DDPP Decarbonization Calculator User's Guide

The DDPP Decarbonization Calculator is an Excel-based energy system model that allows users to explore different pathways to deep decarbonization. This user's guide:

- provides a brief *overview* of the tool;
- walks through key *instructions* for how to use it; and
- describes necessary *data inputs* and where these might be found.

1 Overview

Based on user inputs, the Decarbonization Calculator calculates energy metrics and CO_2 emissions for a Mitigation Case and a Reference Case.

The Decarbonization Calculator is separated into six worksheets:

- *Instructions* — provides a brief overview, basic instructions, recommended steps, and a color key for the controls worksheet;
- *Controls* — contains all inputs for the Calculator;
- *Mitigation Case Calculations* — contains all calculations for the Mitigation Case;
- *Reference Case Calculations* — contains all calculations for the Reference Case;
- *Calculator Outputs* — shows key outputs from the Calculator;
- *Dashboard* — show outputs from the Calculator in the DDPP's standardized format.

2 Instructions

2.1 Recommended Steps

The Instructions worksheet contains five recommended steps for using the Decarbonization Calculator, shown below.

Recommended Steps:

1. Confirm or input new values for Key Overall Parameters, beginning on Row 496 of the Controls worksheet
2. Enter Reference values for Power Sector and Gas & Liquids, from Row 435 to 493
3. Enter Reference values for Buildings, Transportation, and Industry, beginning on Row 35
4. Enter 2050 Mitigation values for all sectors and gauge progress versus sectoral and economy-wide benchmarks in Rows 1 - 29
5. Adjust trajectory (2015 through 2050) for the Mitigation case as needed to meet targets or expected values

Key Overall Parameters, a section in the Controls worksheet, contains a number of generic parameters for conversion efficiencies, plant characteristics, CO_2 emission factors, miscellaneous power sector, and miscellaneous other heating values and conversion factors used throughout the Calculator. This section currently has default values. Users should first check to ensure that these values are consistent with those typically used in their national or local context.

Once key parameter inputs are confirmed, users should then input data for the Reference and Mitigation Cases, as described below. A useful sequence for inputting data is to start with the energy production sectors (Power Sector and Gas & Liquids) and then work through the end-use sectors (Buildings, Transportation, and Industry). This allows users to gauge whether energy sector inputs need to be adjusted to meet targets or desired values.

2.2 Inputting Data

All user inputs are entered in the Controls worksheet. As described in the Instructions, cells are color coded to allow users to identify which cells require user inputs and which are optional, which cells are purely for calculation, and which cells show intermediate and final outputs.

	Calculated or blank cells
	Required User Inputs
	Optional User Inputs
	Intermediate Output
	Output

Within the Controls worksheet, data inputs are organized into seven main sections, organized by end-use sector, energy sector, and key overall parameters. Each section is then broken out into multiple sub-sectors, as shown in the table below. For instance, the passenger transport section includes six transport modes (car, motorcycle, bus, urban rail, inter-urban or long-distance rail, and air). Only the Key Overall Parameters sector has default inputs. Users are required to enter inputs for the remaining sectors

Sector	**Sub-sectors**
End-use Sector	
Buildings	Residential, Commercial
Passenger Transport	Car, Motorcycle, Bus, Urban Rail, Inter-urban Rail, Air
Freight Transport & Pipelines	Freight Trucks, Freight Rail, Domestic Waterway Shipping, Pipelines
Industry	Mining, Iron and Steel Manufacturing, Non-ferrous Metals Manufacturing, Cement Manufacturing, Other Manufacturing, Other Non-manufacturing
Energy Sector	
Power Sector	Central CHP, Net Generation Mix
Gas & Liquids	Pipeline Gas Blend, Liquid Hydrogen Inputs
Key Overall Parameters	
Key Overall Parameters	Conversion Efficiencies and Plant Characteristics, CO2 Emission Factors, Miscellaneous Power Sector & CHP Inputs, Miscellaneous Other Inputs

2.2.1 End-use Sector Inputs

Inputs and metrics in each end-use sector are organized by activity drivers (Activity), shares of final energy consumption (Energy Shares), shares of different fuels (Fuel Shares), and CO_2 metrics (CO2). These categories are highlighted in the A column of the Controls worksheet, as shown below.

