SUPPLEMENTARY MATERIAL:

A Hypothetical Chinese Energy Transition Policy and an Exploration of the Potential Implementation Obstacles

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Top-Level Model

Formulation Source: David Wheat - *Model-Based Policy Design that Takes Implementation Seriously* - in Johnston, E. W. (Ed.). (2015). Governance in the information era: Theory and practice of policy informatics. Routledge.

Electricity_Pollution(t) = Electricity_Pollution(t - dt) + (Emission_Rate - Dispersion_Rate) * dt

INIT Electricity_Pollution = Initial_Electricity_Pollution

UNITS: Tonnes*CO2eq

DOCUMENT: This stock represents the pollution coming from electricity pollution that accumulates in the atmosphere. It increases through the emission rate and decreases through the dispersion rate. It's initial value is set as the historical pollution level of 1990.

Dispersion_Rate = Electricity_Pollution/Dispersion_Time

UNITS: Tonnes*CO2eq/Years

DOCUMENT: This flow represents the natural process of pollution dispersion (sequestration in biomass, oceans, etc). As it takes time to disperse the current level of pollution, the formulation is a first order material delay.

Emission_Rate = SUM(Electricity_Generation_by_source*Emission_by_Source)

UNITS: Tonnes*CO2eq/Years

DOCUMENT: This flow represents the total amount of CO2 equivalent emissions generated from electricity production each year. It's the sum of the product of the electricity generated from each source with the carbon intensity of each source.

Dispersion_Time = 2

UNITS: Years

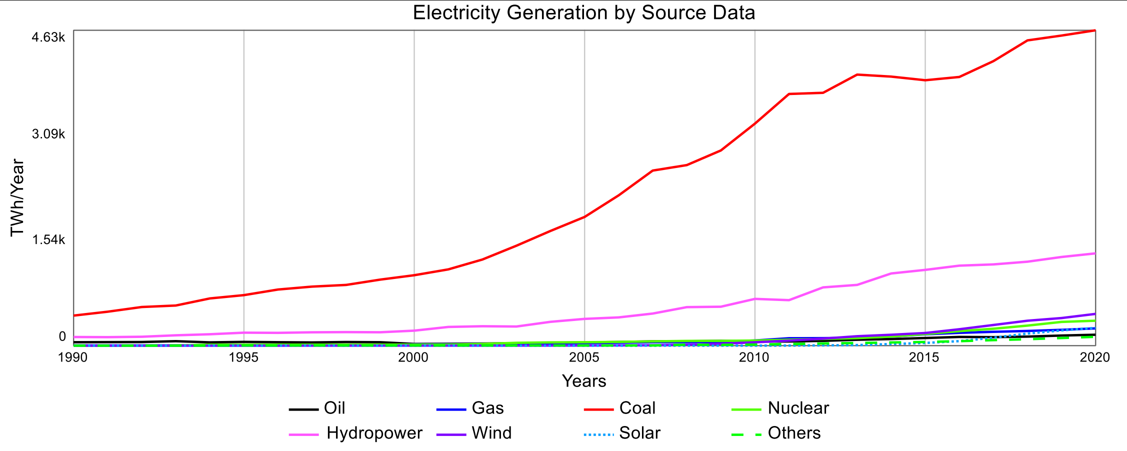
DOCUMENT: This converter represents the time it takes for natural processes of dispersion to occur.

Electricity_Generation_by_source[Energy_Source] = IF Implementation_Switch=0 THEN Calculation.Desired_Electricity_Generation_by_Source ELSE Implementation.Expected_Electricity_Generation_by_Source

UNITS: TWh/Year

DOCUMENT: This converter represents the electricity generation of each source each year.

Electricity_Generation_by_Source_Data[Energy_Source] = Electricity_Generation_by_source_Extrapolated_Data



UNITS: TWh/Year

DOCUMENT: This converter represents the historical amount of electricity generated each year by each source.

Source: Hannah Ritchie and Max Roser (2020) - "Energy". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/energy' [Online Resource]

Emission_by_Source[Energy_Source] = Emission_by_Source_in_Grams/Grams_per_Tones*kWh_per_TWh

UNITS: CO2eq*Tonnes/TWh

DOCUMENT: Also referred as Carbon Intensity, this converter represents the amount of CO2 equivalent tonnes to produce 1 Terra-Watt-hour of electricity. Each source of electricity having different values, the converter is arrayed.

Emission_by_Source_in_Grams[Energy_Source]

UNITS: Grams*CO2eq/kWh

DOCUMENT: Also referred as Carbon Intensity, this converter represents the amount of CO2 equivalent grams to produce 1 kilo-Watt-hour of electricity. Each source of electricity having different values, the converter is arrayed.

