.733 | 4.474 | 3.909 | 3.907 | 3.994 | 4.597 | 5.256 | 6.516 | 6.681 |
| 2 PM | 6.565 | 5.686 | 5.445 | 4.826 | 4.618 | 4.055 | 4.046 | 4.151 | 4.637 | 5.299 | 6.607 | 6.702 |
| 3 PM | 6.489 | 5.600 | 5.375 | 4.829 | 4.711 | 4.070 | 4.057 | 4.186 | 4.698 | 5.229 | 6.548 | 6.671 |
| 4 PM | 6.421 | 5.555 | 5.338 | 4.848 | 4.780 | 4.017 | 4.121 | 4.168 | 4.815 | 5.183 | 6.531 | 6.657 |
| 5 PM | 6.359 | 5.520 | 5.391 | 4.886 | 4.763 | 3.944 | 4.062 | 4.130 | 4.793 | 5.198 | 6.546 | 6.628 |
| 6 PM | 6.397 | 5.507 | 5.347 | 4.961 | 4.580 | 3.855 | 3.812 | 3.968 | 4.600 | 5.178 | 6.571 | 6.628 |
| 7 PM | 6.428 | 5.742 | 5.531 | 4.871 | 4.287 | 3.855 | 3.732 | 3.828 | 4.539 | 5.379 | 6.494 | 6.510 |
| 8 PM | 6.130 | 5.527 | 5.460 | 4.697 | 3.998 | 3.777 | 3.580 | 3.723 | 4.501 | 5.347 | 6.204 | 6.247 |
| 9 PM | 5.966 | 5.363 | 5.226 | 4.688 | 3.930 | 3.648 | 3.451 | 3.653 | 4.401 | 5.052 | 6.001 | 6.172 |
| 10 PM | 5.878 | 5.247 | 5.070 | 4.620 | 3.933 | 3.577 | 3.425 | 3.596 | 4.190 | 4.969 | 5.955 | 6.213 |
| 11 PM | 6.029 | 5.280 | 5.113 | 4.609 | 3.853 | 3.528 | 3.374 | 3.555 | 4.185 | 5.029 | 6.152 | 6.357 |
| Grand Total | 151.349 | 133.927 | 128.377 | 116.442 | 103.676 | 91.000 | 89.104 | 92.459 | 108.428 | 125.489 | 152.248 | 155.975 |

# 0.3 Supply Chain Risk scores

| | Fused AL Oxide | | Silicon Carbide | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Aluminium** | 2018 | 2019 | 2018 | 2019 | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
| United States | 60,000 | 60,000 | 40,000 | 40,000 | 4.71% | 78.99384054 | 3.717357202 | 57.3 |
| Argentina | — | 0 | 5,000 | 5,000 | 0.00% | 42.21330039 | 0 | |
| Australia | 50,000 | 50,000 | | | 3.92% | 91.18427531 | 3.575853934 | |
| Austria | 60,000 | 60,000 | | | 4.71% | 90.04623795 | 4.237470021 | |
| Brazil | 50,000 | 50,000 | 40,000 | 40,000 | 3.92% | 40.81806405 | 1.600708394 | |
| China | 800,000 | 800,000 | 450,000 | 450,000 | 62.75% | 44.06116374 | 27.64622039 | |
| France | 40,000 | 40,000 | 20,000 | 20,000 | 3.14% | 81.86018372 | 2.568162626 | |
| Germany | 80,000 | 80,000 | 35,000 | 35,000 | 6.27% | 89.43319956 | 5.611494875 | |
| India | 40,000 | 40,000 | 5,000 | 5,000 | 3.14% | 47.7993412 | 1.499587175 | |
| Japan | 15,000 | 15,000 | 60,000 | 60,000 | 1.18% | 88.73260625 | 1.043913015 | |
| Mexico | | | 45,000 | 45,000 | 0.00% | 31.93078709 | 0 | |
| Norway | | | 80,000 | 80,000 | 0.00% | 96.82661947 | 0 | |
| Venezuela | | | 30,000 | 30,000 | 0.00% | 3.261176288 | 0 | |
| Other | 80,000 | 80,000 | 190,000 | 190,000 | 6.27% | | | |
| World | 1,300,000 | 1,300,000 | 1,000,000 | 1,000,000 | | | **51.50076763** | |

| **Chromium** | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | — | 0 | 620 | 0% | 78.99384054 | 0.079815164 | 90.0 |
| Finland | 2,210 | 2,200 | 13,000 | 2% | 97.00160853 | 2.402829845 | |
| India | 4,300 | 4,100 | 100,000 | 17% | 47.7993412 | 8.109108926 | |
| Kazakhstan | 6,690 | 6,700 | 230,000 | 39% | 42.04158465 | 16.21727305 | |
| South Africa | 17,600 | 17,000 | 200,000 | 35% | 51.35069784 | 18.15961251 | |
| Turkey | 8,000 | 10,000 | 26,000 | 6% | 35.23606904 | 2.067237844 | |
| Other Contries | 4,250 | 4,000 | | 1% | | | |
| World total | 43,100 | 44,000 | 570,000 | | | **47.03587734** | |

| **Cobalt** | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | 490 | 500 | 55,000 | 0.07% | 78.99384054 | 0.056839679 | 68.0 |
| Australia | 4,880 | 5,100 | 71,200,000 | 92.32% | 91.18427531 | 84.17758442 | |
| Canada | 3,520 | 3,000 | 230,000 | 0.30% | 91.72706858 | 0.277088718 | |
| China | 2,000 | 2,000 | 80,000 | 0.11% | 44.06116374 | 0.046841978 | |
| Congo Kinsasha | 104,000 | 100,000 | 3,600,000 | 4.80% | 12.2685914 | 0.588520824 | |
| Cuba | 3,500 | 3,500 | 500,000 | 0.65% | 35.31973966 | 0.230559157 | |
| Madagascar | 3,300 | 3,300 | 120,000 | 0.16% | 22.70872513 | 0.036301221 | |
| Morocco | 2,100 | 2,100 | 18,000 | 0.03% | 40.62635835 | 0.010586913 | |
| New Caledonia | 2,100 | 1,600 | 0 | 0.00% | 81.86018372 | 0.00169808 | |
| Papua New Guinea | 3,280 | 3,100 | 56,000 | 0.08% | 27.11560822 | 0.020776493 | |
| Philippines | 4,600 | 4,600 | 260,000 | 0.34% | 38.35872523 | 0.131588947 | |
| Russia | 6,100 | 6,100 | 250,000 | 0.33% | 26.78473822 | 0.088932887 | |
| South Africa | 2,300 | 2,400 | 50,000 | 0.07% | 51.35069784 | 0.034885347 | |
| Other | 5,540 | 5,700 | 570,000 | 0.75% | | | |
| World | 148,000 | 140,000 | 76,989,000.00 | | | **85.70220467** | |

| Copper | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | 1,220 | 1,300 | 51,000 | 3% | 78.99384054 | 2.442708823 | 48.0 |
| Australia | 920 | 960 | 887,000 | 53% | 91.18427531 | 47.87294411 | |
| Chile | 5,830 | 5,600 | 200,000 | 12% | 73.4654541 | 8.93064983 | |
| China | 1,590 | 1,600 | 26,000 | 2% | 44.06116374 | 0.719021421 | |
| Congo | 1,230 | 1,300 | 19,000 | 1% | 12.2685914 | 0.147254144 | |
| Indonesia | 651 | 340 | 28,000 | 2% | 48.91132736 | 0.819570048 | |
| Kazakhstan | 603 | 700 | 20,000 | 1% | 42.04158465 | 0.514548369 | |
| Mexico | 751 | 770 | 53,000 | 3% | 31.93078709 | 1.015141176 | |
| Peru | 2,440 | 2,400 | 87,000 | 5% | 40.80554517 | 2.156917264 | |
| Russia | 751 | 750 | 61,000 | 4% | 26.78473822 | 0.977915099 | |
| Zambia | 854 | 790 | 19,000 | 1% | 31.76507537 | 0.371682803 | |
| Other | 3,540 | 3,800 | 220,000 | 13% | | | |
| World | 20,400 | 20,000 | 1,671,000 | | | 65.96835309 | |

| Graphite | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | | | | 0.00% | 78.99384054 | 0 | 0 |
| Austria | 1,000 | 1,000 | | 0.00% | 90.04623795 | 0.00029814 | |
| Brazil | 95,000 | 96,000 | 72,000,000 | 23.87% | 40.81806405 | 9.743574436 | |
| Canada | 40,000 | 40,000 | | 0.01% | 91.72706858 | 0.012148209 | |
| China | 693,000 | 700,000 | 73,000,000 | 24.40% | 44.06116374 | 10.75172594 | |
| Germany | 800 | 800 | | 0.00% | 89.43319956 | 0.000236888 | |
| India | 35,000 | 35,000 | 8,000,000 | 2.66% | 47.7993412 | 1.271635157 | |
| Korea, North | 6,000 | 6,000 | 2,000,000 | 0.66% | 7.275036256 | 0.048319321 | |
| Madagascar | 46,900 | 47,000 | 1,600,000 | 0.55% | 22.70872513 | 0.123834338 | |
| Mexico | 9,000 | 9,000 | 3,100,000 | 1.03% | 31.93078709 | 0.328688932 | |
| Mozambique | 104,000 | 100,000 | 25,000,000 | 8.31% | 21.38310719 | 1.77704845 | |
| Namibia | 3,460 | 3,500 | | 0.00% | 60.10453097 | 0.000696514 | |
| Norway | 16,000 | 16,000 | 600,000 | 0.20% | 96.82661947 | 0.197483227 | |
| Pakistan | 14,000 | 14,000 | | 0.00% | 24.43806529 | 0.00113279 | |
| Russia | 25,200 | 25,000 | | 0.01% | 26.78473822 | 0.002217084 | |
| Sri Lanka | 4,000 | 4,000 | | 0.00% | 44.63527362 | 0.000591144 | |
| Tanzania | 150 | 150 | 18,000,000 | 5.96% | 32.13688024 | 1.91529014 | |
| Turkey | 2,000 | 2,000 | 90,000,000 | 29.80% | 35.23606904 | 10.50012205 | |
| Ukraine | 20,000 | 20,000 | | 0.01% | 31.89271243 | 0.002111914 | |
| Vietnam | 5,000 | 5,000 | 7,600,000 | 2.52% | 42.25464598 | 1.063967642 | |
| Zimbabwe | 2,000 | 2,000 | | 0.00% | 11.34755913 | 7.51428E-05 | |
| Other | 200 | 200 | | 0.00% | | | |
| World | 1,120,000 | 1,100,000 | 300,000,000 | | | 37.74119746 | |