	Buildings		
	Residential		
Activity	Population	Million	
	Household size	persons/household	
	Residential floor space	m2/cap	
	Unit energy consumption	MJ/m2	If traditional biomass is included in this estimate, it should be on a primary energy basis
Energy Shares	Final electricity	%	
	Central CHP (heat)	%	
	Solar thermal	%	
	Fuels	%	Fuels are the residual energy source
Fuel Shares	Pipeline gas	%	Pipeline gas is the residual fuel
	LPG	%	
	Kerosene	%	
	Coal	%	
	Coal gas	%	
	Biomass (direct)	%	This value should be primary energy; improvements in conversion efficiency are captured
	Biomass sustainability factor	%	Percentage of biomass (direct) use that exceeds growth increment; increasing this value
CO2	Fuel CO2 emission factor	gCO2/MJ	
	Total fuel CO2	MtCO2	
	Total electric CO2	MtCO2	
	Total central CHP CO2 (heat)	MtCO2	
	Total CO2	MtCO2	

Activity drivers determine total final demand for energy within an end-use sector. For instance, in the residential buildings sub-sector, energy demand is driven by the product of population, residential floor space, and energy consumption per unit floor space ("Unit energy consumption").

Energy shares determine how much total final energy demand is met with different energy sources. In residential buildings, for instance, final energy demand can be met with electricity, central-scale CHP, solar thermal, or "fuels." Fuels are the residual energy source and do not require a user input — if the user inputs 50% under final electricity, for instance, fuel share will fall to 50%. Users then specify the share of different fuels, which in residential buildings includes pipeline gas, liquefied petroleum gas (LPG), kerosene, coal, coal gas, and directly combusted biomass. With the "biomass sustainability factor" users can specify how much direct biomass combustion is CO_2-neutral.

			Notes	Reference Value									Mitigation Value	If no value is entered here, reference values are used						
			Data is not necessary for all points: model will interpolate between input data points.	2010	2015	2020	2025	2030	2035	2040	2045	2050	2015	2020	2025	2030	2035	2040	2045	2050
	Buildings																			
	Residential																			
Activity	Population	Million		1.0								1								1
	Household size	persons/household		1.0								1								1
	Residential floor space	m2/cap		1.0								1.0								1.0
	Unit energy consumption	MJ/m2	If traditional biomass is included in this estimate, it should be on a primary energy basis	1								1								1
Energy Shares	Final electricity	%		0%								0%								0%
	Central CHP (heat)	%		0%								0%								0%
	Solar thermal	%		0%								0%								0%
	Fuels	%	Fuels are the residual energy source	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Fuel Shares	Pipeline gas	%	Pipeline gas is the residual fuel																	
	LPG	%		0%								0%								0%
	Kerosene	%		0%								0%								0%
	Coal	%		0%								0%								0%
	Coal gas	%		0%								0%								0%
	Biomass (direct)	%	This value should be primary energy; improvements in conversion efficiency are captured	0%								0%								0%
	Biomass sustainability factor	%	Percentage of biomass (direct) use that exceeds growth increment; increasing this value	0%								0%								0%
CO2	Fuel CO2 emission factor	gCO2/MJ		56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0
	Total fuel CO2	MtCO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	Total electric CO2	MtCO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total central CHP CO2 (heat)	MtCO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total CO2	MtCO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Data inputs are separated into a Reference Case section (columns I through Q) and a Mitigation Case section (columns R through Y). The orange cells, shown in the screenshot above, indicate required inputs, for the years 2010 (Reference) and 2050 (Reference and Mitigation). The yellow cells for years 2015, 2020, 2025, 2030, 2040, and 2045 are optional. If users do not specify values, the Calculator assumes a linear trend between data inputs. For instance, if users enter data for 2010, 2020, 2030, 2040, and 2050, the Calculator will linearly interpolate values for 2015, 2025, 2035, and 2045.

