IRENA's Renewable Energy Roadmap – REmap

A manual for the REmap tool

Version 4

13 June 2016

Contents

Introduction

This manual assists national REmap experts in reviewing and inputing data into the REmap excel tool. The excel tool consists of 16 sheets, 9 of which are worksheets (WS) allowing for data entry. The REmap worksheets may be received pre-populated by IRENA and include inputs specific to your country. An overview of the worksheets are as follows:

Home/Disclaimer: Table of contents with hyperlinks to other sheets.

WS0: Country Energy Balances: an overview of the 2010, 2020 and 2030 energy balances in IRENA's REmap format; and the compound annual growth rate (CAGR) tables used to generate the 2020 and 2030 energy balances.

WS1: Specific country data and standardized international commodity prices.

WS2 (a/b): A comprehensive list of renewable energy and conventional energy technologies and their international performance characteristics and costs for 2020 (WS2a) and 2030 (WS2b). Although it is possible to provide data for both years, the key is to populate the year 2030 (WS2b).

WS3-7: Sectorial worksheets for industry (WS3), buildings (WS4), transport (WS5), power (WS6), and heat (WS7) on which the substitution process takes place - **these sheets are the core component of the REmap tool.**

WS8: A summary sheet where the results of the process are overviewed and two macro functions are provided for the creation of two cost-supply curves (see **Curve REmap 1** and **Curve REmap 2** worksheets).

Summary table: A summary sheet with detailed results by sector and technology for consultation.

Curve REmap 1: The cost-supply curve plotting technologies separately for 2020 and 2030.

Curve REmap 2: The cost-supply curve plotting the weighted average cost for 2020 and 2030 for technologies.

Curve Reference: A graph showing Reference Case developments based on sector and TFEC.

Assumptions: A listing of assumptions used for each sheet.

** PLEASE NOTE: this excel tool utilizes a macro funtion to produce the cost supply curves in WS8. Therefore it must be saved as an macro enabled excel file. BEFORE beginning any work in this file, please make sure this macro function is turned on and the file is saved as macro enabled.

The cost supply curve

The aim of the **REmap tool** is to create a cost supply curve of additional renewable energy options beyond what is already planned and commissioned between 2010 and 2030 represented by the **Reference Case**. The horizontal *x*-axis of this curve presents the **potential** to substitute conventional technologies with renewable energy technology options between the 2010 base year and 2030 (expressed in %), while the vertical *y*-axis represents the **average incremental costs of substitution** associated with each renewable energy option (expressed in 2010 US Dollars (USD) per gigajoule of primary energy[1]). The substitution potential and the average incremental costs are calculated relative to the **Reference Case**, which reflects changes in the energy system between 2010 and 2030 under current policies (including any structural changes that are projected, such as increased/reduced energy demand, shifts between energy carriers, or changes in energy consumption patterns in the end-use sectors). The energy system which includes the additional renewable energy options is referred to as the **REmap**.

The focus of this tool is on the creation of the **REmap Options** and **cost-supply curve**. The tool allows the national REmap expert to substitute conventional technologies in the **Reference Case** with renewable energy counterparts. For each additional renewable energy option, the national REmap expert has to decide what is 'realistically feasible' between 2010 and 2030 considering national conditions like planning processes, national regulation, and national policies. The national REmap expert needs also to make an explicit decision on what conventional energy technology has to be replaced if additional renewable energy options are introduced.

Each country will receive a pre-populated **version** of the REmap tool for their country. In this version, the cost and performance data for each technology option and the price for commodities will ideally be regionalized by IRENA if sufficient data is available to do so (**"national" version)**. If it is not, the figures provided will represent data derived from international sources, such as IRENA-IEA ETSAP technology briefs (**"international" version**). Additionally, the tool will include the additional renewable energy amounts entered into the sectorial worksheets based on a preliminary analysis of country specific studies and scenarios. The national experts may change the additional renewable energy amounts associated with the different renewable energy technologies, and their associated substitution technology. If data is available that differs from that provided by IRENA (for the "national" version), the national experts are also asked to change cost and performance data associated with each of the renewable and conventional energy technology options and the prices projections for the commodities. All cells that can be altered are indicated in **BLUE**. Please do not make any changes to other cells as many have formulas or other required data that needs to be referenced.

Based on the final version reviewed by the country expert, IRENA will create a cost supply curve that represents the average increment costs of substitutions based on the local situation. In a later step IRENA will also create a cost supply curve for each country based on standardised international cost assumptions as a means for comparing and aggregating the results across regions.

[1] 1 GJ = 10^9 J = 239 megacalories = 23.9 kilogram of oil equivalent = 34.1 kilogram of coal equivalent

WS0 – 2010 Energy Balance (Fig. 1)

1. This worksheet provides an overview of the 2010 (base year) and 2020/2030 energy balance projections for the country Referece Case and also the results of REmap with the aggregation of REmap Options. The 2010 energy balance is populated using the International Energy Agency's (IEA) extended energy balance for 2010, apart from an assesment for energy use disaggregation in the building sector. Experts may use trusted data from other sources or provided by a national organisation or ministry to prepare an improved energy balance for 2010 or for another year which they regard representative for the base year.
2. For 2020 and 2030, energy balance tables need to be established by the REmap expert. The result of this process is the creation of the "**Reference Case**" (or business as usual case, or baseline case). As a basis of which the expert can develop the Reference Case various methods could have been used, including external studies or other sources such as national energy plans:
    a. The Reference Case includes future energy demand projections for 2020 and 2030. For individual energy carriers of each sector, the compound annual growth rates (CAGR, in %/yr) are provided which are used to estimate the energy use between today and 2020/2030. CAGR accounts for the developments in activity growth, energy efficiency improvements, structural changes and the fuel mix. The analyst can develop the Reference Case by altering the estimates in blue in the energy balance table, or by altering the growth rates found in the table below the energy balance. PLEASE NOTE: do not change the values for the "TFC" row and the "Total" column because they are sum calculations. Changes should be made to the Power/Heat or end-use sector totals.
3. The results of this process form the basis for the 2020/2030 Reference Case energy balances provided in the sectorial worksheets 3-7. If the national expert makes adaptations to WS0, the sectoral energy balances in W3-W7 will be automatically updated.