Source: Schlömer S., T. Bruckner, L. Fulton, E. Hertwich, A. McKinnon, D. Perczyk, J. Roy, R. Schaeffer, R. Sims, P. Smith, and R. Wiser, 2014: Annex III: Technology-specific cost and performance parameters. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P.Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Grams_per_Tones = 10^6

UNITS: Grams/Tonnes

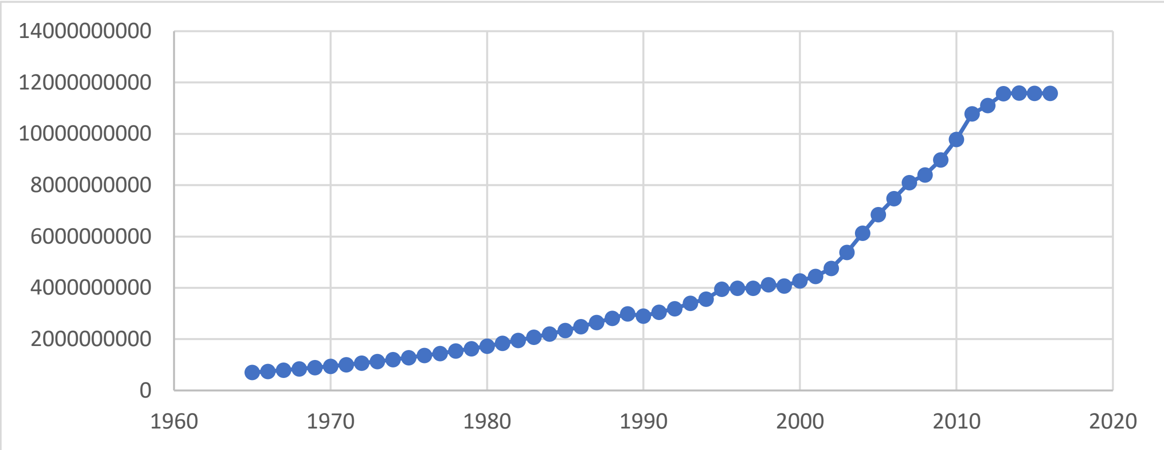
DOCUMENT: This converter converts grams to tonnes.

Historical_Electricity_Pollution = Share_of_Electricity_in_Pollution*Historical_Pollution

UNITS: Tonnes*CO2eq

DOCUMENT: This converter represents the historical electricity pollution.

Historical_Pollution = GRAPH(TIME)



UNITS: Tonnes*CO2eq

DOCUMENT: This converter represents the historical pollution of china through the 1965 till 2016 period.

Source: Hannah Ritchie and Max Roser (2020) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions' [Online Resource]

Implementation_Switch = 1

UNITS: unitless

DOCUMENT: This converter serves as a switch to turn on the implementation structure. If the switch is equal to 1 then the implementation structure is active. If the switch is equal to 0 then the implementation isn't active anymore.

Initial_Electricity_Pollution = HISTORY(Historical_Electricity_Pollution, 1990)

UNITS: Tonnes*CO2eq

DOCUMENT: This converter represents the initial value of the Electricity Pollution Stock.

kWh_per_TWh = 10^9

UNITS: kWh/TWh

DOCUMENT: This converter converts kilo-Watt-hour to Terra-Watt-hour.

Policy_Deadline = 2100 UNITS: years DOCUMENT: This converter represents the year at chich the policy ends.
Policy_Start_Time = 2020 UNITS: years DOCUMENT: This converter represents the year at which the policy starts.
Policy_Time_Period = Policy_Deadline-Policy_Start_Time UNITS: years DOCUMENT: This converter represents the amount of years the policy expands upon.
Pollution_Gap = Pollution_Goal-Electricity_Pollution UNITS: Tonnes*CO2eq DOCUMENT: This converter represents the gap between the current level of pollution and the the goal the policy sees to achieve. In other words, it's the difference between the two.
Pollution_Goal = IF(TIME<Policy_Start_Time)THEN(Electricity_Pollution)ELSE(HISTORY(Electricity_Pollution, 1990)) UNITS: Tonnes*CO2eq DOCUMENT: This converter represents the goal we desire to achieve by the end of the policy. It is set as the historical value of 1990 once the policy starts. If the policy hasn't start it will take the value of the current pollution.
Share_of_Electricity_in_Pollution = 0.5 UNITS: Dimensionless DOCUMENT: This converter represents the share of pollution comes from electricity production. It's value of 0.5 means 50% of the total emissions come from generating electricity. Source: IEA (2021), An energy sector roadmap to carbon neutrality in China, IEA, Paris https://www.iea.org/reports/an-energy-sector-roadmap-to-carbon-neutrality-in-china
Shares_in_Electricity_Mix_Data[Energy_Source] = Electricity_Generation_by_Source_Data/Total_Electricity_Generation_Data UNITS: Dimensionless DOCUMENT: This converter represents the generation shares of each electricity source in the total amount of electricity generated.
Total_Electricity_Generation_Data = SUM(Electricity_Generation_by_Source_Data)