All end-use sector inputs follow the same general format, with variations on activity drivers and energy and fuel shares. For both passenger and freight transport, users specify mode shares (e.g., for passenger transport, car, motorcycle, bus, urban rail, inter-urban rail, air) of total vehicle-kilometers or ton-kilometers traveled. These are converted to final energy demand using vehicle energy efficiencies. In the industrial sector, for heavy industries users specify physical output (million tons per year) and an energy intensity (GJ per ton). Other Manufacturing and Other Non-manufacturing are driven by user-inputted GDP, shares of value added, and economic energy intensity (MJ per $). If users do not have sufficient data to enter inputs for heavy industrial sectors, these can be subsumed within Other Manufacturing.

For cars and freight trucks, the Decarbonization Calculator tracks the stock of vehicles over time, based on user-inputted stock and lifetimes.

2.2.2 Energy Sector Inputs

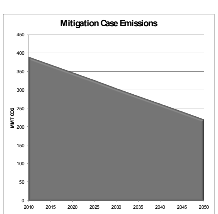
For the power sector, users must input key parameters, central CHP inputs, and the net generation mix. Average heat rates are in gross terms — they do not include the “own-use” electricity used by generators to power facilities and pollution control equipment. The net generation mix, alternatively, should be net of generator own-use. Whether electricity statistics are in net or gross terms varies by country, and users should ensure that they are using the correct input data. For the gas and liquid fuel sectors, users input the energy mix in pipeline gas, and the energy inputs and processes used in liquid hydrogen production. In all energy sector inputs, users should ensure that the units of data inputs match what is in the Calculator. For instance, a heat rate that is in Btu/kWh must be converted to MJ/kWh to be consistent with units in the Calculator.

2.2.3 Key Overall Parameters

As noted previously, the Decarbonization Calculator requires a number of general inputs, located in the Key Overall Parameters section. These include inputs for energy conversion efficiencies and plant characteristics, CO_2 emission factors, and miscellaneous inputs. Although these parameters have default values, again users should check to make sure these are consistent with national conditions and assumptions. In particular, users should pay attention to CO_2 emission factors, capacity factors, and fuel heating values, which often vary significantly among countries.

2.3 Reviewing Outputs

The Decarbonization Calculator allows users to view outputs in a range of formats. As users work through inputs on the Controls worksheet, they can view how input choices in the Mitigation Case affect CO_2 emissions and key resource indicators.



Emissions Results

Mitigation Case CO2 Emissions: MtCO2	2010	2015	2020	2025	2030	2035	2040	2045	2050
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0
Passenger transport	266	249	233	216	200	183	166	150	133
Freight transport	124	120	115	110	106	101	96	92	87
Industrial	0	0	0	0	0	0	0	0	0
Power	0	0	0	0	0	0	0	0	0
Total	**391**	**369**	**348**	**327**	**306**	**284**	**263**	**242**	**220**

Mitigation Case CO2 Emissions: Tons/Capita	2010	2015	2020	2025	2030	2035	2040	2045	2050
Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commercial	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Passenger transport	266.1	249.5	232.8	216.2	199.6	183.0	166.3	149.7	133.1
Freight transport	124.2	119.5	114.9	110.2	105.6	100.9	96.2	91.6	86.9
Industrial	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Power	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Total	**390.6**	**369.3**	**348.1**	**326.8**	**305.5**	**284.3**	**263.0**	**241.7**	**220.5**