Fig. 1

2030 Energy Balance (PJ/yr) (Reference case)	Coal	Oil and oil products	Natural gas	Nuclear	Hydro	Geothermal	Solar photovoltaics	CSP	Wind	Solid biomass	of which	Liquid & Gaseous Biofuels	of which	Solar thermal	Electricity	Heat	Total
	TOT	TOT	TOT	TOT	TOT	TOT	TOT	TOT	TOT	TOT	Traditional	TOT	Biogas	TOT			
Production	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Imports	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Exports	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Intl. Bunkers	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stock Changes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TPES	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Power generation	**-1,418**	**-36**	**-357**	**0**	**-45**	**0**	**-5**	**0**	**-84**	**-44**	**0**	**-45**	**0**	**0**	**859**		**-1,175**
Electricity: Main activity	-1,417	-13	-318	0	-45	0	0	0	-84	-44	0	-45	0	0	824		-1,143
Electricity: Autoproducer	-1	-23	-38	0	0	0	-5	0	0	0	0	0	0	0	35		-33
CHP	**-59**	**0**	**-56**	**0**	**0**	**0**	**0**	**0**	**0**	**-261**	**0**	**-2**	**0**	**0**	**83**		**-295**
Heat generation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**0**	**0**
Heat: Main activity																	
Heat: Autoproducer																	
Other energy sectors	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Refineries (including own use)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BF & CO (including own use)	-80	-1	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	-84
Liquefaction Plants (incl. Own use)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Others	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Own Use (excl. Refineries & BF & CO)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Distribution Losses	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TFC	**113**	**1,572**	**577**	**0**	**0**	**0**	**0**	**0**	**0**	**175**	**0**	**13**	**0**	**11**	**910**	**0**	**3,371**
Industry (excl. Feedstocks)	**106**	**197**	**360**	**0**	**0**	**0**	**0**	**0**	**0**	**114**	**0**	**0**	**0**	**0**	**320**		**1,098**
Iron and Steel	26	1	23	0	0	0	0	0	0	0	0	0	0	0	16	0	66
Chem. & Petroch.	7	11	73	0	0	0	0	0	0	12	0	0	0	0	21	0	128
of which: Feedstocks	0	106	43	0	0	0	0	0	0	0	0	0	0	0	0	0	149
Non-ferrous Metals	37	64	125	0	0	0	0	0	0	2	0	0	0	0	164	0	391
Non-metallic mineral	22	16	62	0	0	0	0	0	0	1	0	0	0	0	19	0	120
Food and tobacco	11	3	31	0	0	0	0	0	0	55	0	0	0	0	23	0	124
Paper, Pulp, Printing	2	0	22	0	0	0	0	0	0	24	0	0	0	0	17	0	66
Textile and leather	0	1	5	0	0	0	0	0	0	0	0	0	0	0	3	0	10
Others	1	101	13	0	0	0	0	0	0	20	0	0	0	0	57	0	192
Transport	**5**	**1,324**	**21**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**0**	**0**	**17**	**0**	**1,379**
Intl. civil aviat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dom. aviat	0	107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	107
Road	0	1,136	2	0	0	0	0	0	0	0	0	12	0	0	0	0	1,150
Rail	0	40	0	0	0	0	0	0	0	0	0	0	0	0	10	0	50
Pipeline Transport	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Internal Navigation	5	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38
Non-specified & other	0	8	1	0	0	0	16	0	0	0	0	0	0	0	6	0	16
Buildings	**2**	**50**	**196**	**0**	**0**	**0**	**0**	**0**	**0**	**61**	**0**	**1**	**0**	**11**	**574**		**894**
space cooling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	0	86
space heating	1	36	139	0	0	0	0	0	0	31	0	1	0	6	0	0	213
water heating	0	5	21	0	0	0	0	0	0	21	0	0	0	4	0	0	50
cooking	0	1	2	0	0	0	0	0	0	2	0	0	0	0	0	0	5
lighting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0	67
appliances	0	0	0	0	0	0	0	0	0	0	0	0	0	0	191	0	191
others	0	9	34	0	0	0	0	0	0	7	0	0	0	1	223	0	281
Other sectors	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Agriculture	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Non energy use	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Electricity Gen. - TWh	**152**	**3**	**41**	**0**	**12**	**0**	**4**	**0**	**20**	**2**	**0**	**4**	**0**	**0**			**239**
Electricity: Main activity	151	1	38	0	12	0	0	0	20	2	0	4	0	0			229
Electricity: Autoproducer	0	2	4	0	0	0	4	0	0	0	0	0	0	0			10
CHP (electricity) - TWh	**5**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**0**	**0**	**0**	**0**			**23**
CHP (heat) - PJ																	**0**
Heat generation - PJ																	**0**
Heat: Main activity																	
Heat: Autoproducer																	
Power Capacity - GW	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Compound annual growth rates (%/yr): 2020-2030	Coal	Oil and oil products	Natural gas	Nuclear	Hydro	Geothermal	Solar photovoltaics	CSP	Wind	Solid biomass	of which traditional	Liquid & Gaseous Biofuels	of which biogas	Solar thermal	Electricity	Heat	Total
Power generation (fuel input)	-2.1	0.0	0.2	0.0	0.0	5.0	5.0	5.0	5.0	16.3	16.3	16.3	16.3	5.0			
CHP (fuel input)	-2.1	0.0	0.2	0.0	0.0	5.0	5.0	5.0	5.0	16.3	16.3	16.3	16.3	5.0			
Heat generation (fuel input)	-2.1	0.0	0.2	0.0	0.0	5.0	5.0	5.0	5.0	16.3	16.3	16.3	16.3	5.0			
BF & CO (including own use)	0.0	0.0	0.0	0.0						0.0	0.0	0.0	0.0		0.0	0.0	
Industry (excl. Feedstocks)	-0.2	1.2	1.1	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	1.5	1.5	1.5	1.5	-100.0	0.7	-100.0	
of which: Feedstocks	0.8	0.8	0.8	0.8													

WS1 – Country Data & Energy Prices (Fig. 2)