UNITS: TWh/Year DOCUMENT: This converter represents the total electricity generated. It's the sum of all the electricity generated by each source.
Calculation sub model: DOCUMENT: This module allows the user to define the desired electricity generation by source based on the pollution gap. As one can imagine in order to achieve the pollution goal, there is many different combinations of energy mixes. Indeed, one could enforce having a lot of nuclear (which has a low carbon footprint), reduce fossil fuels and maintain renewable energies at their current level. The other could attempt to have a lot of renewables and little nuclear whilst also reducing the share of fossil fuels. In both scenarios the pollution gap could be closed. In mathematical terms, this would mean that it's impossible to express our change in shares as a function of our pollution gap (since a function from a set X to a set Y assigns to each element of X one and only one element of Y). So how do we decide which mix we want? To do so we to make the user choose the electricity mix he desires but in all cases he will have to pay attention to close the gap. See interface instructions.
Implementation sub model DOCUMENT: This module represents how we will attempt to close the gap between the goal and the current level of electricity pollution.

Calculation sub model

Change_in_Shares_from_2020_to_deadline[Energy_Source] = 0

UNITS: Dimensionless

DOCUMENT: This converter represents the change of each share in percentage from the policy start time till the policy deadline. If the change is 20, that means that we will increase the correspondent share of 20% based on the value it had in 2020.

Desired_Electricity_Generation_by_Source[Energy_Source] = IF TIME<.Policy_Start_Time THEN .Shares_in_Electricity_Mix_Data*.Total_Electricity_Generation_Data ELSE Shares_by_deadline*.Total_Electricity_Generation_Data

UNITS: TWh/Year

DOCUMENT: This converter represents the desired electricity generation of each source. In other words, it's the amount of electricity we want to generate for each source based on the increase in shares we chose.

Historical_Share_in_2020[Energy_Source]

UNITS: Dimensionless

DOCUMENT: This converter represents the historical share of electricity generation of each source for the year 2020.

Percentage_of_Shares_to_be_distributed = (1-Sum_of_Shares_by_deadline)*100

UNITS: unitless

DOCUMENT: This converter is the sum of the shares by the deadline expressed in percentage. It serves as indicator for the user (see interface).

Shares_by_deadline[Energy_Source] = (100*Historical_Share_in_2020+Change_in_Shares_from_2020_to_deadline)/100

UNITS: Dimensionless

DOCUMENT: This converter represents the shares each electricity source will have by the policy deadline.

Sum_of_Shares_by_deadline = SUM(Shares_by_deadline)

UNITS: Dimensionless

DOCUMENT: This converter is the sum of the shares by the deadline.

Implementation sub model

Formulation Source: Sterman, John. D. (2009). Business dynamics: Systems thinking and modeling for a complex world (Nachdr.). Irwin/McGraw-Hill.

Operational_Power_Capacity[Energy_Source](t) = Operational_Power_Capacity[Energy_Source](t - dt) + (Acquisition_Rate_by_Source[Energy_Source] - Discard_Rate_by_Source[Energy_Source] - Closing_Rate_by_Source[Energy_Source]) * dt INIT Operational_Power_Capacity[Energy_Source] = Implementation.Initial_Operational_Power_Capacity UNITS: GW DOCUMENT: This stock represents the operational power capacity. In other words it's the amount of power plants currently operating and producing electricity. The stock increases through acquiring new power plants. It decreases by closing and discarding the capital. Its initial value is set as a parameter.
Under_Construction_Capacity[Energy_Source](t) = Under_Construction_Capacity[Energy_Source](t - dt) + (Order_Rate_by_Source[Energy_Source] - Acquisition_Rate_by_Source[Energy_Source] - Construction_Cancellation_Rate[Energy_Source]) * dt INIT Under_Construction_Capacity[Energy_Source] = Expected_Acquisition_Delay*Desired_Acquisition_Rate_by_Source UNITS: GW DOCUMENT: This stock represents the capacity under construction. In other words it's the amount of power plants that have been ordered and yet to be build. The stock increases by ordering capital. It decreases by completing the orders (building it) and by canceling the orders.
Acquisition_Rate_by_Source[Energy_Source] = Acquisition_Obstacles.Feasible_Acquisition_Rate UNITS: GW/Years DOCUMENT: This flow represents the process of transforming orders of power plants into operational capacity. In that regards it represents the building process of capital. Its the amount of power plants that are built each year.
Closing_Rate_by_Source[Energy_Source] = MAX(Closing_Obstacles.Feasible_Closing_Rate_by_Source, 0)*Willingness_to_Close_down_Capacity UNITS: GW/Years