Emissions Reductions % of 2010	2010	2015	2020	2025	2030	2035	2040	2045	2050
Residential	0%	0%	0%	0%	0%	0%	0%	0%	0%
Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%
Passenger transport	0%	6%	13%	19%	25%	31%	38%	44%	50%
Freight transport	0%	4%	8%	11%	15%	19%	23%	26%	30%
Industrial	0%	-10%	-18%	-24%	-29%	-32%	-34%	-34%	-33%
Power	0%	-414%	-920%	-1480%	-2058%	-2623%	-3149%	-3611%	-3990%
Total	**0%**	**5%**	**11%**	**16%**	**22%**	**27%**	**33%**	**38%**	**44%**

Resource Indicators

Biomass (Mt)	2010	2015	2020	2025	2030	2035	2040	2045	2050
Buildings	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0
Industry	0	0	0	0	0	0	0	0	0
Power generation	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Nat Gas (BCM)	2010	2015	2020	2025	2030	2035	2040	2045	2050
Buildings	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0
Industry	0	0	0	0	0	0	0	0	0
Central CHP	0	0	0	0	0	0	0	0	0
Power generation	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

CCS (Mt CO2)	2010	2015	2020	2025	2030	2035	2040	2045	2050
Buildings									
Transportation									
Industry	0	0	0	0	0	0	0	0	0
Central CHP	0	0	0	0	0	0	0	0	0
Power generation	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

In this segment, shown above, the figure on the far left shows emission trajectories over time in the Mitigation Case. The middle set of tables shows total CO_2 emissions by sector, per capita CO_2 emissions by sector, and CO_2 emission reductions relative to 2010 for all model years. The rightmost set of tables shows three key resource indicators: biomass, natural gas, and the amount of CO_2 sequestered through CCS. These indicators provide a means to check whether inputs are realistic.

Users can examine more detailed outputs in the Calculator Outputs worksheet, shown below. This worksheet shows: aggregate results; activity assumptions and energy and CO_2 results by sector; and electricity generation, fuel production, passenger vehicle, and freight vehicle stocks.

Calculator Outputs

Aggregate		2010	2015	2020	2025	2030	2035	2040	2045	2050
Aggregate Indicators										
Population	Millions	1	1	1	1	2	2	2	2	2
GDP (real US$)	B$	1	1	1	1	1	1	1	1	1
Final energy consumption (FEC)	Mtoe	132	125	117	110	103	96	88	81	74
Total primary energy supply (TEPS)	Mtoe	132	125	117	110	103	96	89	81	74
Total CO2 emissions	MtCO2	391	369	348	327	306	284	263	242	220
Energy intensity of GDP	toe/M$	131822	124595	117366	110137	102907	95605	88446	81214	73982
CO2 intensity of FEC	tCO2/toe	2.96	2.96	2.97	2.97	2.97	2.97	2.97	2.98	2.98
Electricity Indicators										
Electricity consumption	TWh	0	0	0	0	0	0	0	0	0
Electricity CO2 emissions	MtCO2	0	0	0	0	0	0	0	0	0
Electricity consumption % FEC	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average net CO2 emission factor	kgCO2/kWh	1.214	1.170	1.125	1.081	1.037	0.993	0.948	0.904	0.860
Non-electricity Indicators										
Non-electricity FEC	Mtoe	132	125	117	110	103	96	88	81	74
Non-electricity CO2 emissions	MtCO2	391	369	348	327	305	284	263	242	220
Average CO2 emission factor	tCO2/toe	2.96	2.96	2.97	2.97	2.97	2.97	2.97	2.98	2.98