1. WS1 contains country specific data relating to a wide range of inputs. These inputs themselves are used in calculations in later sheets; and some data may be used later in the REmap process by IRENA for further analysis, such as macro-economic analysis. This sheet may be received pre-populated by IRENA with estimates for international prices for the commodities but may also be received with some localized price inputs done by IRENA. All price and economic data presented in this worksheet is based on 2010 real USD.
2. The data is color coded based on input actions required:
    a. Required input (dark blue): this data is used in later sheets as a basis for cost calculations and should be reviewed carefully and updated by the expert
    b. Suggested input (light blue): economic and energy use data that will be used by IRENA for macroeconomic analysis at a later phase of the REmap project
    c. Calculated data (yellow): results of formula based on inputted data
3. The data presented are only tentative estimates and should be reviewed and updated by the national expert.
4. The last row is a carbon price. This price is applied to select fossil fuel commodities based on the emission factors in column K and the resulting price adjustment is shown in columns F-I. These adjusted prices are used for cost calculations in later sheets. The expert is invited to alter the carbon price or the emission factors. By changing emission factors to 0, some fossil commodities can be excluded from carbon price effects, i.e. “natural gas household”, or “Gasoline”.
5. These prices do not include VAT or other local taxes because they are international estimates; however experts are invited to include local prices that include taxes and any applicable subsidy on these commodity prices when updating their own country specific prices.
6. There are three primary biomass and biomass residues and two traditional biomass commodity listings. This is meant to allow the experts to assign different types of fuel to these for differentiation in use by the technologies (pellets vs. bagasse for instance). The expert can assign costs to these and make a note for themselves, but if they rename the commodity the “name manager” function in excel has to be used to create a new reference name for the commodity and its corresponding 2020 or 2030 price.
7. Special attention should be paid to the data in the dark blue cells. These values have significant impact on the costs associated with fossil fuel technologies in later worksheets. Since local costs can differ greatly between countries, and cost estimates depend heavily on energy use developments, it is very important for the expert to review, and update, these prices. Please keep in mind, however, that the purpose of the analysis is to assume a significant uptake in renewable energy use over the next two decades; the cost projections should include this assumption and the effect this will have on costs.

WS1 – Country Data & Energy Prices cont. (Fig. 2)

Fig. 2

COUNTRY: Country

	Units		Statistics		Plans/Projections	
		### 2009	2010	2012	2020	2030
Population, POP	(1000 cap)	NPUT	INPUT		INPUT	INPUT
Urban population	% POP	NPUT	INPUT		INPUT	INPUT
GDP nominal	(USD2010)	NPUT	INPUT		INPUT	INPUT
No of private cars/1000 inhab.	x1000 inhab	NPUT	INPUT		INPUT	INPUT
average annual private car mileag	km/y	NPUT	INPUT		INPUT	INPUT
Number of households	millions		INPUT		INPUT	INPUT
Floor space (residential)	m2		INPUT		INPUT	INPUT
Floor space (commercial)	m2		INPUT		INPUT	INPUT
Other energy-economic data						
Total primary energy demand, TI	EJ				INPUT	INPUT
Total final consumption, TFC	EJ				INPUT	INPUT
Total electricty generation ELG	TWh				INPUT	INPUT
Total electricty consumption, ELC	TWh				INPUT	INPUT
Total Renewable Energy , RE	EJ				INPUT	INPUT
Total CO2 eq emissions , CO2	Mt CO2				C	C
Electricity penetration ELC/TFC	%				#VALUE!	#VALUE!
Renewable energy share of TFC, R	%				INPUT	INPUT
Biomass share of TFC	%	NPUT	INPUT		INPUT	INPUT
Traditional biomass share of TFC	%	NPUT	INPUT		INPUT	INPUT
Energy efficiency improvement rat	(%/y)		INPUT		INPUT	INPUT

Legend:
SUGGESTED INPUT= data from statistics or projectons
REQUIRED INPUT= data from statistics or projectons
EB= data from energy balance 2010
C = calculated data

2b

2a

Energy commodities prices (excl. VAT, but including CO2 tax, annual average)					Emission factors (based on IPCC, if		Additional fuel prices due to CO2 price				Energy Commodities Prices (excluding CO2 Tax)		
								2010	2020	2030	2010	2020	2030
Crude_oil	(USD/GJ)	15.313	16.466	20.4685	(kg CO2/TJ)	73300	(USD/GJ)	0.733	1.466	3.2985	14.58	15	17.17
Steam_coal	(USD/GJ)	3.661	5.422	8.8245	(kg CO2/TJ)	96100	(USD/GJ)	0.961	1.922	4.3245	2.7	3.5	4.5
Electricity_Household	(USD/kWh)	0.1	0.2	0.25	(kg CO2/TJ)		(USD/GJ)		0	0	0.1	0.2	0.25
Electricity_Industry	(USD/kWh)	0.1	0.2	0.25	(kg CO2/TJ)		(USD/GJ)		0	0	0.1	0.2	0.25
Natural_gas_Household	(USD/GJ)	5.561	8.122	12.0245	(kg CO2/TJ)	56100	(USD/GJ)	0.561	1.122	2.5245	5	7	9.5
Natural_gas_Industry	(USD/GJ)	5.561	8.122	12.0245	(kg CO2/TJ)	56100	(USD/GJ)	0.561	1.122	2.5245	5	7	9.5
Petroleum_products	(USD/GJ)	12.774	19.548	28.483	(kg CO2/TJ)	77400	(USD/GJ)	0.774	1.548	3.483	12	18	25
Diesel	(USD/GJ)	21.741	31.482	38.3345	(kg CO2/TJ)	74100	(USD/GJ)	0.741	1.482	3.3345	21	30	35
Gasoline	(USD/GJ)	21.693	31.386	38.1185	(kg CO2/TJ)	69300	(USD/GJ)	0.693	1.386	3.1185	21	30	35
Kerosene	(USD/GJ)	25.7	36.4	43.15	(kg CO2/TJ)	70000	(USD/GJ)	0.7	1.4	3.15	25	35	40
Biodiesel	(USD/GJ)	25	25	27	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	25	25	27
Biofuel	(USD/GJ)	21	30	35	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	21	30	35
First_generation_bioethanol	(USD/GJ)	18	22	25	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	18	22	25
Second_generation_bioethanol	(USD/GJ)	32	32	33	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	32	32	33
Biomethane	(USD/GJ)	20	20	22	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	20	20	22
Biokerosene	(USD/GJ)	35	45	55	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	35	45	55
Hydrogen	(USD/GJ)	20	25	30	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	20	25	30
Primary_biomass_1	(USD/GJ)	11.4	12	15.8	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	11.4	12	15.8
Primary_biomass_2	(USD/GJ)	11.4	12	15.8	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	11.4	12	15.8
Primary_biomass_3	(USD/GJ)	11.4	12	15.8	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	11.4	12	15.8
Biomass_residues_1	(USD/GJ)	4	5	6	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	4	5	6
Biomass_residues_2	(USD/GJ)	4	5	6	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	4	5	6
Biomass_residues_3	(USD/GJ)	4	5	6	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	4	5	6
Traditional_biomass_1	(USD/GJ)	5	4	3	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	5	4	3
Traditional_biomass_2	(USD/GJ)	5	4	3	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	5	4	3
Municipal_waste	(USD/GJ)	1	1	2	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	1	1	2
Nuclear_fuel	(USD/GJ)	2.5	3.5	5	(kg CO2/TJ)	0	(USD/GJ)	0	0	0	2.5	3.5	5
Carbon_price	(USD/t CO2)										10	20	45