DOCUMENT: This flow represents the amount of capital closed each year purposefully and not by simply discarding it. The formulation is justified by the fact that only a certain share of the feasible closing rate is actually closed, based on the willingness to do so.
Construction_Cancellation_Rate[Energy_Source] = MIN(Desired_Cancellation_Rate, Maximum_Cancellation_Rate)*Share_of_Desired_canceled_orders_Canceled UNITS: GW/Years DOCUMENT: This flow represents the amount of orders that are canceled each year to reach the desired operational capital. As not all of the orders that we desire to cancel are actually canceled and that their is a maximum cancellation rate, the formulation takes the minimum between the desired cancellation rate and the desired one, then is multiplied by the share that is actually canceled.
Discard_Rate_by_Source[Energy_Source] = Operational_Power_Capacity/Average_lifetime UNITS: GW/Years DOCUMENT: This flow represents the "natural" discarding of capital. In other words, the installed capacity doesn't last forever and at one point it is incapable of producing electricity. The formulation is a first order material delay.
Order_Rate_by_Source[Energy_Source] = MAX(0, Orders_Obstacles.Feasible_Orders) UNITS: GW/Years DOCUMENT: This flow represents the amount of orders that are placed each year to build power plants. It's solely based on the feasible orders that can be placed.
Adjustment_for_Supply_Line[Energy_Source] = (Desired_Supply_Line-Under_Construction_Capacity)/Supply_Line_Adj_Time UNITS: GW/Years DOCUMENT: This converter represents the adjustment needed to order the desired supply line capital. The formulation is a classic goal-gap formulation, where the gap (difference between the desired supply line and the current one) seeks to be closed. It adjust itself through the adjustment time.
Average_lifetime[Energy_Source] UNITS: Years DOCUMENT: This converter represents the average lifetime of power plants.
Cancellation_Time[Energy_Source] = 1 UNITS: Years DOCUMENT: This parameter represents the amount of time it takes to cancel an order.
Capacity_Adjustment_by_Source[Energy_Source] = (Implementation.Desired_Future_Operational_Capital_by_Source-Operational_Power_Capacity)/Implementation.Capacity_Adj_Time UNITS: GW/Years

DOCUMENT: This converter represents the adjustment needed to acquire the desired operational capital by the policy deadline. The formulation is a classic goal-gap formulation, where the gap (difference between the desired capital and the current one) seeks to be closed.
Desired_Acquisition_Rate_by_Source[Energy_Source] = Expected_Loss_Rate+Capacity_Adjustment_by_Source UNITS: GW/Years DOCUMENT: This converter represents the true adjustment needed which also takes into account the expected loss that occurs through discarding. The formulation then reads the sum of the adjustment and expected loss.
Desired_Cancellation_Rate[Energy_Source] = MAX(0, -Indicated_Orders) UNITS: GW/Years DOCUMENT: This converter represents the desired cancellation rate. In other words it's the amount of orders that we want to cancel each year for each source. For formulation, this means we take the indicated orders that have negative values. Therefore the formulation is the maximum value between 0 and the negative value of the indicated orders.
Desired_Closing_Rate_by_Source[Energy_Source] = MAX(0, -Desired_Acquisition_Rate_by_Source) UNITS: GW/Years DOCUMENT: This converter represents the desired closing rate by source. For formulation, this means we take the desired acquisition rate that have negative values. Therefore the formulation is the maximum value between 0 and the negative value of the indicated orders.
Desired_Supply_Line[Energy_Source] = Expected_Acquisition_Delay*Desired_Acquisition_Rate_by_Source UNITS: GW DOCUMENT: This converter represents the desired supply line. In other words, its the amount of Giga-Watts we desire to have under construction.
Expected_Acquisition_Delay[Energy_Source] = Time_to_build_capacity UNITS: Years DOCUMENT: This represents the expected delay to build capital, which is equivalent to the time to build capital.
Expected_Loss_Rate[Energy_Source] = Discard_Rate_by_Source UNITS: GW/Years DOCUMENT: This converter represents the expected loss for each source that comes from discarding the capital. Equivalently it's the discard rate of each source.