Buildings		2010	2015	2020	2025	2030	2035	2040	2045	2050
Total Buildings										
Buildings FEC	Mtoe	0	0	0	0	0	0	0	0	0
Buildings CO2 emissions	MtCO2	0	0	0	0	0	0	0	0	0
CO2 intensity of buildings FEC	tCO2/toe	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34
Residential										
Floor area, residential units	Msqm	1	1	1	1	2	2	2	2	2
Residential FEC	Mtoe	0	0	0	0	0	0	0	0	0
Residential electricity consumption	TWh	0	0	0	0	0	0	0	0	0
Residential CO2 emissions	MtCO2	0	0	0	0	0	0	0	0	0
Per capita residential floor area	sqm/cap	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Residential energy intensity	kWh/sqm	0	0	0	0	0	0	0	0	0
CO2 intensity of residential FEC	tCO2/toe	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34
Electricity share in residential FEC	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Commercial										
Floor area, commercial units	Msqm	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Commercial FEC	Mtoe	0	0	0	0	0	0	0	0	0
Commercial electricity consumption	TWh	0	0	0	0	0	0	0	0	0
Commercial CO2 emissions	MtCO2	0	0	0	0	0	0	0	0	0
Commercial floor area per GDP	sqm/$	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Commercial energy intensity	kWh/sqm	0	0	0	0	0	0	0	0	0
CO2 intensity of commercial FEC	tCO2/toe	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34
Electricity share in commercial FEC	%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Transportation		2010	2015	2020	2025	2030	2035	2040	2045	2050
Total Transportation										
Transport FEC	Mtoe	132	125	117	110	103	96	88	81	74
Transport electricity consumption	TWh	0	0	0	0	0	0	0	0	0
Transport CO2 emissions	MtCO2	390	369	348	326	305	284	263	241	220
CO2 intensity of transport FEC	tCO2/toe	2.96	2.96	2.96	2.97	2.97	2.97	2.97	2.97	2.98
Passenger Transportation										
Total passenger km traveled (PKT)	Gpkm	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Passenger FEC	Mtoe	92	86	80	75	69	63	57	52	46
Passenger electricity consumption	TWh	0	0	0	0	0	0	0	0	0
Passenger CO2 emissions	MtCO2	266	249	233	216	200	183	166	150	133
PKT per capita	pkm/cap	1,000,000	888,889	800,000	727,273	666,667	615,385	571,429	533,333	500,000
Passenger energy intensity	toe/Mpkm	92	86	80	75	69	63	57	52	46
CO2 intensity of passenger FEC	tCO2/toe	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90
Freight Transportation										
Freight movement (tons-km)	Gt-km	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Freight FEC	Mtoe	40	39	37	36	34	33	31	30	28
Freight electricity consumption	TWh	0	0	0	0	0	0	0	0	0
Freight CO2 emissions	MtCO2	124	120	115	110	106	101	96	92	87
Freight intensity of GDP	ton-km/$	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
Freight energy intensity	toe/Mt-km	40	39	37	36	34	33	31	30	28
CO2 intensity of freight FEC	tCO2/Mtoe	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10

Industry		2010	2015	2020	2025	2030	2035	2040	2045	2050
Total Industry										
Industry value added	B$	0	0	0	0	0	0	0	0	0
Industry FEC	Mtoe	0	0	0	0	0	0	0	0	0
Industry electricity consumption	TWh	0	0	0	0	0	0	0	0	0
Industry CO2 emissions	MtCO2	0	0	0	0	0	0	0	0	0
Share of industry in GDP	%	1%	3%	5%	7%	9%	11%	13%	15%	17%
Industry energy intensity	toe/M$	5111	1911	1258	969	801	689	606	540	486
CO2 intensity of industry FEC	tCO2/toe	4.07	4.25	4.43	4.60	4.75	4.87	4.97	5.05	5.09