| | Refinery Production | | | | | Recycling Score %: |
|---|---|---|---|---|---|---|
| Indium | 2018 | 2019 | Weightd Mining | Governance Index | Weighted index | 1 |
| Belgium | 22 | 20 | 2.63% | 84.07547251 | 2.212512435 | |
| Canada | 58 | 60 | 7.89% | 91.72706858 | 7.241610678 | |
| China | 300 | 300 | 39.47% | 44.06116374 | 17.39256464 | |
| France | 40 | 50 | 6.58% | 81.86018372 | 5.385538402 | |
| Japan | 70 | 75 | 9.87% | 88.73260625 | 8.756507196 | |
| Korea, | 235 | 240 | 31.58% | 80.29484558 | 25.35626703 | |
| Peru | 11 | 10 | 1.32% | 40.80554517 | 0.536915068 | |
| Russia | 5 | 5 | 0.66% | 26.78473822 | 0.176215383 | |
| World | 741 | 760 | | | 67.05813082 | |

| | Usable Ore | | Iron Content | | Reserves | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Iron Ore | 2018 | 2019 | 2018 | 2019 | Crude Ore | Iron Content | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
| United States | 49,500 | 48,000 | 31,300 | 31,000 | 3,000 | 1,000 | 1.28% | 78.99384054 | 1.01108476 | 71.8 |
| Australia | 900,000 | 930,000 | 557,000 | 580,000 | 848,000 | 823,000 | 56.12% | 91.18427531 | 51.17077316 | |
| Brazil | 460,000 | 480,000 | 250,000 | 260,000 | 29,000 | 15,000 | 11.00% | 40.81806405 | 4.489825412 | |
| Canada | 52,400 | 54,000 | 31,500 | 33,000 | 6,000 | 2,300 | 1.41% | 91.72706858 | 1.295139583 | |
| Chile | 14,000 | 14,000 | 8,940 | 9,000 | | | 0.36% | 73.4654541 | 0.264466114 | |
| China | 335,000 | 350,000 | 209,000 | 220,000 | 20,000 | 6,900 | 9.08% | 44.06116374 | 3.998847263 | |
| India | 205,000 | 210,000 | 126,000 | 130,000 | 5,500 | 3,400 | 5.34% | 47.7993412 | 2.550481029 | |
| Iran | 36,400 | 38,000 | 23,900 | 25,000 | 2,700 | 1,500 | 1.06% | 11.8421394 | 0.125522159 | |
| Kazakhstan | 41,900 | 43,000 | 11,700 | 12,000 | 2,500 | 900 | 0.52% | 42.04158465 | 0.216926767 | |
| Mexico | 22,300 | 23,000 | 14,000 | 14,000 | | | 0.56% | 31.93078709 | 0.178805971 | |
| Peru | 14,200 | 15,000 | 9,530 | 10,000 | | | 0.40% | 40.80554517 | 0.163216305 | |
| Russia | 96,100 | 99,000 | 56,700 | 59,000 | 25,000 | 14,000 | 2.92% | 26.78473822 | 0.782086201 | |
| South Africa | 74,300 | 77,000 | 47,200 | 49,000 | 1,100 | 690 | 1.99% | 51.35069784 | 1.020609728 | |
| Sweden | 35,800 | 37,000 | 22,200 | 23,000 | 1,300 | 600 | 0.94% | 94.7515475 | 0.894422409 | |
| Ukraine | 60,300 | 62,000 | 37,700 | 39,000 | 96,500 | 92,300 | 5.25% | 31.89271243 | 1.674944959 | |
| Other | 62,500 | 62,000 | 35,800 | 35,000 | 18,000 | 9,500 | 1.78% | | | |
| World | 2,460,000 | 2,500,000 | 1,470,000 | 1,529,000 | 170,000 | 971,090 | | | 69.83715182 | |

| Lead | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | 280 | 280 | 5,000 | 0.59% | 78.99384054 | 0.466092437 | 71.7 |
| Australia | 432 | 430 | 836,000 | 93.47% | 91.18427531 | 85.2303862 | |
| Bolivia | 112 | 100 | 1,600 | 0.19% | 24.04151487 | 0.045672592 | |
| China | 2,100 | 2,100 | 18,000 | 2.25% | 44.06116374 | 0.989684857 | |
| India | 192 | 190 | 2,500 | 0.30% | 47.7993412 | 0.143687535 | |
| Kazakhstan | 86 | 90 | 2,000 | 0.23% | 42.04158465 | 0.09819068 | |
| Mexico | 240 | 240 | 5,600 | 0.65% | 31.93078709 | 0.208385442 | |
| Peru | 289 | 290 | 6,300 | 0.74% | 40.80554517 | 0.300503478 | |
| Russia | 220 | 220 | 6,400 | 0.74% | 26.78473822 | 0.198148277 | |
| Sweden | 65 | 60 | 1,100 | 0.13% | 94.7515475 | 0.122825688 | |
| Turkey | 76 | 70 | 860 | 0.10% | 35.23606904 | 0.036619744 | |
| Other | 468 | 430 | 5,000 | 0.61% | | | |
| World | 4,560 | 4,500 | 890,360 | 100.00% | | 87.84019693 | |

| Lithium | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | | | 630,000 | 0.82% | 78.99384054 | 0.649161119 | 1 |
| Argentina | 6,400 | 6,400 | 1,700,000 | 2.23% | 42.21330039 | 0.939612688 | |
| Australia | 58,800 | 42,000 | 62,800,000 | 81.97% | 91.18427531 | 74.74612298 | |
| Brazil | 300 | 300 | 95,000 | 0.12% | 40.81806405 | 0.050741585 | |
| Canada | 2,400 | 200 | 370,000 | 0.48% | 91.72706858 | 0.442947904 | |
| Chile | 17,000 | 18,000 | 8,600,000 | 11.24% | 73.4654541 | 8.258637026 | |
| China | 7,100 | 7,500 | 1,000,000 | 1.31% | 44.06116374 | 0.579054899 | |
| Namibia | 500 | 0 | | 0.00% | 60.10453097 | 0 | |
| Portugal | 800 | 1,200 | 60,000 | 0.08% | 81.46109009 | 0.065030989 | |
| Zimbabwe | 1,600 | 1,600 | 230,000 | 0.30% | 11.34755913 | 0.034281493 | |
| Other7 | — | 0 | 1,100,000 | 1.43% | | | |
| World | 895,000 | 877,000 | 76,585,000 | | | 85.76559068 | |

| Manganese | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | — | 0 | 0 | 0.00% | 78.99384054 | 0 | 53.0 |
| Australia | 3,480 | 3,200 | 12,100,000 | 94.33% | 91.18427531 | 86.01212072 | |
| Brazil | 1,310 | 1,200 | 140,000 | 1.10% | 40.81806405 | 0.449186396 | |
| Burma | 207 | 210 | | 0.00% | 8.562470357 | 0.000140139 | |
| China | 1,200 | 1,300 | 54,000 | 0.43% | 44 | 0.189898087 | |
| Cote d'Ivoire | 395 | 400 | | 0.00% | 32.82674567 | 0.001023357 | |
| Gabon | 2,330 | 2,400 | 61,000 | 0.49% | 26.47298304 | 0.130807195 | |
| Georgia | 200 | 200 | | 0.00% | 60.99433295 | 0.000950734 | |
| Ghana | 1,360 | 1,400 | 13,000 | 0.11% | 50.77295049 | 0.056981567 | |
| India | 961 | 1,000 | 34,000 | 0.27% | 47.7993412 | 0.130385546 | |
| Kazakhstan, | 140 | 130 | 5,000 | 0.04% | 42.04158465 | 0.01680877 | |
| Malaysia | 390 | 420 | | 0.00% | 62.52833112 | 0.002046754 | |
| Mexico | 210 | 190 | 5,000 | 0.04% | 31.93078709 | 0.012915656 | |
| South Africa | 5,800 | 5,500 | 260,000 | 2.07% | 51.35069784 | 1.062552434 | |
| Ukraine, | 517 | 540 | 140,000 | 1.10% | 31.89271243 | 0.349325992 | |
| Other | 397 | 910 | 0 | 0.01% | | | |
| World | 18,900 | 19,000 | 12,812,000 | 1 | | 88.41514334 | |