4

WS2b – Technology List 2030 (Fig. 3)

1. WS2a and WS2b are the technology lists for 2020 and 2030, respectively. For practical matter in REmap, the key sheet to populate is the one containing data for 2030. Technologies are listed by sector and are categorized by renewable (left) and non-renewable technologies (right). They are then broken down further into subcategories within those sectors.
2. Renewable technologies which are provided in column "B" replace non-renewable technologies listed in column "O" and only those non-renewable technologies listed in the same subsection as the renewable options can be replaced later in the sectoral worksheets (with a few exceptions in the building sectoral sheet).
3. This default list is not exhaustive and the expert can add additional technology options or differentiate an existing technology by duplicating it and changing fuel input (primary biomass 1 vs. 2), capacity factors or other data. Extra rows have been provided for these additions under each subsection list. If a technology is duplicated, the name must be slightly different for the reference function to work, for example if duplicating "biomass steam cycle" as adding primary biomass 2 as a fuel input, rename the technology "biomass steam cycle 2"
4. The data provided has been determined by IRENA to represent a best estimate of international costs and performance/efficiencies. However the expert should provide regionalized input into the cost/performance characteristics of the existing technologies for their own country. Please note the following when making changes:
   a. Some values allow for data input: capacity factors; lifetimes; overnight capital cost; operation and maintenance cost (O&M) (as % of cap. cost); conversion efficiency; etc. These are indicated by "light blue" cells.
   b. Some values are calculations based on formulas and do not allow for data input: total annualized cost; levelized cost; in some cases fuel demand. These are indicated by "yellow" cells.
   c. Please also note that for the "Reference Capacity or Production Volume" column in the industry/buildings/power sectors (column F/S), this number is a reference size of which the cost assumptions are based (i.e. the average size of a wind farm in country X is Y and entails overnight capital costs of USD/kW$_e$,etc). Later in the substitution process the total installed capacity is used for cost calculations.

The following are descriptions for each of the 5 sector lists:

5. Industry Sector:
   a. Please note that for Autoproducer CHP (captive) plants, the electricity and heat portions are assigned separately in the sector sheets therefore they are listed separately here.
   b. Bio-based feedstocks are provided as a technology and substitution can take place in the sectoral sheet, but feedstocks are excluded from total final energy consumption, so they will not be included in the TFEC RE total, nor the cost-supply curve.

B	C	D	E	F	G	H	I	J	K	L	M
Renewable Energy Technology											
2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Reference capacity or production volume	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost
INDUSTRY SECTOR											
Electricity:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)
Solar cooling		10	25	500	1060	15.9		0.01	100.0	66,777	42.3
Autoproducers (PV)		16	30	100	1400	14		0.01	100.0	16,339	32.4
Autoproducers (Biodiesel)	Biodiesel	50	25	100	150	3.8	21.0	0.01	75.0	58,880	37.3
Autoproducers, CHP electricity part (biomass)	rimary_biomass	50	25	10000	320	8.0	27.2	0.01	58.0	4,736,709	30.0
Heat generation:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)
Solar thermal		10	25	500	656	9.8		0.01	100.0	41,493	26.3
Geothermal		55	42	100	1500	37.5		0.07	100.0	19,529	11.3
Biomass boilers	rimary_biomass	85	25	500	580	14.5	30.5	0.05	88.0	281,715	21.0
Biomass gasification	rimary_biomass	80	25	500	2000	50.0	28.7	0.05	88.0	363,529	28.8
Charcoal									100.0		10.0
Autoproducers, CHP heat part (biomass)	rimary_biomass	90	25	32000	204	5.1	56.8	0.05	50.0	29,702,660	32.7
Bio-based feedstocks:	(-)	(%, cap)	(years)	(kt/yr)	(USD/t)	(USD/t/yr)	(GJf/t)	(GJe/t)	(%, eff)	(USD/yr)	(USD/t)
Bio-based metahnol	rimary_biomass	85	30	200	4400	440.0	50.00	1.00	40.0	310,342,500	1826
Bio-based ethylene	rimary_biomass	85	30	200	1200	120.0	110.00	5.00	40.9	343,672,500	2022

N	O	P	Q	R	S	T	U
	Conventional Fossil Fuel Technology						
	2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Reference capacity or production volume	Overnight Cap. Cost	O&M Costs
	INDUSTRY SECTOR						
	Electricity:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)
	Electricity						
	Autoproducer diesel	Diesel	50	25	100	200.0	5.0
	Heat generation:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)
	Coal (steam boiler)	Steam_coal	85	25	2000	300.0	7.5
	Petroleum products (steam boiler)	etroleum_produ	85	25	2000	200.0	5.0
	Natural gas (steam boiler)	atural_gas_Indus	85	25	2000	100.0	2.5
	Coal (furnace)	Steam_coal	85	25	2000	200.0	5.0
	Petroleum products (furnace)	etroleum_produ	85	25	2000	150.0	3.8
	Natural gas (furnace)	atural_gas_Indus	85	25	2000	100.0	2.5
	Coking coal						
	Fossil feedstocks:	(-)	(%, cap)	(years)	(kt/yr)	(USD/t)	(USD/t/yr)
	Natural gas methanol	atural_gas_Indus	85	45	100	400.0	40.0
	Naphtha steam cracking	etroleum_produ	85	45	100	500.0	50.0

6. Building Sector:
   a. Retrofits of existing building stock to allow for modern renewable energy technology or electrification of systems may be necessary. If this is desired, please discuss with the IRENA experts the best method to incorporate this technology option.
   b. Fuel type can be chosen in columns C/P. At the same time, the name of the fuel must be manually altered in cost calculations in columns L/M and Y/Z for consistency with the choices in columns C/P. HOWEVER, in the sectoral sheet the correct fuel type cost is referenced for the cost calculations used there, which are costs that are used in the cost-supply curve. The costs provided here are only for your reference.