Power & Fuel Production		2010	2015	2020	2025	2030	2035	2040	2045	2050
Fossil fuel generation	**%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Coal w/o CCS	%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Coal w/ CCS	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Natural gas w/o CCS	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Natural gas w/ CCS	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Non-fossil fuel generation	**%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Nuclear	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wind	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Solar	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other	%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share of intermittent renewables	**%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Fossil fuel generation capacity	**GW**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coal	GW	0	0	0	0	0	0	0	0	0
Coal w/ CCS	GW	0	0	0	0	0	0	0	0	0
Fuel Oil	GW	0	0	0	0	0	0	0	0	0
Fuel Oil w/ CCS	GW	0	0	0	0	0	0	0	0	0
Natural gas	GW	0	0	0	0	0	0	0	0	0
Natural gas w/ CCS	GW	0	0	0	0	0	0	0	0	0
Non-fossil generation capacity	**GW**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Nuclear	GW	0	0	0	0	0	0	0	0	0
Hydropower	GW	0	0	0	0	0	0	0	0	0
Wind-Onshore	GW	0	0	0	0	0	0	0	0	0
Wind-Offshore	GW	0	0	0	0	0	0	0	0	0
Solar PV	GW	0	0	0	0	0	0	0	0	0
Solar Thermal	GW	0	0	0	0	0	0	0	0	0
Biomass	GW	0	0	0	0	0	0	0	0	0
Geothermal	GW	0	0	0	0	0	0	0	0	0
Other renewables	GW	0	0	0	0	0	0	0	0	0
Hydrogen production	**EJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
H2 Production - Steam Reformation	EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2 Production - Electrolysis	EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Stock Additions and Replacements		2010	2015	2020	2025	2030	2035	2040	2045	2050
Fossil fuel generation capacity additions and replacements										
Coal	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal w/ CCS	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Oil	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Oil w/CCS	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas w/ CCS	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-fossil fuel generation capacity additions and replacements										
Nuclear	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydropower	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wind-Onshore	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wind-Offshore	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solar PV	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solar Thermal	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biomass	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geothermal	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other renewables	GW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel production capacity additions and replacements										
Hydrogen Production-Steam Reformation	EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydrogen Production - Electrolysis	EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Power-to-Gas Production	EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biorefinery - Ethanol	EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biorefinery - Diesel	EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biogas Production - SNG	EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Passenger vehicle sales										
EV	Million Vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PHEV	Million Vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HFCV	Million Vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	Million Vehicles	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Freight vehicle sales										
Compressed Pipeline Gas	Million Vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liquified Pipeline Gas	Million Vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydrogen	Million Vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	Million Vehicles	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Lastly, the Dashboard worksheet shows results in the DDPP's "mini-dashboard" format, which the DDPP uses to compare results across country studies. A toggle at the top of the worksheet allows users toggle energy units between exajoules and million tons oil equivalent.

Dashboard

Color Key:	
Inputs	
Indicators	

Select Energy Units: EJ

		2010	2020	2030	2040	2050	2050/2010	AAG 2010-50
Aggregate Inputs and Indicators								
Aggregate Inputs								
Population	Millions	1	1	1	1	1	-1%	0.00%
Number of Households	Millions	1	1	1	1	1	-1%	0.00%
GDP (real US$)	B$	$1	$1	$1	$1	$1	-1%	0.00%
Final energy consumption (FEC)	EJ	6	5	4	4	3	-44%	-1.43%
Total primary energy supply	EJ	6	5	4	4	3	-44%	-1.43%
Fuel combustion CO2 emissions	MtCO2	391	348	306	263	220	-44%	-1.42%
Fuel combustion, fugitive, and industrial process CO2 emissions	MtCO2	391	348	306	263	220	-44%	-1.42%
total GHG emissions (all s'ources)	MtCO2e	391	348	306	263	220	-44%	-1.42%
Aggregate Indicators								
Energy intensity of GDP	TJ/M$	5,519.1	4,913.9	4,308.5	3,703.0	3,097.5	-44%	-1.43%
CO2 intensity of FEC	tCO2/TJ	70.77	70.83	70.91	71.02	71.17	1%	0.01%
Energy transformation efficiency	%	1.00	1.00	1.00	1.00	1.00	-1%	0.00%
Per Capita Aggregate Indicators								
Per capita GDP	GDP/cap	$1,000	$1,000	$1,000	$1,000	$1,000	0%	0.00%
Per capita FEC	TJ/cap	5.52	4.91	4.31	3.70	3.10	-44%	-1.43%
Per capita fuel combustion CO2 emissions	tCO2/cap	390.6	348.1	305.5	263.0	220.5	-44%	-1.42%
Per capita fuel combustion, fugitive, and industrial process CO2 emissions	tCO2/cap	390.6	348.1	305.5	263.0	220.5	-44%	-1.42%
Per capita total GHG emissions (all sources)	tCO2/cap	390.6	348.1	305.5	263.0	220.5	-44%	-1.42%
Aggregate Electricity Inputs								
Electricity generation	TWh	0	0	0	0	0	1262%	10.52%
Electricity consumption	TWh	0	0	0	0	0	1227%	10.67%
Electricity CO2 emissions	MtCO2	0	0	0	0	0	987%	9.72%
Aggregate Electricity Indicators								
Electricity consumption % FEC	%	0%	0%	0%	0%	0%	-98%	12.28%
Average net CO2 emission factor	kgCO2/kWh generated	1.093	1.027	0.959	0.889	0.817	-26%	-0.72%
Aggregate Non-electricity Inputs								
Non-electricity FEC	EJ	5.52	4.91	4.31	3.70	3.10	-44%	-1.43%
Non-electricity CO2 emissions	MtCO2	391	348	305	263	220	-44%	-1.42%
Aggregate Non-electricity Indicators								
Average CO2 emission factor	tCO2/TJ	70.77	70.83	70.90	71.00	71.14	1%	0.01%