| Molybdenum | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | 41,400 | 44,000 | 2,700 | 15.08% | 78.99384054 | 11.91183641 | 30.0 |
| Argentinae | 600 | 600 | 100 | 0.23% | 42.21330039 | 0.095414847 | |
| Armenia | 5,000 | 5,400 | 150 | 1.79% | 46.211085 | 0.828147623 | |
| Canada | 4,680 | 4,700 | 100 | 1.55% | 91.72706858 | 1.421698034 | |
| Chile | 60,200 | 54,000 | 1,400 | 17.89% | 73.4654541 | 13.14200243 | |
| China | 133,000 | 130,000 | 8,300 | 44.66% | 44.06116374 | 19.67645037 | |
| Iran | 3,500 | 3,500 | 43 | 1.14% | 11.8421394 | 0.135478361 | |
| Mexico | 15,100 | 16,000 | 130 | 5.21% | 31.93078709 | 1.663077938 | |
| Mongolia | 1,800 | 1,800 | 210 | 0.65% | 47.26727867 | 0.306778746 | |
| Peru | 28,000 | 28,000 | 2,900 | 9.98% | 40.80554517 | 4.071423461 | |
| Russiae | 2,800 | 2,800 | 1,000 | 1.23% | 26.78473822 | 0.328654523 | |
| Turkeye | 900 | 900 | 700 | 0.52% | 35.23606904 | 0.182043864 | |
| Uzbekistane | 200 | 200 | 60 | 0.08% | 28.41022205 | | |
| World | 297,000 | 290,000 | 18,000 | 99.45% | | 53.7630066 | |

| Neodysium | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | — | — | 210,000 | 2% | 78.99384054 | 1.287533201 | 1 |
| Brazil | 59,000 | 65,000 | 11,000,000 | 86% | 40.81806405 | 35.05498085 | |
| Canada | 7,700 | 7,600 | 1,600,000 | 12% | 91.72706858 | 11.44514832 | |
| Other | 1,460 | 1,500 | | 0% | | | |
| World | 68,200 | 74,000 | 13,000,000 | | | 47.78766237 | |

| Nickel | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | 17,600 | 14,000 | 110,000 | 0.014% | 78.99384054 | 0.010988697 | 59.3 |
| Australia | 170,000 | 180,000 | 820,000,000 | 92.011% | 91.18427531 | 83.89969724 | |
| Brazil | 74,400 | 67,000 | 11,000,000 | 1.242% | 40.81806405 | 0.506773131 | |
| Canada | 176,000 | 180,000 | 2,600,000 | 0.312% | 91.72706858 | 0.286070832 | |
| China | 110,000 | 110,000 | 2,800,000 | 0.326% | 44.06116374 | 0.143840181 | |
| Cuba | 51,000 | 51,000 | 5,500,000 | 0.623% | 35.31973966 | 0.219947986 | |
| Indonesia | 606,000 | 800,000 | 21,000,000 | 2.446% | 48.91132736 | 1.196181855 | |
| New Caledonia | 216,000 | 220,000 | NA | 0.025% | 81.86018372 | 0.020203502 | |
| Philippines | 345,000 | 420,000 | 4,800,000 | 0.586% | 38.35872523 | 0.224629058 | |
| Russia | 272,000 | 270,000 | 6,900,000 | 0.804% | 26.78473822 | 0.2154457 | |
| Other | 366,000 | 370,000 | 14,000,000 | 1.612% | | | |
| World | 2,400,000 | 2,700,000 | 888,710,000 | 100.002% | | **86.72377818** | |

| Silver | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | 934 | 980 | 25,000 | 1.63% | 78.99384054 | 1.290583442 | 58.8 |
| Argentina | 1,020 | 1,200 | | 0.08% | 42.21330039 | 0.031855488 | |
| Australia | 1,220 | 1,400 | 1,090,000 | 68.63% | 91.18427531 | 62.58317805 | |
| Bolivia | 1,190 | 1,200 | 22,000 | 1.46% | 24.04151487 | 0.350754723 | |
| Chile | 1,370 | 1,300 | 26,000 | 1.72% | 73.4654541 | 1.261245203 | |
| China | 3,570 | 3,600 | 41,000 | 2.80% | 44.06116374 | 1.235789598 | |
| Mexico | 6,120 | 6,300 | 37,000 | 2.72% | 31.93078709 | 0.869463256 | |
| Peru | 4,160 | 3,800 | 120,000 | 7.79% | 40.80554517 | 3.176826832 | |
| Poland | 1,470 | 1,700 | 100,000 | 6.40% | 66.6814785 | 4.264615555 | |
| Russia | 2,100 | 2,100 | 45,000 | 2.96% | 26.78473822 | 0.793344886 | |
| Other | 3,730 | 3,600 | 57,000 | 3.81% | | | |
| World | 26,900 | 27,000 | 1,563,000 | | | **75.85765703** | |

| | Sponge Production | | Capacity | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Titanium** | 2018 | 2019 | Sponge | Pigment | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
| United States | | | 13,100 | 1,370,000 | 17.36% | 78.99384054 | 13.71275568 | 91.0 |
| Australia | | | — | 260,000 | 3.26% | 91.18427531 | 2.97557723 | |
| Canada | | | — | 104,000 | 1.31% | 91.72706858 | 1.197315988 | |
| China | 75,000 | 84,000 | 117,000 | 3,250,000 | 42.26% | 44.06116374 | 18.61988558 | |
| Germany | — | — | — | 472,000 | 5.92% | 89.43319956 | 5.298082233 | |
| India | 250 | 250 | 500 | 108,000 | 1.36% | 47.7993412 | 0.650922939 | |
| Japane | 49,000 | 54,000 | 68,800 | 314,000 | 4.80% | 88.73260625 | 4.263174355 | |
| Kazakhstane | 16,000 | 20,000 | 31,000 | 1,000 | 0.40% | 42.04158465 | 0.168852301 | |
| Mexico | — | — | — | 300,000 | 3.77% | 31.93078709 | 1.202288814 | |
| Russia | 44,000 | 44,000 | 46,500 | 55,000 | 1.27% | 26.78473822 | 0.341217563 | |
| Saudi Arabia | — | — | 15,600 | 210,000 | 2.83% | 47.99729188 | 1.35904475 | |
| Ukrainee | 8,000 | 9,000 | 12,000 | 120,000 | 1.66% | 31.89271243 | 0.528376284 | |
| United Kingdom | — | — | — | 315,000 | 3.95% | 85.93093872 | 3.397332375 | |
| Other | — | — | — | 784,000 | 9.84% | | | |
| World | 6,192,000 | 6,210,000 | 305,000 | 7,660,000 | | | **53.71482608** | |

| Vanadium | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | — | 470 | 45 | 0.28% | 78.99384054 | 0.219149556 | 1 |
| Australia | — | — | 94,000 | 50.64% | 91.18427531 | 46.17298397 | |
| Brazil | 5,500 | 7,000 | 120 | 3.84% | 40.81806405 | 1.565570157 | |
| China | 40,000 | 40,000 | 9,500 | 26.67% | 44.06116374 | 11.74901072 | |
| Russia | 18,000 | 18,000 | 5,000 | 12.39% | 26.78473822 | 3.318603599 | |
| South Africa | 7,700 | 8,000 | 3,500 | 6.19% | 51.35069784 | 3.181151319 | |
| World | 71,200 | 73,000 | 22,000 | | | **66.20646932** | |

| Zinc | 2018 | 2019 | Reserves | Weightd Mining | Governance Index | Weighted index | Recycling Score %: |
|---|---|---|---|---|---|---|---|
| United States | 824 | 780 | 11,000 | 0.86% | 78.99384054 | 0.682795202 | 41.5 |
| Australia | 1,110 | 1,300 | 1,168,000 | 85.80% | 91.18427531 | 78.23441547 | |
| Bolivia | 480 | 460 | 4,800 | 0.39% | 24.04151487 | 0.092789645 | |
| Canada | 287 | 300 | 2,200 | 0.18% | 91.72706858 | 0.168263324 | |
| China | 4,170 | 4,300 | 44,000 | 3.54% | 44.06116374 | 1.561546912 | |
| India | 750 | 800 | 7,500 | 0.61% | 47.7993412 | 0.291106528 | |
| Kazakhstan | 304 | 290 | 12,000 | 0.90% | 42.04158465 | 0.379125418 | |
| Mexico | 691 | 690 | 22,000 | 1.66% | 31.93078709 | 0.531613574 | |
| Peru | 1,470 | 1,400 | 19,000 | 1.50% | 40.80554517 | 0.610803186 | |
| Russia | 300 | 300 | 22,000 | 1.64% | 26.78473822 | 0.43827249 | |
| Sweden | 234 | 230 | 3,600 | 0.28% | 94.7515475 | 0.266279067 | |
| Other | 1,840 | 1,900 | 34,000 | 2.63% | | | |
| World | 12,500 | 13,000 | 1,339,100 | | | **83.25701081** | |

```
  ___  ____  ____  ____  ____(R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/
  Statistics/Data Analysis

   User: Keisi Kapaj
Project: Thesis - Part 2
```

```
1 . ivregress 2sls Lifeexpectancyatbirth NationalIncome GDPperCapita (kwhpercapita = Residual)

Instrumental variables (2SLS) regression          Number of obs   =        146
                                                  Wald chi2(3)    =     464.23
                                                  Prob > chi2     =     0.0000
                                                  R-squared       =     0.7634
                                                  Root MSE        =     .02419

------------------------------------------------------------------------------
Lifeexpectan~h |     Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------+--------------------------------------------------------------
  kwhpercapita |  .0343612   .0310016     1.11   0.268    -.0264007    .0951232
NationalIncome |  .1304962   .0260942     5.00   0.000     .0793526    .1816399
  GDPperCapita | -.0915458   .0386058    -2.37   0.018    -.1672117   -.0158799
         _cons |  1.583083   .0178272    88.80   0.000     1.548143    1.618024
------------------------------------------------------------------------------
Instrumented:  kwhpercapita
Instruments:   NationalIncome GDPperCapita Residual

2 . estat endog

  Tests of endogeneity
  Ho: variables are exogenous

  Durbin (score) chi2(1)          =  .127513  (p = 0.7210)
  Wu-Hausman F(1,141)             =  .123254  (p = 0.7261)

3 . estat firststage

  First-stage regression summary statistics
  --------------------------------------------------------------------------
               |            Adjusted      Partial
      Variable |   R-sq.       R-sq.        R-sq.     F(1,142)   Prob > F
  -------------+------------------------------------------------------------
  kwhpercapita |  0.8417      0.8384       0.0579      8.73301    0.0037
  --------------------------------------------------------------------------


  Minimum eigenvalue statistic = 8.73301

  Critical Values                      # of endogenous regressors:    1
  Ho: Instruments are weak             # of excluded instruments:     1
  ---------------------------------------------------------------------
                                     |    5%     10%     20%     30%
  2SLS relative bias                 |         (not available)
  -----------------------------------+---------------------------------
                                     |   10%     15%     20%     25%
  2SLS Size of nominal 5% Wald test  |  16.38    8.96    6.66    5.53
  LIML Size of nominal 5% Wald test  |  16.38    8.96    6.66    5.53
  ---------------------------------------------------------------------


4 . ivregress 2sls Expectedyearsofschooling NationalIncome GDPperCapita (kwhpercapita = Residual)

Instrumental variables (2SLS) regression          Number of obs   =        145
                                                  Wald chi2(3)    =     312.94
                                                  Prob > chi2     =     0.0000
                                                  R-squared       =     0.6868
                                                  Root MSE        =     .05477

------------------------------------------------------------------------------
Expectedyear~g |     Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------+--------------------------------------------------------------
  kwhpercapita |  .0531675   .0722325     0.74   0.462    -.0884055    .1947406
NationalIncome |  .1545424   .0610559     2.53   0.011      .034875    .2742099
  GDPperCapita | -.0704628   .0960966    -0.73   0.463    -.2588086    .1178831
         _cons |  .6137938   .0439845    13.95   0.000     .5275858    .7000017
------------------------------------------------------------------------------
Instrumented:  kwhpercapita
Instruments:   NationalIncome GDPperCapita Residual
```

```
5 . estat endog

  Tests of endogeneity
  Ho: variables are exogenous

  Durbin (score) chi2(1)          =  .024806  (p = 0.8749)
  Wu-Hausman F(1,140)             =  .023955  (p = 0.8772)

6 . estat firststage
```