Indicated_Acquisition_Rate[Energy_Source] = Under_Construction_Capacity/Time_to_build_capacity UNITS: GW/Years DOCUMENT: This converter represents the amount of power plants that we desire to build. It's a first order material delay, where each year a certain amount of capacity is built based on the time it takes to build this capacity.
Indicated_Orders[Energy_Source] = Adjustment_for_Supply_Line+Desired_Acquisition_Rate_by_Source UNITS: GW/Years DOCUMENT: This converter represents the desired orders we need to place based on the adjustment needed. Note that it needs to take into account both the desired acquisition and the adjustment that takes place in the supply line.
Maximum_Cancellation_Rate[Energy_Source] = Under_Construction_Capacity/Cancellation_Time UNITS: GW/Years DOCUMENT: This converter represents the maximum cancellation rate. It's a first order material delay stating that we can cancel more orders than the orders we have based on the time it takes to cancel them.
Share_of_Desired_canceled_orders_Canceled = 1 UNITS: Dimensionless DOCUMENT: This converter represents the share of orders that are actually canceled. It can be interpreted as the willingness to cancel orders.
Supply_Line_Adj_Time[Energy_Source] = 1 UNITS: Years DOCUMENT: This converter represents the supply line adjustment time. In other words, the time it takes for the supply line to change.
Time_to_build_capacity[Energy_Source] UNITS: Years DOCUMENT: This converter represents the time it takes to build capacity for each source of energy.
Total_Acquisition_Rate = SUM(Indicated_Acquisition_Rate) UNITS: GW/Years DOCUMENT: This converter represents the total acquisition rate that we desire.
Total_indicated_Cancellation_Rate = SUM(Desired_Cancellation_Rate) UNITS: GW/Years DOCUMENT: This converter represents the total cancellation rate that we desire.

Total_Indicated_Closing_Rate = SUM(Desired_Closing_Rate_by_Source) UNITS: GW/Years DOCUMENT: This converter represents the total closing rate that we desire.
Willingness_to_Close_down_Capacity = 1 UNITS: Dimensionless DOCUMENT: This converter represents the willingness of the actors to close down the operating capacity. The value ranges from 0 to 1. Where 0 means that actors aren't willing at all and 1 means that actors are fully willing to close the feasible capacity down.

Obstacle sub models

Acquisition Obstacles

This sub model represents the obstacles that we could come across when we try to build the capital. In other words, we may desire to build a certain amount of capital each year, but in reality we only build a certain share of that capital.

Builders_Productivity = 0.0003 UNITS: GW/People/Year DOCUMENT: This converter represents the productivity of power plants builders. In other words, it's the amount of giga-watts that one person can contribute to build each year.
Cost_of_Equipment[Energy_Source] UNITS: $/GW DOCUMENT: This converter represents the cost of 1 Giga-Watt of capacity for each energy source.
Expected_Acquisition_Rate_based_on_Builders[Energy_Source] = Expected_Builders_Rate_by_Source*Builders_Productivity*Time_to_build_capacity UNITS: GW/Years DOCUMENT: This converter represents the expected acquisition rate based on hiring builders. In other words, it's the amount of giga-watts that can be build each year based on the amount of builders hired that same year.
Expected_Acquisition_Rate_based_on_Investment[Energy_Source] = Expected_Investment_Rate_by_source/Cost_of_Equipment UNITS: GW/Years DOCUMENT: This converter represents the expected acquisition rate based on investment. In other words, it's the amount of giga-watts that can be build each year based on the investment completed that same year.
Expected_Builders_Rate_by_Source[Energy_Source] = Share_of_Builders_Rate_by_source*Expected_Total_Builders_Rate UNITS: People/Years DOCUMENT: This converter represents the expected builders rate for each source. Out of the total expected builders hired, the builders are re-distributed as indicated to the different energy sources.
Expected_Investment_Rate_by_source[Energy_Source] = Share_of_Investment_by_Source*Expected_Total_Investment_Rate UNITS: US Dollars Per Year