2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Reference capacity or production volume	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost
BUILDINGS SECTOR											
Electricity:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJ/h/kW/yr)	(GJe/h/kW/yr)	(%, eff)	(USD/yr)	(USD/GJe)
PV		16	30	100	1400	14		0.01	100.0	16,339	32.4
Mini-hydro		50	40	50	4000	80		0.01	100.0	24,496	31.1
Biodiesel	Biodiesel	50	25	1	300	7.5	19.7	0.01	80.0	574	36.4
Electrification for cooling:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJ/h/kW/yr)	(GJe/h/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)
Space cooling: Air conditioner		15	14	12	572	14.3		1.8	90	2,620	46.1
Space cooling: With seasonal cold		50	25	15	5000	125.0		3.942	400	10,152	60.2
Space cooling: Air conditioning heat		50	25	10	1500	37.5		3.942	400	4,765	30.2
Space heating: With seasonal storage		50	25	25	5000	125.0		3.942	350	16,921	60.2
Space heating: Geothermal heat pumps		50	15	12	1500	37.5		4.505	350	6,571	34.7
Space heating: Air-to-Air heat pumps		50	15	12	780	19.5		4.505	350	5,219	27.6
Space heating: Electricity		10	10	23	346	8.7		0.7884	90	2,753	38.0
Water heating: Electricity		10	10	23	346	8.7		0.7884	90	2,753	38.0
Cooking electricity		10	10	7.4	24	0.6		4.2	75	2,194	94.0
District heating:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJ/h/kW/yr)	(GJe/h/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)
Biomass	rimary_biomass	30	25	100	600	15.0	12.6	0.07	75.0	28,541	30.2
Geothermal		40	25	100	1500	37.5		0.05	100.0	20,622	16.3
Waste-to-energy	Municipal_waste	85	25	100	800	20.0	59.6	0.05	45.0	23,074	8.6
Space and water heating/cooling:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJ/h/kW/yr)	(GJe/h/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)
Water heating: Biomass	rimary_biomass	30	15	20	600	15.0	11.8	0.05	80.0	5,684	30.0
Water heating: Solar		12	20	82	1200	30.0		0.05	100.0	14,303	46.1
Space heating: Solar		12	20	5	1200	30.0		0.05	100.0	872	46.1
Space heating: Biogas	omass_residues	50	15	50	600	15.0	19.7	0.05	80	10,791	13.7
Space heating: Pellet burners	rimary_biomass	30	15	20	774	19.4	11.1	0.05	85	6,009	31.8
Space Cooling: Solar		12	20	5	1350	33.8		0.05	100.0	979	51.7
Fuels for cooking:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJ/h/kW/yr)	(GJe/h/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)
Cooking biogas (from AD)	omass_residues	10	25	9	39	1.0	6.6		48	402	14.2
Cooking biomass (solid)	rimary_biomass	10	20	5	15	0.4	10.5		30	841	53.3
Cooking bioethanol	eneration_bioe	10	20	5	10	0.3	6.3		50	796	50.5

2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Reference capacity or production volume	Overnight Cap. Cost	O&M Costs
BUILDINGS SECTOR						
Electricity:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)
Diesel	Diesel	40	20	100	800.0	20.0
District heating:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)
Space and water heating/cooling:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)
Space heating: coal (boiler)	Steam_coal	85	15	20	175.0	6.1
Space heating: petroleum products (boiler)	troleum_produ	85	15	20	175.0	6.1
Space heating: natural gas (boiler)	ural_gas_House	85	15	20	162.0	5.7
Water heating: natural gas (boiler)	ural_gas_House	80	15	20	150.0	5.3
Retrofit Space heating: natural gas (boiler)	ural_gas_House	85	15	20	0.0	0.0
Space & Water heating: traditional biomass	aditional bioma	85	25	2000	100.0	2.5
Space and water heating/cooling: Electricity						
Water heating: electricity		10	10	5	150	3.8
Space cooling: electricity		10	10	10	150	3.8
Fuels for cooking:	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)
Cooking LPG/kerosene	troleum_produ	10	20	5	10	0.3
Cooking natural gas	ural_gas_House	10	25	9	39	1.0
Cooking electricity		10	10	7.4	24	0.6
Cooking traditional biomass	aditional bioma	10	3	5	10	0.25

7. Transport Sector:
   a. The "unit activity" refers to either the annual passenger or tonne kilometers per vehicle
   b. For "plug-in hybrid and battery electric" vehicles the cost of eventual battery replacement has been added to the O&M cost column in addition to the common O&M costs of these vehicles
   c. Vehicles using blended fuels are not provided, the expert must instead use the first/second generation biofuel vehicle and in the substitution table estimate a partial energy amount utilized based on the blend total. For example, if there is 10% ethanol blend requirement, enter the amount of PJ that the amount of ethanol would represent.
   d. Other structural change costs, such as public rail infrastructure or electric/hydrogen/natural gas refueling stations have not been accounted for in the unit cost calculations. These numbers can be revised to account for these costs.