First-stage regression summary statistics

| Variable | R-sq. | Adjusted R-sq. | Partial R-sq. | F(1,141) | Prob > F |
|---|---|---|---|---|---|
| kwhpercapita | 0.8399 | 0.8365 | 0.0566 | 8.45928 | 0.0042 |

Minimum eigenvalue statistic = 8.45928

| Critical Values | # of endogenous regressors: 1 | | | |
|---|---|---|---|---|
| Ho: Instruments are weak | # of excluded instruments: 1 | | | |
| 2SLS relative bias | 5% | 10% | 20% | 30% |
| | (not available) | | | |
| | 10% | 15% | 20% | 25% |
| 2SLS Size of nominal 5% Wald test | 16.38 | 8.96 | 6.66 | 5.53 |
| LIML Size of nominal 5% Wald test | 16.38 | 8.96 | 6.66 | 5.53 |

```
7 . ivregress 2sls Meanyearsofschooling NationalIncome GDPperCapita (kwhpercapita = Residual)

Instrumental variables (2SLS) regression          Number of obs   =        145
                                                  Wald chi2(3)    =     350.14
                                                  Prob > chi2     =     0.0000
                                                  R-squared       =     0.7240
                                                  Root MSE        =     .10455
```

| Meanyearsofs~g | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| kwhpercapita | .1488715 | .1378936 | 1.08 | 0.280 | -.1213951 | .4191381 |
| NationalIncome | .238623 | .1165573 | 2.05 | 0.041 | .0101748 | .4670712 |
| GDPperCapita | -.1098591 | .1834509 | -0.60 | 0.549 | -.4694162 | .2496981 |
| _cons | -.142776 | .0839675 | -1.70 | 0.089 | -.3073493 | .0217972 |

```
Instrumented:  kwhpercapita
Instruments:   NationalIncome GDPperCapita Residual

8 . estat endog

  Tests of endogeneity
  Ho: variables are exogenous

  Durbin (score) chi2(1)          =  .086392  (p = 0.7688)
  Wu-Hausman F(1,140)             =  .083463  (p = 0.7731)

9 . estat firststage
```

First-stage regression summary statistics

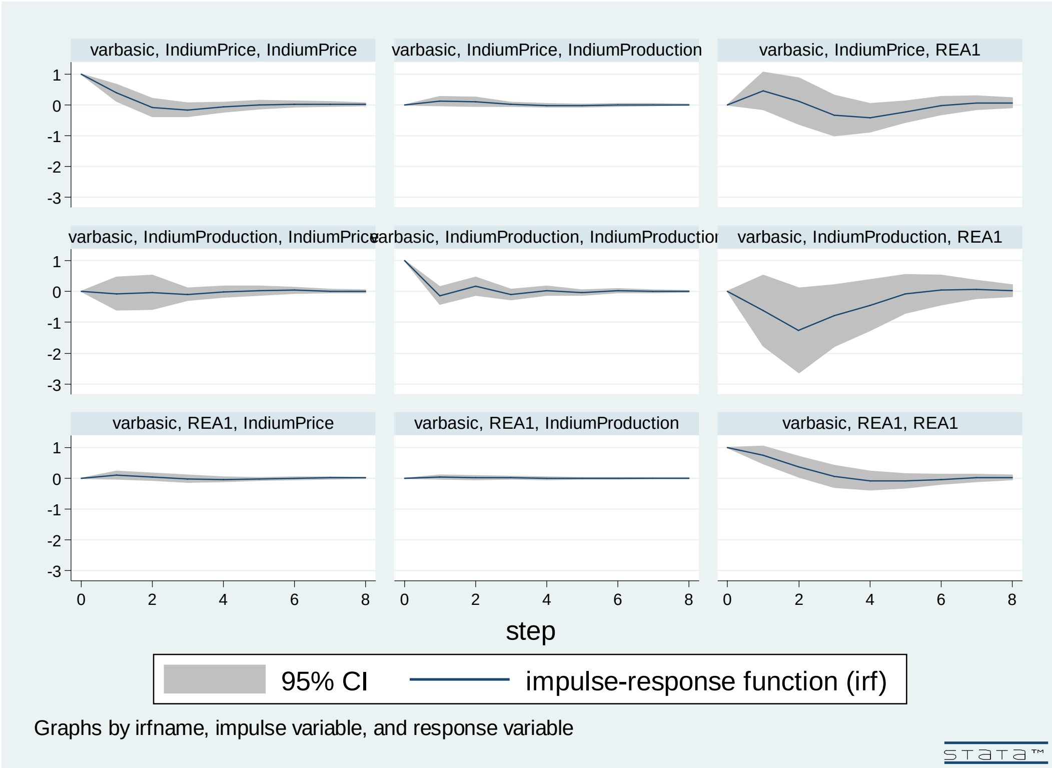
| Variable | R-sq. | Adjusted R-sq. | Partial R-sq. | F(1,141) | Prob > F |
|---|---|---|---|---|---|
| kwhpercapita | 0.8399 | 0.8365 | 0.0566 | 8.45928 | 0.0042 |

Minimum eigenvalue statistic = 8.45928

```
Critical Values                        # of endogenous regressors:    1
Ho: Instruments are weak               # of excluded instruments:     1
```

| | | | | |
|---|---|---|---|---|
| | 5% | 10% | 20% | 30% |
| 2SLS relative bias | (not available) | | | |
| | 10% | 15% | 20% | 25% |
| 2SLS Size of nominal 5% Wald test | **16.38** | **8.96** | **6.66** | **5.53** |
| LIML Size of nominal 5% Wald test | **16.38** | **8.96** | **6.66** | **5.53** |

10 .


varbasic, IndiumPrice, IndiumPrice
varbasic, IndiumPrice, IndiumProduction
varbasic, IndiumPrice, REA1
varbasic, IndiumProduction, IndiumPrice
varbasic, IndiumProduction, IndiumProduction
varbasic, IndiumProduction, REA1
varbasic, REA1, IndiumPrice
varbasic, REA1, IndiumProduction
varbasic, REA1, REA1
1
0
-1
-2
-3
0
2
4
6
8
step
95% CI
impulse-response function (irf)
Graphs by irfname, impulse variable, and response variable

```
  ___  ____  ____  ____  ____(R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/
  Statistics/Data Analysis

   User: Keisi Kapaj
Project: Thesis - Part 3
```

1 . varbasic IndiumPrice IndiumProduction REA1, lags(1/2) step(8) irf

Vector autoregression

| | | | |
|---|---|---|---|
| Sample: | 1970 - 2014 | Number of obs = | 45 |
| Log likelihood = | 53.95139 | AIC = | -1.464506 |
| FPE = | .0000468 | HQIC = | -1.150203 |
| Det(Sigma_ml) = | .0000182 | SBIC = | -.6213969 |

| Equation | Parms | RMSE | R-sq | chi2 | P>chi2 |
|---|---|---|---|---|---|
| IndiumPrice | 7 | .17337 | 0.1870 | 10.35263 | 0.1106 |
| IndiumProduction | 7 | .093334 | 0.1307 | 6.768214 | 0.3428 |
| REA1 | 7 | .376775 | 0.4694 | 39.81101 | 0.0000 |

| | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| **IndiumPrice** | | | | | | |
| IndiumPrice | | | | | | |
| L1. | .3913282 | .1396921 | 2.80 | 0.005 | .1175368 | .6651196 |
| L2. | -.2774656 | .1426399 | -1.95 | 0.052 | -.5570345 | .0021034 |
| IndiumProduction | | | | | | |
| L1. | -.0736547 | .2702025 | -0.27 | 0.785 | -.6032418 | .4559325 |
| L2. | .0490905 | .2710923 | 0.18 | 0.856 | -.4822407 | .5804217 |
| REA1 | | | | | | |
| L1. | .098126 | .0662785 | 1.48 | 0.139 | -.0317774 | .2280295 |
| L2. | -.0645198 | .0669777 | -0.96 | 0.335 | -.1957937 | .0667541 |
| _cons | .0056514 | .0260893 | 0.22 | 0.829 | -.0454827 | .0567855 |
| **IndiumProduction** | | | | | | |
| IndiumPrice | | | | | | |
| L1. | .1121667 | .075203 | 1.49 | 0.136 | -.0352285 | .2595618 |
| L2. | .0591405 | .0767899 | 0.77 | 0.441 | -.091365 | .209646 |
| IndiumProduction | | | | | | |
| L1. | -.1347798 | .1454631 | -0.93 | 0.354 | -.4198822 | .1503225 |
| L2. | .1867694 | .1459421 | 1.28 | 0.201 | -.0992719 | .4728107 |
| REA1 | | | | | | |
| L1. | .0360503 | .0356809 | 1.01 | 0.312 | -.033883 | .1059836 |
| L2. | -.0190595 | .0360573 | -0.53 | 0.597 | -.0897306 | .0516116 |
| _cons | .0226652 | .0140451 | 1.61 | 0.107 | -.0048628 | .0501932 |
| **REA1** | | | | | | |
| IndiumPrice | | | | | | |
| L1. | .4530836 | .3035842 | 1.49 | 0.136 | -.1419304 | 1.048098 |
| L2. | -.3320257 | .3099904 | -1.07 | 0.284 | -.9395958 | .2755443 |
| IndiumProduction | | | | | | |
| L1. | -.6174783 | .5872144 | -1.05 | 0.293 | -1.768397 | .5334408 |
| L2. | -.8471059 | .5891482 | -1.44 | 0.150 | -2.001815 | .3076034 |
| REA1 | | | | | | |
| L1. | .7469936 | .1440389 | 5.19 | 0.000 | .4646825 | 1.029305 |
| L2. | -.2163047 | .1455585 | -1.49 | 0.137 | -.5015941 | .0689848 |
| _cons | .0603782 | .0566983 | 1.06 | 0.287 | -.0507484 | .1715049 |

2 . varstable

Eigenvalue stability condition

| Eigenvalue | Modulus |
|---|---|
| .4132601 + .482703*i* | .635442 |
| .4132601 - .482703*i* | .635442 |
| -.534862 | .534862 |
| .4829338 | .482934 |
| .114475 + .3727593*i* | .389941 |
| .114475 - .3727593*i* | .389941 |

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

3 . predict error44, resid
(10 missing values generated)

4 . summarize error44

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| error44 | 45 | 1.24e-10 | .1611165 | -.265579 | .4872707 |

5 . tsline error44, yline(1.24e-10 )

6 . varlmar

Lagrange-multiplier test

| lag | chi2 | df | Prob > chi2 |
|---|---|---|---|
| 1 | 6.2785 | 9 | 0.71175 |
| 2 | 15.2943 | 9 | 0.08316 |

H0: no autocorrelation at lag order

7 . vargranger

Granger causality Wald tests

| Equation | Excluded | chi2 | df | Prob > chi2 |
|---|---|---|---|---|
| IndiumPrice | IndiumProduction | .12041 | 2 | 0.942 |
| IndiumPrice | REA1 | 2.1927 | 2 | 0.334 |
| IndiumPrice | ALL | 2.3191 | 4 | 0.677 |
| IndiumProduction | IndiumPrice | 3.7654 | 2 | 0.152 |
| IndiumProduction | REA1 | 1.0428 | 2 | 0.594 |
| IndiumProduction | ALL | 4.5874 | 4 | 0.332 |
| REA1 | IndiumPrice | 2.6866 | 2 | 0.261 |
| REA1 | IndiumProduction | 2.8563 | 2 | 0.240 |
| REA1 | ALL | 7.4342 | 4 | 0.115 |

8 .  irf table fevd, impulse( IndiumPrice IndiumProduction REA1 ) response( IndiumPrice IndiumProduction R
> i

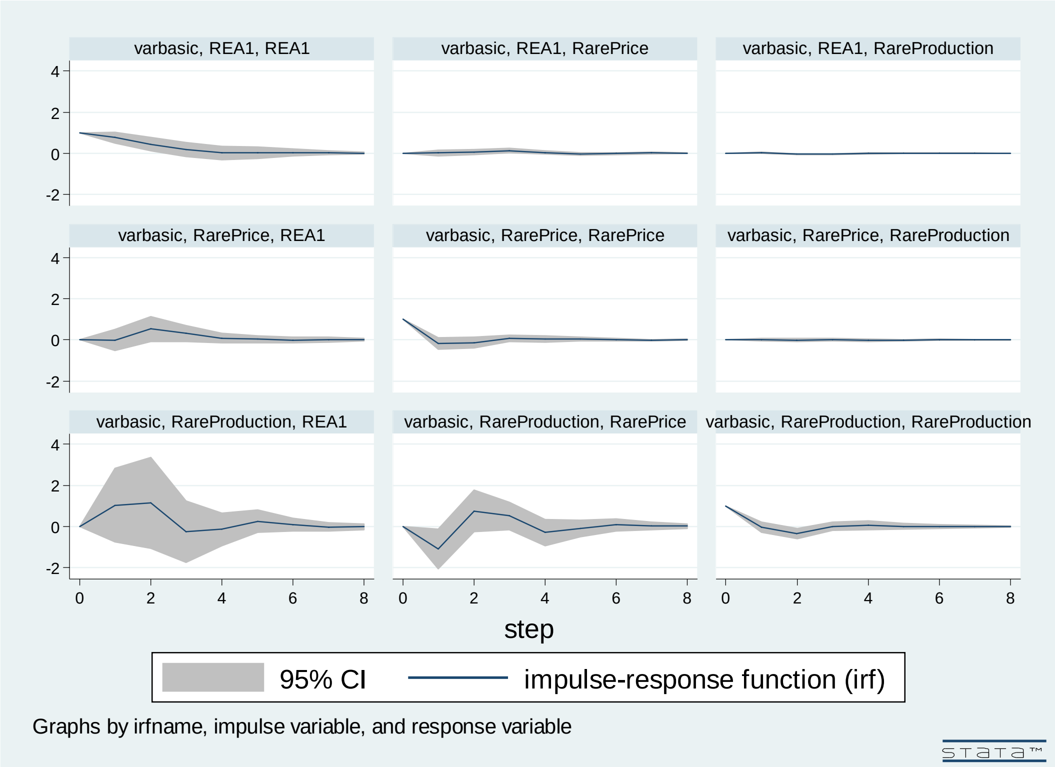
Results from varbasic

| step | (1) fevd | (2) fevd | (3) fevd | (4) fevd | (5) fevd | (6) fevd | (7) fevd | (8) fevd |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | .050863 | .137219 | 0 | .949137 | .00381 | 0 | 0 |
| 2 | .964912 | .063184 | .098485 | .000573 | .919466 | .009598 | .034515 | .01735 |
| 3 | .958612 | .098733 | .099624 | .000647 | .882673 | .054475 | .040741 | .018594 |
| 4 | .955724 | .097995 | .122367 | .002955 | .88098 | .071187 | .041321 | .021025 |
| 5 | .950807 | .098462 | .138138 | .003023 | .880351 | .075837 | .04617 | .021187 |
| 6 | .949468 | .099376 | .139947 | .003096 | .878984 | .075597 | .047437 | .02164 |
| 7 | .949218 | .099315 | .139868 | .003398 | .878584 | .075577 | .047384 | .022101 |
| 8 | .948997 | .099365 | .140351 | .003459 | .878515 | .075696 | .047544 | .02212 |

| step | (9) fevd |
|---|---|
| 0 | **0** |
| 1 | **.858971** |
| 2 | **.891918** |
| 3 | **.845901** |
| 4 | **.806447** |
| 5 | **.786025** |
| 6 | **.784456** |
| 7 | **.784554** |
| 8 | **.783953** |

(1) irfname = varbasic, impulse = IndiumPrice, and response = IndiumPrice
(2) irfname = varbasic, impulse = IndiumPrice, and response = IndiumProduction
(3) irfname = varbasic, impulse = IndiumPrice, and response = REA1
(4) irfname = varbasic, impulse = IndiumProduction, and response = IndiumPrice
(5) irfname = varbasic, impulse = IndiumProduction, and response = IndiumProduction
(6) irfname = varbasic, impulse = IndiumProduction, and response = REA1
(7) irfname = varbasic, impulse = REA1, and response = IndiumPrice
(8) irfname = varbasic, impulse = REA1, and response = IndiumProduction
(9) irfname = varbasic, impulse = REA1, and response = REA1

9 .


varbasic, REA1, REA1
varbasic, REA1, RarePrice
varbasic, REA1, RareProduction
varbasic, RarePrice, REA1
varbasic, RarePrice, RarePrice
varbasic, RarePrice, RareProduction
varbasic, RareProduction, REA1
varbasic, RareProduction, RarePrice
varbasic, RareProduction, RareProduction
4
2
0
-2
0
2
4
6
8
step
95% CI
impulse-response function (irf)
Graphs by irfname, impulse variable, and response variable

Statistics/Data Analysis

User: Keisi Kapaj
Project: Thesis - Part 3

```
1 . varbasic RarePrice RareProduction  REA1, lags(1/2) step(8) irf
```