DOCUMENT: This converter represents the expected investment rate for each source. Out of the total expected investment rate, the budget is distributed as indicated to the different energy sources.
Expected_Total_Builders_Rate = Indicated_Total_Builders_Rate*Share_of_Indicated_Builders_hired UNITS: People/Years DOCUMENT: This converter represents the expected total builders needed for all the different source. It takes into account the fact that not all desired builders are hired. In other words, only a certain share of builders are hired.
Expected_Total_Investment_Rate = Indicated_Total_Investment_Rate*Share_of_Indicated_Investment_completed UNITS: US Dollars Per Year DOCUMENT: This converter represents the expected total investment needed for all the different source. It takes into account the fact that not all desired investment will be completed. In other words, only a certain share of investment is completed.
Feasible_Acquisition_Rate[Energy_Source] = MIN(Expected_Acquisition_Rate_based_on_Builders, Expected_Acquisition_Rate_based_on_Investment) UNITS: GW/Years DOCUMENT: This converter represents the amount of power plants that is feasible to build. The feasibility is based on the amount of builders hired to build the capacity and the investment completed to develop the capital.
Indicated_Builders_Rate_by_Source[Energy_Source] = Implementation.Indicated_Acquisition_Rate/Builders_Productivity/Time_to_build_capacit y UNITS: People/Years DOCUMENT: This converter represents the amount of builders that need to be hired. for each source This amount is based on the productivity of the builders and the amount of capacity built.
Indicated_Investment_Rate_by_Source[Energy_Source] = Implementation.Indicated_Acquisition_Rate*Cost_of_Equipment UNITS: US Dollars Per Year DOCUMENT: This converter represents the investment needed by energy source in terms of cost of equipment. It does not take into account the budget to pay the workforce.
Indicated_Total_Builders_Rate = SUM(Indicated_Builders_Rate_by_Source) UNITS: People/Years DOCUMENT: This converter represents the total builders we desire. It's the sum of the builders required for building capacity across all energy sources.

Indicated_Total_Investment_Rate = SUM(Indicated_Investment_Rate_by_Source) UNITS: US Dollars Per Year DOCUMENT: This converter represents the desired total investment needed for all the different source. It's the sum of all the investment needed for each source.
Share_of_Builders_Rate_by_source[Energy_Source] = Indicated_Builders_Rate_by_Source//Indicated_Total_Builders_Rate UNITS: Dimensionless DOCUMENT: This converter represents the share of builders each source desire in the total amount of builders.
Share_of_Indicated_Builders_hired = 1 UNITS: Dimensionless DOCUMENT: This converter represents the share of builders that are actually hired among the desired builders. If the share is equal to 1 then all the desired builders are hired. If the share is equal to 0 then none of the desired builders are hired.
Share_of_Indicated_Investment_completed = 1 UNITS: Dimensionless DOCUMENT: This converter represents the share of investment that are actually completed among the desired investment. If the share is equal to 1 then all the desired investment are completed. If the share is equal to 0 then none of the desired investment are completed.
Share_of_Investment_by_Source[Energy_Source] = Indicated_Investment_Rate_by_Source//Indicated_Total_Investment_Rate UNITS: Dimensionless DOCUMENT: This converter represents the share of investment each source represent in the total investment budget.
Time_to_build_capacity[Energy_Source] UNITS: Years DOCUMENT: This converter represents the time it takes to build capacity for each source of energy.

Orders Obstacles:

Critical_Minerals_by_Source[Energy_Source, Critical_Minerals]

UNITS: kg/MW

DOCUMENT: This converter represents the amount of minerals in kilograms that are necessary to build one Mega-Watt of capacity. For each source of energy, different types of material are needed as can be seen in the table.

Source: IEA (2021), The Role of Critical Minerals in Clean Energy Transitions, IEA, Paris https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

	Copper	Nickel	Manganese	Cobalt	Chromium	Molybdenum	Zinc	Rare ...ments	Silicon	Others
Oil	0	0	0	0	0	0	0	0	0	0
Gas	1100	0	1.8	0	48.5	0	0	0	0	0
Coal	1150	721	0	201	307.5	66.3	0	0	0	33.9
Nuclear	1473	1297.4	147.7	0	2190	0	0	0	0	94.3
Hydropower	0	0	0	0	0	0	0	0	0	0
Wind	2900	403.5	780	0	470	99	5500	239	0	0
Solar	2822.1	0	0	0	0	0	30	0	3948.3	32
Others	0	0	0	0	0	0	0	0	0	0

Expected_Orders_based_on_Critical_Minerals[Energy_Source] = Real_Indicated_Orders_by_Source*Share_of_Critical_Minerals_Acquired

UNITS: GW/Years

DOCUMENT: This converter represents the expected orders that can be placed based on the critical minerals acquired.