2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Unit activity of renewable technology vehicle	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost
TRANSPORT SECTOR											
Renewable fuels:	(-)	(%, cap)	(years)	(p or t km/yr/vehicle)	(USD / vehicle)	(USD / vehicle / yr)	(MJ/h/p or t km)	(MJe/h/p or t km)	(%)	(USD/yr)	(USD/p or t-km)
First generation bioethanol (passenger ro	eneration_bioethanol		12	15000	28000	2800	1.64			7,524	0.50
Second generation bioethanol (passenger	eneration_bioethanol		12	15000	28000	2800	1.64			7,721	0.50
Biodiesel (passenger road vehicles)	Biodiesel		12	15000	30000	3000	1.54			8,027	0.54
Biodiesel (public road vehicles)	Biodiesel		25	60000	100000	10000	0.52			21,859	0.36
Biodiesel (freight road vehicles)	Biodiesel		35	110000	120000	12000	1.15			27,858	0.25
Biodiesel (passenger rail)	Biodiesel		35	500000	500000	50000	1.04			115,885	0.23
Biodiesel (freight rail)	Biodiesel		35	500000	350000	35000	0.54			78,581	0.16
Biodiesel (freight navigation)	Biodiesel		35	500000	800000	80000	0.21			165,787	0.33
Biomethane (passenger road vehicles)	Biomethane		12	15000	30000	3000	1.77			7,987	0.53
Biomethane (public road vehicles)	Biomethane		25	60000	40000	4000	0.6			9,199	0.15
Biomethane (freight road vehicles)	Biomethane		35	100000	150000	15000	1.35			33,823	0.34
Hydrogen (passenger road vehicles)	Hydrogen		12	15000	30000	3000	1.41			8,037	0.54
Hydrogen (public road vehicles)	Hydrogen		25	60000	40000	4000	0.78			9,811	0.16
Hydrogen (freight road vehicles)	Hydrogen		35	100000	150000	15000	1.75			35,803	0.36
Biofuels (passenger aviation)	Biokerosene		30	1000000	5E+07	5000000	5.52			10,607,562	10.61
Biofuels (freight aviation)	eneration bioethanol		30	1000000	5E+07	5000000	32.4			12,085,962	12.09
Electrification:	(-)	(%, cap)	(years)	(p or t km/yr/vehicle)	(USD / vehicle)	(USD / vehicle / yr)	(MJ/h/p or t km)	(MJe/h/p or t km)	(%)	(USD/yr)	(USD/p or t-km)
Plug-in hybrid (passenger road vehicles)			12	15000	35000	3500		0.98		9,658	0.6
Plug-in hybrid (public road vehicles)			15	15000	125000	12500		0.25		29,195	1.9
Plug-in hybrid (light-freight road vehicles)			15	60000	80000	8000		1.36		24,185	0.4
Battery electric (passenger road vehicles)			12	15000	45000	4500		0.69		11,823	0.8
Battery electric (public road vehicles)			15	15000	135000	13500		0.16		31,416	2.1
Battery electric (light-freight road vehicles)			15	60000	100000	10000		1.11		27,772	0.5
Structural changes towards electrification:	(-)	(%, cap)	(years)	(p or t km/yr/vehicle)	(USD / vehicle)	(USD / vehicle / yr)	(MJ/h/p or t km)	(MJe/h/p or t km)	(%)	(USD/yr)	(USD/p or t-km)
City tram for passenger road vehicles			35	500000	500000	50000		0.37		114,692	0.2
High speed train for passenger aviation			35	500000	500000	50000		0.37		114,692	0.2
Long range train for freight road			35	500000	350000	35000		0.115		75,284	0.2
Train electrification			35	500000	500000	50000		0.37		114,692	0.2

2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Unit activity of fossil fuel technology
TRANSPORT SECTOR				
Fossil fuels:	(-)	(%, cap)	(years)	(p or t km/yr/vehicle)
Petroleum products (passenger road vehicl	Gasoline		12	15000
Petroleum products (passenger road vehicl	Diesel		12	15000
Petroleum products (public road vehicles)	Diesel		25	60000
Petroleum products (freight road vehicles)	Diesel		35	110000
Petroleum products (passenger rail)	Diesel		35	500000
Petroleum products (freight rail)	Diesel		35	500000
Petroleum products (freight navigation)	Diesel		35	500000
Petroleum products (passenger aviation)	Diesel		30	1000000
Petroleum products (freight aviation)	Diesel		30	1000000
Natural gas (passenger road vehicles)	ural_gas_Industry		12	15000
Natural gas (public road vehicles)	ural_gas_Industry		25	60000
Natural gas (freight road vehicles)	ural_gas_Industry		35	100000
Electrification:	(-)	(%, cap)	(years)	(p or t km/yr/vehicle)
Petroleum products (passenger road vehicl	Gasoline		12	15000
Petroleum products (public road vehicles)	Diesel		25	60000
Petroleum products (light-freight road vehic	Diesel		35	100000
Structural changes towards electrification:	(-)	(%, cap)	(years)	(p or t km/yr/vehicle)
Petroleum products (passenger road vehicl	Gasoline		12	15000
Petroleum products (passenger aviation)	Kerosene		30	60000
Petroleum products (freight road vehicles)	Diesel		35	100000
Petroleum products (passenger rail)	Diesel		35	500000
Petroleum products (freight rail)	Diesel		35	500000

8. Power Sector:
   a. If one technology, such as a biomass system, can have different fuel inputs (selected in column C), the best method is to copy the technology row, and copy it below in a blank row. Then select the new fuel input from column C, and rename the technology in column B with an identifier so that later in the substitution tables the technology can be differentiated
   b. Please note that we have not differentiated between the variety of non-renewable technologies for coal (supercritical vs. IGCC), natural gas (simple vs. combined cycle) or nuclear (2/3 vs. 4 generation). This could be specified by the expert if he or she chooses.
   c. Currently no tide, wave, or ocean technology is provided, but experts are invited to add technologies of this type

2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Reference capacity or production volume	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost
POWER SECTOR											
	(-)	(%, cap)	(years)	(MW)	(USD/kW)	(USD/kW/yr)	(GJ/kW/yr)	(GJe/kW/yr)	(%)	(USD/yr)	(USD/GJe)
Hydro (Small)		50	40	0.05	4000	80		0.01	100.0	24,496	31.1
Hydro (Large)		50	60	100	1500	30		0.01	100.0	18,136,926	11.5
Wind onshore		38	30	100	1840	73.6		0.01	100.0	26,966,082	22.5
Wind efficient		42	30	100	2200	99		0.01	100.0	33,324,935	25.2
Wind offshore		48	30	50	2870	157.85		0.01	100.0	23,158,622	30.6
Solar PV (Residential/Commercial)		16	30	0.1	1400	14		0.01	100.0	16,339	32.4
Solar PV (Utility)		18	30	1	1000	10		0.01	100.0	116,954	20.6
Solar CSP PT no storage		35	35	50	6250	62.5		0.01	100.0	35,571,783	64.5
Solar CSP PT storage		40	35	50	8150	244.5		0.01	100.0	54,522,305	86.4
Solar CSP ST storage		70	30	20	10000	100		0.01	100.0	23,233,350	52.6
Biomass co-firing (retrofit)	rimary_biomass	70	40	200	500	12.5	58.1	0.05	38	197,048,657	44.6
Biomass steam cycle	rimary_biomass	80	25	50	2750	68.75	66.4	0.05	38	71,222,457	56.5
Biomass (gasification CC)	rimary_biomass	85	25	15	3500	87.5	67.0	0.05	40	23,034,892	57.3
Biomass Fixed-bed Gasifer	rimary_biomass	80	25	1	1100	27.5	168.2	0.05	15	2,809,868	111.4
Biomass Anaerobic Digester	rimary_biomass	85	25	0.5	3300	82.5	76.6	0.05	35	829,943	61.9
Landfill gas ICE	Municipal_waste	80	25	0.5	1350	33.75	78.8	0.05	32	171,953	13.6
Geothermal		80	50	25	3100	124		0.07	10.0	11,041,586	17.5
Tide, wave, ocean		90	25	5	3350	67		0.07	100.0	2,205,315	15.5