3 Sourcing Data Inputs

The Decarbonization Calculator was designed to represent a relatively simple energy-economy system that could be parameterized with a reasonable small number of commonly found data inputs. This section gives an overview of data requirements and possible data sources for the Calculator.

3.1 Activity Drivers

There are seven key activity drivers in the Decarbonization Calculator, shown in the table below. Base year (2010) data for these drivers are likely to be found in national statistical documents. The World DataBank (http://databank.worldbank.org/data/home.aspx), a free World Bank product, is another helpful source for base year data. If users find that base year data does not exist, an alternative approach is to estimate them by benchmarking against other countries. For instance, a medium-sized, medium-income country could estimate ton-kilometers (TKM) by multiplying its GDP by a reference TKM/GDP value in another medium-sized, medium-income country.

Activity Drivers
Population
Residential floor space
Commercial floor space
Passenger-kilometers
Ton-kilometers
Heavy industrial output
GDP

In cases where the effects of simplifying are thought to be small, users are encouraged to focus on important variables and leave less important ones blank. For instance, urban rail travel in a country might be very small, has a negligible impact on the results, and may be usefully ignored.

The Calculator also requires forecasts to 2050. Population projections for most countries can be found in the UN *World Population Prospects* (http://esa.un.org/unpd/wpp/DVD/). A number of research organizations also publish long-term GDP forecasts, though in general it is better to use real growth rates from these studies rather than using their absolute forecasts, given that most estimates are adjusted for purchasing power parity.

If detailed, long-term forecasts for floor space, travel distance, and industrial output do not exist in the user country, users will likely need to rely on a combination of simplified forecasting and expert judgement. In doing so, it is important to bear in mind that many of these activities (e.g., passenger-kilometers) saturate with continued economic growth. For instance, as the number of cars per household increases, passenger-kilometers increase rapidly, but then begins to slow once car ownership has saturated.

3.2 Energy Inputs

Base year energy sector inputs can most likely be found in government statistics. The IEA also publishes high-level energy balances for most countries in a number of formats (see http://www.iea.org/countries/non-membercountries/ for energy balances for non-member countries). For conversion efficiencies and other energy parameters, potential references include the IEA *Technology Roadmap* (http://www.iea.org/roadmaps/) series and studies in other country contexts. The DDPP is another reference for these kinds of inputs.

Forecasted energy inputs are, to a large extent, based on user vision and what changes are required to meet CO_2 targets. Users are strongly encouraged to develop multiple scenarios, and to benchmark inputs against existing forecasts or national strategies.