Feasible_Orders[Energy_Source] = Expected_Orders_based_on_Critical_Minerals

UNITS: GW/Years

DOCUMENT: This converter represents the orders that are feasible after going through the implementation obstacle of mineral resources.

Indicated_Critical_Minerals[Critical_Minerals] = SUM(Real_Indicated_Orders_by_Source[*]*Critical_Minerals_by_Source[*,Critical_Minerals])*MW_per_GW/kg_per_Tons

UNITS: Tons/Years

DOCUMENT: This converter represents the desired critical minerals the orders represent. In other words, it's the amount of tons of minerals we would need each year for the orders to be completed. The critical minerals are regrouped under different types.

Indicated_Total_Critical_Minerals = SUM(Indicated_Critical_Minerals)

UNITS: Tons/Years

DOCUMENT: This converter represents the total amount of critical minerals needed to complete orders.

kg_per_Tons = 1000

UNITS: kg/Tons

DOCUMENT: This converter transforms kilograms into tons.
MW_per_GW = 1000 UNITS: MW/GW DOCUMENT: This converter transforms Mega-Watts into Giga-Watts.
Real_Indicated_Orders_by_Source[Energy_Source] = MAX(0, Implementation.Indicated_Orders) UNITS: GW/Years DOCUMENT: This converter represents the the real desired orders. As orders can't be negative in the real world, the formulation suggest we only take the positive values of desired orders by taking the maximum between 0 and the indicated orders.
Share_of_Critical_Minerals[Critical_Minerals] = Indicated_Critical_Minerals//Indicated_Total_Critical_Minerals UNITS: Dimensionless DOCUMENT: This converter represents the share of critical minerals that are needed for the orders to be completed in the total amount of minerals needed. It indicates which mineral is most critical.
Share_of_Critical_Minerals_Acquired = 1 UNITS: Dimensionless DOCUMENT: This converter represents the share of mineral acquired and therefore the amount of orders that can be placed.

Closing Obstacles

Closing_Workforce_Salary = 50128.96 UNITS: $/People/Years DOCUMENT: This converter represents the amount of money an worker receives each year he is working to close down capital.
Expected_Budget_for_Closing_Workforce = Indicated_Budget_for_Closing_Workforce*Share_of_Budget_for_Closing_Workforce_Covered UNITS: US Dollars Per Year DOCUMENT: This converter represents the total budget expected to cover the salary of the closing workforce. In other words, it's the real budget for the closing workforce. It takes into account that the desired budget may not totally be covered but only a certain share of it.
Expected_Budget_for_Unemployment = Indicated_Budget_for_Unemployment*Share_of_Budget_for_Unemployment_Covered UNITS: US Dollars Per Year DOCUMENT: This converter represents the total budget expected to cover the job loss. In other words, it's the real budget for the unemployment. It takes into account that the desired budget may not totally be covered but only a certain share of it.
Expected_Closing_Rate_by_Source_based_on_Budget_for_Closing_Workforce[Energy_Source] = Expected_Closing_Workforce_by_Source*Workforce_Closing_Productivity*Time_to_Close_Capacity UNITS: GW/Years DOCUMENT: This converter represents the expected closing rate based on the budget allocated to the closing workforce. In other words, it's the amount of giga-watts that can be closed each year based on the salaries of the workforce.
Expected_Closing_Rate_by_Source_based_on_Budget_for_unemployment[Energy_Source] = Expected_Job_Loss_by_Source/Workers_in_Operational_Capacity UNITS: GW/Years DOCUMENT: This converter represents the expected closing rate based on the budget allocated to unemployment. In other words, it's the amount of giga-watts that can be closed each year based on the job loss coverage.
Expected_Closing_Workforce_by_Source[Energy_Source] = Expected_Total_Closing_Workforce*Share_of_Closing_Workforce_by_Source UNITS: People/Years DOCUMENT: This converter represents the expected closing workforce for each source. Out of the total closing workforce, the workforce is distributed as indicated by the different energy sources.