Vector autoregression

| | | | |
|---|---|---|---|
| Sample: | **1970 - 2019** | Number of obs = | **50** |
| Log likelihood = | **77.07347** | AIC = | **-2.242939** |
| FPE = | **.0000214** | HQIC = | **-1.937133** |
| Det(Sigma_ml) = | **9.20e-06** | SBIC = | **-1.439889** |

| Equation | Parms | RMSE | R-sq | chi2 | P>chi2 |
|---|---|---|---|---|---|
| RarePrice | 7 | .203998 | 0.2054 | 12.92648 | 0.0442 |
| RareProduction | 7 | .049966 | 0.3342 | 25.10288 | 0.0003 |
| REA1 | 7 | .376431 | 0.4930 | 48.61953 | 0.0000 |

| | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| **RarePrice** | | | | | | |
| RarePrice | | | | | | |
| L1. | -.1851074 | .1399667 | -1.32 | 0.186 | -.459437 | .0892222 |
| L2. | -.151043 | .1327264 | -1.14 | 0.255 | -.4111819 | .1090958 |
| RareProduction | | | | | | |
| L1. | -1.099868 | .492721 | -2.23 | 0.026 | -2.065583 | -.1341522 |
| L2. | .4913093 | .5278916 | 0.93 | 0.352 | -.5433391 | 1.525958 |
| REA1 | | | | | | |
| L1. | .0193838 | .0732901 | 0.26 | 0.791 | -.1242622 | .1630298 |
| L2. | .0834829 | .0747177 | 1.12 | 0.264 | -.0629611 | .2299269 |
| _cons | .0456845 | .0319127 | 1.43 | 0.152 | -.0168634 | .1082323 |
| **RareProduction** | | | | | | |
| RarePrice | | | | | | |
| L1. | .0143246 | .0342827 | 0.42 | 0.676 | -.0528683 | .0815175 |
| L2. | -.0037957 | .0325093 | -0.12 | 0.907 | -.0675128 | .0599214 |
| RareProduction | | | | | | |
| L1. | -.0364317 | .1206846 | -0.30 | 0.763 | -.2729692 | .2001057 |
| L2. | -.37659 | .1292991 | -2.91 | 0.004 | -.6300115 | -.1231684 |
| REA1 | | | | | | |
| L1. | .0303275 | .0179513 | 1.69 | 0.091 | -.0048564 | .0655114 |
| L2. | -.0732706 | .018301 | -4.00 | 0.000 | -.1091399 | -.0374014 |
| _cons | .0295097 | .0078165 | 3.78 | 0.000 | .0141896 | .0448298 |
| **REA1** | | | | | | |
| RarePrice | | | | | | |
| L1. | -.0059702 | .2582768 | -0.02 | 0.982 | -.5121833 | .5002429 |
| L2. | .5199486 | .2449164 | 2.12 | 0.034 | .0399212 | .999976 |
| RareProduction | | | | | | |
| L1. | 1.030903 | .909205 | 1.13 | 0.257 | -.7511057 | 2.812913 |
| L2. | .391413 | .9741043 | 0.40 | 0.688 | -1.517796 | 2.300622 |
| REA1 | | | | | | |
| L1. | .7656831 | .1352403 | 5.66 | 0.000 | .500617 | 1.030749 |
| L2. | -.1720763 | .1378746 | -1.25 | 0.212 | -.4423055 | .0981528 |
| _cons | -.0424623 | .0588877 | -0.72 | 0.471 | -.1578802 | .0729555 |

```
2 . varstable
```

Eigenvalue stability condition

| Eigenvalue | Modulus |
|---|---|
| .1482841 + .6060266*i* | .623904 |
| .1482841 - .6060266*i* | .623904 |
| -.2557742 + .4883768*i* | .551301 |
| -.2557742 - .4883768*i* | .551301 |
| .4098917 | .409892 |
| .3492326 | .349233 |

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

```
3 . predict error33, resid
(5 missing values generated)

4 . summarize error33
```

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| error33 | 50 | 2.14e-10 | .1911003 | -.39514 | .5868568 |

```
5 . tsline error33, yline(2.14e-10)

6 . varlmar
```

Lagrange-multiplier test

| lag | chi2 | df | Prob > chi2 |
|---|---|---|---|
| 1 | 8.8846 | 9 | 0.44800 |
| 2 | 13.9454 | 9 | 0.12428 |

H0: no autocorrelation at lag order

```
7 . vargranger
```

Granger causality Wald tests

| Equation | Excluded | chi2 | df | Prob > chi2 |
|---|---|---|---|---|
| RarePrice | RareProduction | 6.1054 | 2 | 0.047 |
| RarePrice | REA1 | 2.9679 | 2 | 0.227 |
| RarePrice | ALL | 10.471 | 4 | 0.033 |
| RareProduction | RarePrice | .21198 | 2 | 0.899 |
| RareProduction | REA1 | 17.514 | 2 | 0.000 |
| RareProduction | ALL | 17.94 | 4 | 0.001 |
| REA1 | RarePrice | 4.6696 | 2 | 0.097 |
| REA1 | RareProduction | 1.3997 | 2 | 0.497 |
| REA1 | ALL | 6.4613 | 4 | 0.167 |

```
8 . irf table fevd, impulse( RarePrice RareProduction REA1 ) response( RarePrice RareProduction REA1 ) noc
```

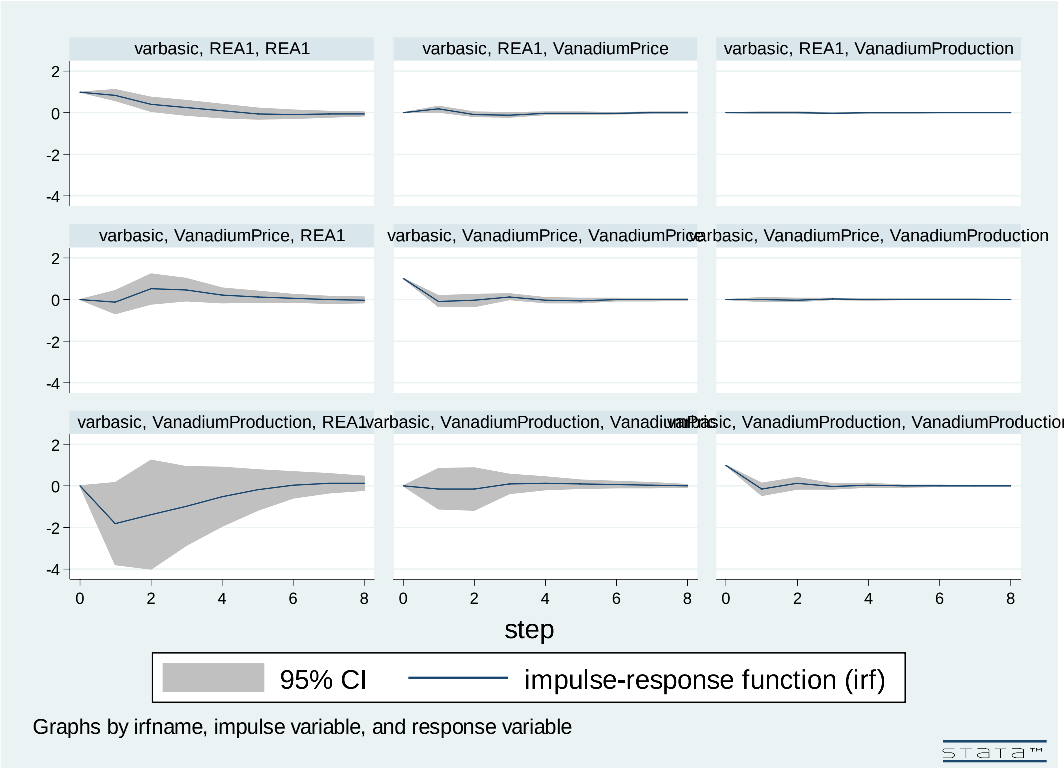
Results from varbasic

| step | (1) fevd | (2) fevd | (3) fevd | (4) fevd | (5) fevd | (6) fevd | (7) fevd | (8) fevd |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | .016332 | .001477 | 0 | .983668 | 5.4e-06 | 0 | 0 |
| 2 | .933597 | .020313 | .000968 | .065236 | .930449 | .01119 | .001167 | .049238 |
| 3 | .897754 | .016147 | .043592 | .090148 | .83459 | .021275 | .012098 | .149262 |
| 4 | .846058 | .014992 | .058508 | .096932 | .750021 | .021173 | .05701 | .234987 |
| 5 | .839427 | .023184 | .059636 | .100051 | .74354 | .021328 | .060522 | .233276 |
| 6 | .837002 | .028599 | .059657 | .100048 | .738 | .021857 | .062951 | .233401 |
| 7 | .836652 | .028935 | .059602 | .100251 | .737742 | .021904 | .063097 | .233323 |
| 8 | .836344 | .029349 | .059614 | .100202 | .737171 | .021906 | .063454 | .23348 |

| step | (9) fevd |
|---|---|
| 0 | **0** |
| 1 | **.998518** |
| 2 | **.987842** |
| 3 | **.935133** |
| 4 | **.920318** |
| 5 | **.919036** |
| 6 | **.918486** |
| 7 | **.918494** |
| 8 | **.918479** |

(1) irfname = varbasic, impulse = RarePrice, and response = RarePrice
(2) irfname = varbasic, impulse = RarePrice, and response = RareProduction
(3) irfname = varbasic, impulse = RarePrice, and response = REA1
(4) irfname = varbasic, impulse = RareProduction, and response = RarePrice
(5) irfname = varbasic, impulse = RareProduction, and response = RareProduction
(6) irfname = varbasic, impulse = RareProduction, and response = REA1
(7) irfname = varbasic, impulse = REA1, and response = RarePrice
(8) irfname = varbasic, impulse = REA1, and response = RareProduction
(9) irfname = varbasic, impulse = REA1, and response = REA1

9 .


varbasic, REA1, REA1
varbasic, REA1, VanadiumPrice
varbasic, REA1, VanadiumProduction
varbasic, VanadiumPrice, REA1
varbasic, VanadiumPrice, VanadiumPrice
varbasic, VanadiumPrice, VanadiumProduction
varbasic, VanadiumProduction, REA1
varbasic, VanadiumProduction, VanadiumPrice
varbasic, VanadiumProduction, VanadiumProduction
2
0
-2
-4
0
2
4
6
8
step
95% CI
impulse-response function (irf)
Graphs by irfname, impulse variable, and response variable