2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Reference capacity or production volume	Overnight Cap. Cost	O&M Costs
POWER SECTOR						
	(-)	(%, cap)	(years)	(MW)	(USD/kW)	(USD/kW/yr)
Coal	Steam_coal	80	60	650	1800	72
Natural gas	tural_gas_Indus	80	30	650	900	36
Oil	troleum_produ	30	50	400	1200	18
Nuclear	Nuclear_fuel	84	60	1200	5000	125
Diesel (Gen-set)	Diesel	40	20	0.1	800.0	20.0
Unserved Energy?						
Electricity						

9. Heat Sector:
   a. This sector applied to technologies used in district heating systems

2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Reference capacity or production volume	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost
HEAT SECTOR											
	(-)	(%, cap)	(years)	(MW)	(USD/kW)	(USD/kW/yr)	(GJ/kW/yr)	(GJe/kW/yr)	(%)	(USD/yr)	(USD/GJth)
Solar thermal		10	25	1	1200.0	12.0		0.01	100.0	145,077	46.0
Biomass waste-to-energy	Municipal_waste	29	25	1	600	15	18.3	0.05	50	121,433	13.3
Biomass steam cycle	rimary_biomass	45	25	1	1500	37.5	18.9	0.05	75	505,463	35.6
Geothermal		50	25	1	800	40		0.07	100.0	133,134	8.4

2030	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Reference capacity or production volume	Overnight Cap. Cost	O&M Costs
HEAT SECTOR						
	(-)	(%, cap)	(years)	(MW)	(USD/kW)	(USD/kW/yr)
Coal	Steam_coal	85	25	2	300.0	4.5
Petroleum products	troleum_produ	85	25	2	200.0	3.2
Natural gas	tural_gas_Indus	85	25	2	100.0	1.5

Substitution Process General: (see Fig. 4) – The following is a general description of the substitution process for all sector tabs. Specific notes regarding the sectorial sheets for Industry/Buildings/Transport/Power/Heat follow later in the document.

1. Renewable Energy technologies are first selected via a drop down list in column B for all sectoral sheets, however some cells do have fixed technologies. Once a technology is selected its corresponding data values (columns E-P) are automatically imported into the table. REMINDER: These technologies are referenced from WS2b, any changes to the technology types and their performance and cost values, must be made in WS2b.
2. Next, the quantities of renewable energy substitution potential are inputted by the user in the "renewable energy technology" column C in petajoules (PJ) per year. This amount should be entered once into the 2030 table to analyze the potential occurring between 2010-2030 (if the expert could also do this twice, once for Table 2020 and again for Table 2030, and input the potential relating to the preceding 10 years to those dates in WS2a).
3. The "substitution potential" represents the total amount of cumulative "additional added" renewable energy that could be put into the system during the timeframe based on the experts analysis ("additional added" is a term used to describe additions above the Reference Case). Any additions that already occurring in the Reference Case during this time should be excluded. Since this additional renewable energy is being deployed in lieu of conventional technologies, this process is defined as a substitution of a conventional variant of which the "average incremental cost of substitution" comparison can be made. Currently the substitution potential does not include early retirement of conventional technologies; however, this option can be discussed with the IRENA experts and added into the tool.
   *PLEASE NOTE: if you do not know the added renewable energy in PJ, and instead know units of capacity (e.g. megawatt electricity (MW_e)), production volume (e.g. kilotonnes (kt) per year) or distance (e.g. 1000 million passenger kilometers per year (bln. p-km/yr)), these values are automatically estimated in column E based on your input in columns C/D. By altering the PJ amount in column C/D, you can arrive at the desired total in column E.
4. Next, in column R the conventional technology that is being substituted must be selected from a drop down list of options. Again, performance and cost data for these technologies is inputted from WS2b automatically. Any changes to the technology types, or values, must be made in WS2a/b
   *PLEASE NOTE: multiple entries for the same renewable energy technology can be entered if the fossil/nuclear technology being replaced differs.
5. The remainder of the process is automated: based on the fuel input and discount rates (WS1) and technical performance and cost (WS2a/b) data, the total annualized costs for both the renewable and conventional technologies are calculated (columns AH, AI). Based on the difference between these two costs and the amount of energy produced the **average incremental cost of substitution** is calculated. This value is later used in the cost supply curve to plot the cost associated with the renewable energy substitution process for each technology (see description for WS8/Curve)

Fig. 4 - **PLEASE NOTE: for all substitution tables only column B & R (for technology selection) and columns C (for energy amounts) require data input.

A	B	C	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	AH	AI	AJ
	Renewable Energy Technology															Conventional Fossil Fuel & Nuclear Technology						
	2020	Power production: new capacity	Renewable energy capacity installed	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Total capacity	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost		2020	Total substituted fossil fuel	Total substituted electricity	Fossil fuel capacity substituted	Annualized total costs: REMAP	Annualized total costs: substituted fossil fuels	Average incremental cost of substitution
	POWER SECTOR															POWER						
		(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(MW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJel/kW/yr)	(%)	(USD/yr)	(USD/GJe)			(PJ/yr)	(PJ/yr)	(MW)	(USD/yr)	(USD/yr)	(USD/GJ)
	A1 Main activity															A1 Main activity						
	Hydro (Small)		0	0	50	40	0	4000	80	0.000	0.013	100	24487	31		Coal	0	0.000	0.0	0	0	0.0
	Hydro (Large)		0	0	50	60	100	1500	30	0.000	0.013	100	18119426	11		Coal	0	0.000	0.0	0	0	0.0
	Wind onshore		0	0	38	30	100	1840	74	0.000	0.013	100	26948582	22		Coal	0	0.000	0.0	0	0	0.0
	Wind efficient		0	0	42	30	100	2200	99	0.000	0.013	100	33307435	25		Coal	0	0.000	0.0	0	0	0.0
	Wind offshore		0	0	48	30	50	2870	158	0.000	0.013	100	23149872	31		Coal	0	0.000	0.0	0	0	0.0
	Solar PV (Residential/Commercial)		0	0	16	30	0	1400	14	0.000	0.013	100	16321	32		Coal	0	0.000	0.0	0	0	0.0
	Solar PV (Utility)		0	0	18	30	1	1000	10	0.000	0.013	100	116779	21		Coal	0	0.000	0.0	0	0	0.0
	Solar CSP PT no storage		0	0	35	35	50	6250	63	0.000	0.013	100	35563033	64		Coal	0	0.000	0.0	0	0	0.0
	Solar CSP PT storage		0	0	40	35	50	8150	245	0.000	0.013	100	54513555	86		Coal	0	0.000	0.0	0	0	0.0
	Solar CSP ST storage		0	0	70	30	20	10000	100	0.000	0.013	100	23229850	53		Coal	0	0.000	0.0	0	0	0.0
	Biomass co-firing (retrofit)		0	rimary_biomass_	70	40	200	500	13	58.093	0.054	38	152748257	35		Coal	0	0.000	0.0	0	0	0.0
	Biomass steam cycle		0	rimary_biomass_	80	25	50	2750	69	66.392	0.054	38	58570557	46		Coal	0	0.000	0.0	0	0	0.0
	Biomass (gasif)/cation CC)		0	rimary_biomass_	85	25	15	3500	88	67.014	0.054	40	19203844	48		Coal	0	0.000	0.0	0	0	0.0
		1															3				4	
		2																				