Expected_Job_Loss_by_Source[Energy_Source] = Share_of_Job_Loss_by_Source*Expected_Total_Job_Loss UNITS: People/Years DOCUMENT: This converter represents the expected job loss for each source. Out of the total expected job loss, the losses is distributed as indicated by the different energy sources.
Expected_Total_Closing_Workforce = Expected_Budget_for_Closing_Workforce/Closing_Workforce_Salary/Time_to_Close_Capacity UNITS: People/Years DOCUMENT: This parameter represents the real total workforce hired to close down capital. It takes into account the budget that is actually covered.
Expected_Total_Job_Loss = Expected_Budget_for_Unemployment/Time_Unemployed/Unemployed_Salary UNITS: People/Years DOCUMENT: This parameter represents the real total loss of jobs, by taking into account the budget that is actually covered.
Feasible_Closing_Rate_by_Source[Energy_Source] = MIN(Expected_Closing_Rate_by_Source_based_on_Budget_for_unemployment, Expected_Closing_Rate_by_Source_based_on_Budget_for_Closing_Workforce) UNITS: GW/Years DOCUMENT: This converter represents the amount of capital that are feasible to close after going through the implementation obstacle of budget for unemployment and closing workforce.
Indicated_Budget_for_Closing_Workforce = Indicated_Total_Closing_Workforce*Closing_Workforce_Salary*Time_to_Close_Capacity UNITS: US Dollars Per Year DOCUMENT: This converter represents the total budget needed to pay the workforce responsible for closing the capital. In other words, it's the budget for the closing the capital. It takes into account how much a worker would receive and for how long it will take to close down capacity.
Indicated_Budget_for_Unemployment = Indicated_Total_Job_Loss*Time_Unemployed*Unemployed_Salary UNITS: US Dollars Per Year DOCUMENT: This converter represents the total budget needed to cover the job loss. In other words, it's the budget for the unemployment. It takes into account how much an unemployed worker would receive and for how long he will stay unemployed.

Indicated_Closing_Workforce_by_Source[Energy_Source] = Implementation.Desired_Closing_Rate_by_Source/Workforce_Closing_Productivity/Time_to_Close_Capacity

UNITS: People/Years

DOCUMENT: This converter represents the desired workforce needed to close down the capital. It's measured by taking into account the workers' productivity and the time it takes to close capacity.

Indicated_Job_Loss_by_Source[Energy_Source] = Implementation.Desired_Closing_Rate_by_Source*Workers_in_Operational_Capacity

UNITS: People/Years

DOCUMENT: This converter represents the indicated job loss that comes from closing down capacity. It's measured by taking into account the amount of workers that worked in the operational capacity.

Indicated_Total_Closing_Workforce = SUM(Indicated_Closing_Workforce_by_Source)

UNITS: People/Years

DOCUMENT: This parameter represents the total workforce desired to close down capital, taking into account all the energy sources. It's therefore the sum of the workforce needed for all energy sources.

Indicated_Total_Job_Loss = SUM(Indicated_Job_Loss_by_Source)

UNITS: People/Years

DOCUMENT: This parameter represents the total loss of jobs, taking into account all the energy sources. It's therefore the sum of the loses of all energy sources.

Share_of_Budget_for_Closing_Workforce_Covered = 1

UNITS: Dimensionless

DOCUMENT: This converter represents the share of the budget that actually covers the desired budget for the closing workforce. If the share is equal to 1 then all the desired budget is covered. If the share is equal to 0 then none of the desired budget is covered.

Share_of_Budget_for_Unemployment_Covered = 1

UNITS: Dimensionless

DOCUMENT: This converter represents the share of the budget that actually covers the unemployment. If the share is equal to 1 then all the desired budget is covered. If the share is equal to 0 then none of the desired budget is covered.

Share_of_Closing_Workforce_by_Source[Energy_Source] = Indicated_Closing_Workforce_by_Source//Indicated_Total_Closing_Workforce

UNITS: Dimensionless

DOCUMENT: This converter represents the share of closing workforce each energy source represent in the total workforce needed.

Share_of_Job_Loss_by_Source[Energy_Source] = Indicated_Job_Loss_by_Source//Indicated_Total_Job_Loss UNITS: Dimensionless DOCUMENT: This converter represents the share of job loss each energy source represent in the total job loss.
Time_to_Close_Capacity = 1 UNITS: Years DOCUMENT: This converter represents the time it takes to close down capacity.
Time_Unemployed = 1 UNITS: Years DOCUMENT: This converter represents the time a worker who lost his job remains unemployed.
Unemployed_Salary = 2856 UNITS: $/People/Years DOCUMENT: This converter represents the amount of money an unemployed worker receives each year he is unemployed.
Workers_in_Operational_Capacity[Energy_Source] UNITS: People/GW DOCUMENT: This converter represents the amount of people that work in a power plant of 1 Giga-Watts for each energy source.
Workforce_Closing_Productivity = 0.0003 UNITS: GW/People/Years DOCUMENT: This converter represents the productivity of the workforce dedicated to close capacity. In other words, it's the amount of giga-watts one worker can close down in one year.

Link to Interactive Learning Environment

https://exchange.iseesystems.com/public/henricontor/chinese-electricity-transition