Statistics/Data Analysis

User: Keisi Kapaj
Project: Thesis - Part 3

```
1 . varbasic VanadiumPrice VanadiumProduction  REA1, lags(1/2) step(8) irf
```

Vector autoregression

| | | | |
|---|---|---|---|
| Sample: | **1970 - 2019** | Number of obs = | **50** |
| Log likelihood = | **84.04813** | AIC = | **-2.521925** |
| FPE = | **.0000162** | HQIC = | **-2.216119** |
| Det(Sigma_ml) = | **6.96e-06** | SBIC = | **-1.718875** |

| Equation | Parms | RMSE | R-sq | chi2 | P>chi2 |
|---|---|---|---|---|---|
| VanadiumPrice | **7** | **.180665** | **0.1897** | **11.70639** | **0.0688** |
| VanadiumProduc~n | **7** | **.053999** | **0.0538** | **2.841185** | **0.8285** |
| REA1 | **7** | **.368186** | **0.5150** | **53.08636** | **0.0000** |

| | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| **VanadiumPrice** | | | | | | |
| VanadiumPrice | | | | | | |
| L1. | **-.0870717** | **.1370181** | **-0.64** | **0.525** | **-.3556223** | **.1814789** |
| L2. | **-.0395604** | **.1422833** | **-0.28** | **0.781** | **-.3184305** | **.2393097** |
| VanadiumProduction | | | | | | |
| L1. | **-.1397534** | **.4960095** | **-0.28** | **0.778** | **-1.111914** | **.8324073** |
| L2. | **.1537236** | **.5019498** | **0.31** | **0.759** | **-.83008** | **1.137527** |
| REA1 | | | | | | |
| L1. | **.1818439** | **.0666095** | **2.73** | **0.006** | **.0512917** | **.312396** |
| L2. | **-.2069445** | **.0668446** | **-3.10** | **0.002** | **-.3379576** | **-.0759314** |
| _cons | **.0205741** | **.0270157** | **0.76** | **0.446** | **-.0323757** | **.0735239** |
| **VanadiumProduction** | | | | | | |
| VanadiumPrice | | | | | | |
| L1. | **-.0109584** | **.0409533** | **-0.27** | **0.789** | **-.0912255** | **.0693086** |
| L2. | **-.0274083** | **.042527** | **-0.64** | **0.519** | **-.1107598** | **.0559432** |
| VanadiumProduction | | | | | | |
| L1. | **-.1524282** | **.1482522** | **-1.03** | **0.304** | **-.4429972** | **.1381409** |
| L2. | **.1303844** | **.1500277** | **0.87** | **0.385** | **-.1636645** | **.4244334** |
| REA1 | | | | | | |
| L1. | **.0144648** | **.0199089** | **0.73** | **0.468** | **-.0245559** | **.0534855** |
| L2. | **-.0147656** | **.0199792** | **-0.74** | **0.460** | **-.0539241** | **.0243928** |
| _cons | **.0193673** | **.0080747** | **2.40** | **0.016** | **.0035411** | **.0351934** |
| **REA1** | | | | | | |
| VanadiumPrice | | | | | | |
| L1. | **-.1267078** | **.2792353** | **-0.45** | **0.650** | **-.673999** | **.4205834** |
| L2. | **.5795115** | **.2899654** | **2.00** | **0.046** | **.0111897** | **1.147833** |
| VanadiumProduction | | | | | | |
| L1. | **-1.808436** | **1.01084** | **-1.79** | **0.074** | **-3.789646** | **.1727734** |
| L2. | **-.1401569** | **1.022946** | **-0.14** | **0.891** | **-2.145094** | **1.86478** |
| REA1 | | | | | | |
| L1. | **.8502516** | **.1357464** | **6.26** | **0.000** | **.5841936** | **1.11631** |
| L2. | **-.2675444** | **.1362256** | **-1.96** | **0.050** | **-.5345417** | **-.000547** |
| _cons | **.0283389** | **.0550565** | **0.51** | **0.607** | **-.0795698** | **.1362476** |

2 . varstable

Eigenvalue stability condition

| Eigenvalue | Modulus |
|---|---|
| .5912314 + .3261711*i* | .675235 |
| .5912314 - .3261711*i* | .675235 |
| -.197975 + .5003265*i* | .538071 |
| -.197975 - .5003265*i* | .538071 |
| -.4236271 | .423627 |
| .247866 | .247866 |

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

3 . predict error11, resid
(5 missing values generated)

4 . summarize error11

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| error11 | 50 | -4.42e-10 | .169243 | -.3790916 | .3782963 |

5 . tsline error11, yline(-4.42e-10 )

6 . varlmar

Lagrange-multiplier test

| lag | chi2 | df | Prob > chi2 |
|---|---|---|---|
| 1 | 17.8585 | 9 | 0.03685 |
| 2 | 12.5871 | 9 | 0.18220 |

H0: no autocorrelation at lag order

7 . vargranger

Granger causality Wald tests

| Equation | Excluded | chi2 | df | Prob > chi2 |
|---|---|---|---|---|
| VanadiumPrice | VanadiumProduct~n | .20486 | 2 | 0.903 |
| VanadiumPrice | REA1 | 10.391 | 2 | 0.006 |
| VanadiumPrice | ALL | 10.609 | 4 | 0.031 |
| VanadiumProduct~n | VanadiumPrice | .46706 | 2 | 0.792 |
| VanadiumProduct~n | REA1 | .64515 | 2 | 0.724 |
| VanadiumProduct~n | ALL | 1.2385 | 4 | 0.872 |
| REA1 | VanadiumPrice | 4.3318 | 2 | 0.115 |
| REA1 | VanadiumProduct~n | 3.2209 | 2 | 0.200 |
| REA1 | ALL | 9.0186 | 4 | 0.061 |

8 . irf table fevd, impulse( VanadiumPrice VanadiumProduction REA1 ) response( VanadiumPrice VanadiumProdu
> 1 ) noci

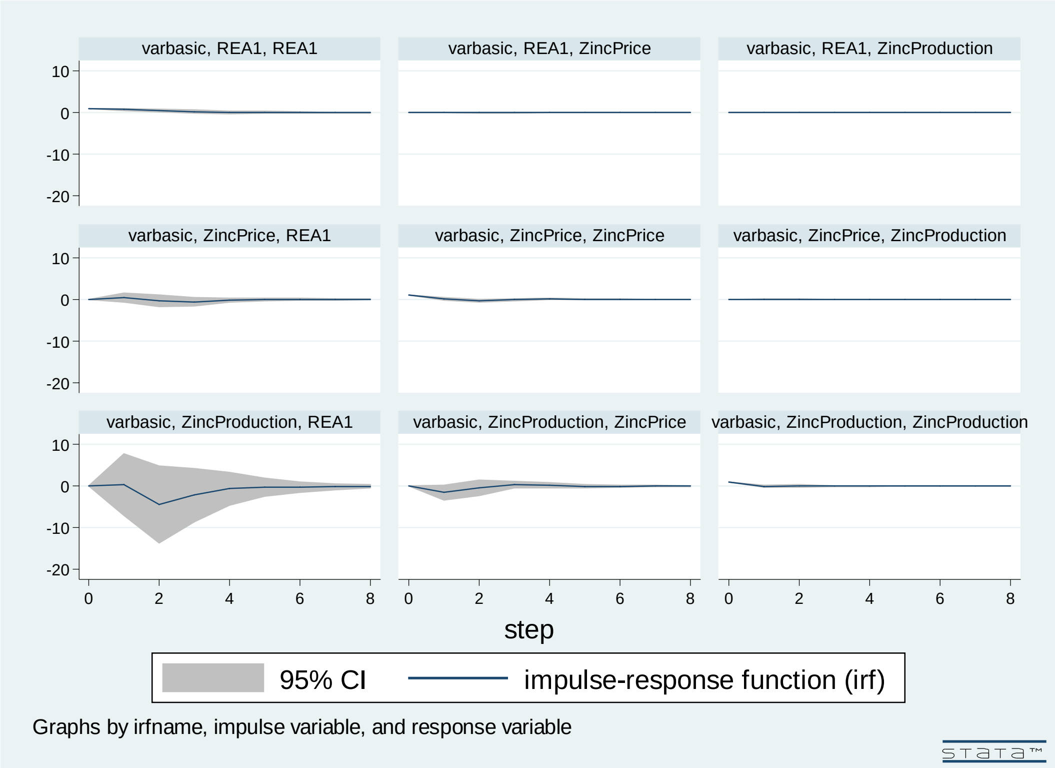
Results from varbasic

| step | (1) fevd | (2) fevd | (3) fevd | (4) fevd | (5) fevd | (6) fevd | (7) fevd | (8) fevd |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | .114571 | .005648 | 0 | .885429 | .036698 | 0 | 0 |
| 2 | .883537 | .117424 | .007848 | .000882 | .873544 | .025893 | .11558 | .009032 |
| 3 | .865914 | .117786 | .029579 | .00473 | .871443 | .029679 | .129356 | .010771 |
| 4 | .839299 | .118401 | .0477 | .004621 | .868185 | .031918 | .15608 | .013414 |
| 5 | .836729 | .11839 | .050115 | .005145 | .868176 | .033156 | .158126 | .013433 |
| 6 | .834693 | .118618 | .05115 | .005227 | .867944 | .033671 | .16008 | .013439 |
| 7 | .833305 | .118621 | .051249 | .005294 | .867924 | .033602 | .161401 | .013456 |
| 8 | .833247 | .118618 | .051196 | .005378 | .867905 | .033546 | .161375 | .013477 |

| step | (9) fevd |
|---|---|
| 0 | **0** |
| 1 | **.957654** |
| 2 | **.96626** |
| 3 | **.940742** |
| 4 | **.920382** |
| 5 | **.916729** |
| 6 | **.91518** |
| 7 | **.915149** |
| 8 | **.915258** |

(1) irfname = varbasic, impulse = VanadiumPrice, and response = VanadiumPrice
(2) irfname = varbasic, impulse = VanadiumPrice, and response = VanadiumProduction
(3) irfname = varbasic, impulse = VanadiumPrice, and response = REA1
(4) irfname = varbasic, impulse = VanadiumProduction, and response = VanadiumPrice
(5) irfname = varbasic, impulse = VanadiumProduction, and response = VanadiumProduction
(6) irfname = varbasic, impulse = VanadiumProduction, and response = REA1
(7) irfname = varbasic, impulse = REA1, and response = VanadiumPrice
(8) irfname = varbasic, impulse = REA1, and response = VanadiumProduction
(9) irfname = varbasic, impulse = REA1, and response = REA1

9 .



varbasic, REA1, REA1
varbasic, REA1, ZincPrice
varbasic, REA1, ZincProduction
varbasic, ZincPrice, REA1
varbasic, ZincPrice, ZincPrice
varbasic, ZincPrice, ZincProduction
varbasic, ZincProduction, REA1
varbasic, ZincProduction, ZincPrice
varbasic, ZincProduction, ZincProduction
10
0
-10
-20
0
2
4
6
8
step
95% CI
impulse-response function (irf)
Graphs by irfname, impulse variable, and response variable

```
  ___  ____  ____  ____  ____(R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/
  Statistics/Data Analysis

    User: Keisi Kapaj
 Project: Thesis - Part 3
```

1 . varbasic ZincPrice ZincProduction  REA1, lags(1/2) step(8) irf

Vector autoregression

| | | | | | |
|---|---|---|---|---|---|
| Sample: | **1970 - 2019** | | Number of obs | = | **50** |
| Log likelihood | = | **178.3668** | AIC | = | **-6.29467** |
| FPE | = | **3.73e-07** | HQIC | = | **-5.988864** |
| Det(Sigma_ml) | = | **1.60e-07** | SBIC | = | **-5.491621** |

| Equation | Parms | RMSE | R-sq | chi2 | P>chi2 |
|---|---|---|---|---|---|
| ZincPrice | **7** | **.095864** | **0.1594** | **9.482004** | **0.1482** |
| ZincProduction | **7** | **.014927** | **0.0748** | **4.039964** | **0.6713** |
| REA1 | **7** | **.386845** | **0.4646** | **43.38163** | **0.0000** |

| | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| **ZincPrice** | | | | | | |
| ZincPrice | | | | | | |
| L1. | **.0972489** | **.1440814** | **0.67** | **0.500** | **-.1851454** | **.3796433** |
| L2. | **-.2981991** | **.1382792** | **-2.16** | **0.031** | **-.5692214** | **-.0271769** |
| ZincProduction | | | | | | |
| L1. | **-1.562741** | **.931103** | **-1.68** | **0.093** | **-3.387669** | **.2621877** |
| L2. | **-.3825191** | **.9554966** | **-0.40** | **0.689** | **-2.255258** | **1.49022** |
| REA1 | | | | | | |
| L1. | **.0395836** | **.0373292** | **1.06** | **0.289** | **-.0335803** | **.1127474** |
| L2. | **-.0053895** | **.0354144** | **-0.15** | **0.879** | **-.0748004** | **.0640214** |
| _cons | **.0381301** | **.0178394** | **2.14** | **0.033** | **.0031656** | **.0730947** |
| **ZincProduction** | | | | | | |
| ZincPrice | | | | | | |
| L1. | **.0209841** | **.0224349** | **0.94** | **0.350** | **-.0229875** | **.0649557** |
| L2. | **.000239** | **.0215315** | **0.01** | **0.991** | **-.0419619** | **.0424399** |
| ZincProduction | | | | | | |
| L1. | **-.0535437** | **.1449821** | **-0.37** | **0.712** | **-.3377033** | **.2306159** |
| L2. | **.0025925** | **.1487804** | **0.02** | **0.986** | **-.2890117** | **.2941967** |
| REA1 | | | | | | |
| L1. | **.0068224** | **.0058125** | **1.17** | **0.241** | **-.00457** | **.0182147** |
| L2. | **-.0011793** | **.0055144** | **-0.21** | **0.831** | **-.0119873** | **.0096287** |
| _cons | **.0074774** | **.0027778** | **2.69** | **0.007** | **.002033** | **.0129217** |
| **REA1** | | | | | | |
| ZincPrice | | | | | | |
| L1. | **.4170945** | **.5814159** | **0.72** | **0.473** | **-.7224597** | **1.556649** |
| L2. | **-.7512431** | **.5580022** | **-1.35** | **0.178** | **-1.844907** | **.3424212** |
| ZincProduction | | | | | | |
| L1. | **.297657** | **3.757308** | **0.08** | **0.937** | **-7.066531** | **7.661845** |
| L2. | **-4.039985** | **3.855744** | **-1.05** | **0.295** | **-11.5971** | **3.517134** |
| REA1 | | | | | | |
| L1. | **.7436412** | **.1506355** | **4.94** | **0.000** | **.448401** | **1.038881** |
| L2. | **-.0920177** | **.1429087** | **-0.64** | **0.520** | **-.3721137** | **.1880782** |
| _cons | **.0369365** | **.0719877** | **0.51** | **0.608** | **-.1041569** | **.1780299** |

```
2 . varstable
```

Eigenvalue stability condition

| Eigenvalue | Modulus |
|---|---|
| .08931262 + .5428354*i* | .550134 |
| .08931262 - .5428354*i* | .550134 |
| .4634904 | .46349 |
| -.2280627 | .228063 |
| .1866468 + .02782901*i* | .18871 |
| .1866468 - .02782901*i* | .18871 |

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

```
3 . predict error22, resid
  (5 missing values generated)

4 . summarize error22
```

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| error22 | 50 | -4.76e-10 | .0898036 | -.1800298 | .3649224 |

```
5 . stline error22, yline(-4.76e-10)
  command stline is unrecognized
  r(199);

6 . tsline error22, yline(-4.76e-10)

7 . varlmar
```

Lagrange-multiplier test

| lag | chi2 | df | Prob > chi2 |
|---|---|---|---|
| 1 | 7.2530 | 9 | 0.61079 |
| 2 | 11.0325 | 9 | 0.27349 |

H0: no autocorrelation at lag order

```
8 . vargranger
```

Granger causality Wald tests

| Equation | Excluded | chi2 | df | Prob > chi2 |
|---|---|---|---|---|
| ZincPrice | ZincProduction | 2.8815 | 2 | 0.237 |
| ZincPrice | REA1 | 1.4225 | 2 | 0.491 |
| ZincPrice | ALL | 3.2255 | 4 | 0.521 |
| ZincProduction | ZincPrice | .88025 | 2 | 0.644 |
| ZincProduction | REA1 | 1.6793 | 2 | 0.432 |
| ZincProduction | ALL | 4.0292 | 4 | 0.402 |
| REA1 | ZincPrice | 2.2084 | 2 | 0.331 |
| REA1 | ZincProduction | 1.1274 | 2 | 0.569 |
| REA1 | ALL | 3.4625 | 4 | 0.484 |

```
9 . irf table fevd, impulse( ZincPrice ZincProduction REA1 ) response( ZincPrice ZincProduction REA1 ) noc
```

Results from varbasic

| step | (1) fevd | (2) fevd | (3) fevd | (4) fevd | (5) fevd | (6) fevd | (7) fevd | (8) fevd |
|---|---|---|---|---|---|---|---|---|
| 0 | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| 1 | **1** | **.008957** | **.064699** | **0** | **.991043** | **.10716** | **0** | **0** |
| 2 | **.947178** | **.040667** | **.093061** | **.033314** | **.934912** | **.107048** | **.019508** | **.024421** |
| 3 | **.945834** | **.043147** | **.084037** | **.032647** | **.922907** | **.095743** | **.021519** | **.033946** |
| 4 | **.944712** | **.044545** | **.085348** | **.033748** | **.918338** | **.092943** | **.02154** | **.037117** |
| 5 | **.944377** | **.045198** | **.085496** | **.033961** | **.917354** | **.092492** | **.021662** | **.037448** |
| 6 | **.944371** | **.045237** | **.085521** | **.033979** | **.917277** | **.092404** | **.02165** | **.037486** |
| 7 | **.944289** | **.045306** | **.085548** | **.034025** | **.91719** | **.092379** | **.021687** | **.037504** |
| 8 | **.944298** | **.045306** | **.085549** | **.03402** | **.91718** | **.092375** | **.021683** | **.037514** |

| step | (9) fevd |
|---|---|
| 0 | **0** |
| 1 | **.828141** |
| 2 | **.799891** |
| 3 | **.82022** |
| 4 | **.821709** |
| 5 | **.822012** |
| 6 | **.822075** |
| 7 | **.822073** |
| 8 | **.822076** |

(1) irfname = varbasic, impulse = ZincPrice, and response = ZincPrice
(2) irfname = varbasic, impulse = ZincPrice, and response = ZincProduction
(3) irfname = varbasic, impulse = ZincPrice, and response = REA1
(4) irfname = varbasic, impulse = ZincProduction, and response = ZincPrice
(5) irfname = varbasic, impulse = ZincProduction, and response = ZincProduction
(6) irfname = varbasic, impulse = ZincProduction, and response = REA1
(7) irfname = varbasic, impulse = REA1, and response = ZincPrice
(8) irfname = varbasic, impulse = REA1, and response = ZincProduction
(9) irfname = varbasic, impulse = REA1, and response = REA1

10 .