Substitution Process cont.: (Fig. 5)

*No data entry is required for this section. The table shown in Fig. 5 is provided as a reference tool for the expert to better assess the substitution potential and the results in broad terms on the country's energy balance for a particular sector.

6. In each sectorial sheet (WS3-7) a summary energy balance for that sector for 2030 is provided (also 2020 in data grouped in rows 1 to 70) (columns AL to BC). This is a projection of the energy balance based on Reference Case and data is imported from WS0. The reason for providing this data is to allow the expert to see:
    a. The amounts of fossil or nuclear energy used in the sector (6a),
    b. and in which subsectors (6b).
    c. The substitution potential entered into the tables for 2020 and 2030 (Fig. 4) is summarized in "REmap Options summary" (6c). Additionally a comparison of the Reference Case and REmap Options as a share of renewable energy relative to the sector total energy use is provided[1] (6d). For this, in the buildings sector a percentage is provided both including, and excluding, traditional biomass.

6b

6a

Fig. 5

	Coal	Oil and oil products	Natural gas	Nuclear	Hydro	Geothermal	Solar photovoltaics	CSP	Wind	Solid biomass	of which	Liquid & Gaseous Biofuels	of which	Solar thermal	Electricity	Heat	Total
EB 2020: Reference case	TOT	TOT	TOT	TOT	TOT	TOT	TOT	TOT	TOT	TOT	Traditional	TOT	Biogas	TOT			
Industry (excl. Feedstock, BF & CO)	189	175	326	0	0	0	0	0	0	98	0	0	0	0	300	0	1,088
Iron and Steel (incl. BF & CO)	107	2	23	0	0	0	0	0	0	0	0	0	0	0	15	0	147
Chem. & Petroch	7	10	71	0	0	0	0	0	0	10	0	0	0	0	19	0	116
of which: Feedstocks	0	98	40	0	0	0	0	0	0	0	0	0	0	0	0	0	139
Non-ferrous Metals	37	56	112	0	0	0	0	0	0	2	0	0	0	0	154	0	361
Non-metallic mineral	22	14	56	0	0	0	0	0	0	1	0	0	0	0	18	0	111
Food and tobacco	12	3	28	0	0	0	0	0	0	47	0	0	0	0	22	0	112
Paper, Pulp, Printing	2	0	20	0	0	0	0	0	0	21	0	0	0	0	16	0	59
Textile and leather	0	1	5	0	0	0	0	0	0	0	0	0	0	0	3	0	9
Others	1	89	12	0	0	0	0	0	0	17	0	0	0	0	53	0	172

	Fossil fuels	Renewables	Electricity	Heat	Total
EB 2020: Reference case					
Industry (excl. Feedstock)	690	99	300	0	1,088

	Fossil fuels	Renewables	Electricity	Heat	Total
EB 2020: REMAP options summary					
Industry (excl. Feedstock)	690	99	300	0	1,088

Renewable share (excl. feedstock; excluding electricity & heat)	Reference case	REMAP options
2010	9.7%	
2020	12.5%	12.5%

Renewable share (excl. Feedstock, incl. electricity & heat)	Reference case	REMAP options
2010	9.5%	
2020	12.4%	15.5%

6c

6d

Fossil fuel & nuclear use after substitution in 2020 (main activity and autoproducer plants) (PJ/yr):	2,136
Coal use after substitution in 2020 (PJ/yr):	1,752
Oil use after substitution in 2020 (PJ/yr):	36
NG use after substitution in 2020 (PJ/yr):	348
Nuclear use after substitution in 2020 (PJ/yr):	0

9

7. It is assumed that renewable energy technologies do not use any fossil fuel to meet their auxiliary energy needs or for other purposes. However, most technologies (including conventional) use electricity for purposes such as running motors, etc. The difference between the electricity demand of the substituted conventional technology and the renewable energy technology is taken into account and is input to the sectoral energy balance "REmap Summary" electricity use column.
8. PLEASE NOTE: the REmap analysis attempts to identify technological pathways that address the gap on an international level between business-as-usual (represented by the Reference Case) and the aspirational global target of a doubling renewable energy by 2030. Therefore, the renewable energy substitution potential in the sectoral substitution tables are only "additional added", i.e. increases above Reference Case growth. The table provided in Fig. 5 is designed to give experts insight into what the Reference Case projection is, and based on that growth allow them to determine what the "additional added" potential is. Therefore any additions need to exclude this reference growth.
9. Also contained below each substitution table in each sector sheet is a dynamic table that shows the remaining fossil, nuclear, or traditional biomass after the substitution. PLEASE NOTE: the Reference Case tables (Fig. 5) are not dynamic and the numbers will not change based on substitution amounts.

[1] For the purpose of this analysis the definition of energy use and "modern" renewable energy is based on off the Global Tracking Framework of the UN's SE4ALL Initiative

PLEASE NOTE: If an analysis for both 2020 and 2030 will be done, the technology list order for both sector tables for the renewable energy technologies **must be the same**. This is necessary for the cost-supply curve to function properly. Please also note that **no rows can be added in the substitution tables**.

The following pages provide specific descriptions for each sectoral worksheet. The worksheets should be completed in the order they are presented (industry/buildings/transport/power/heat). These descriptions elaborate on the aforementioned substitution process described for Figs. 5 & 6.

WS3 – Industry Sector (Fig. 6)

1. In this worksheet the substitution process for the industry sector will take place. As in all sectoral worksheets, the process entails entering energy substitution potentials. PLEASE NOTE: these totals should be "additional added" as described in point 8 of the substitution process description.
2. **Electricity:**
   a. Autoproducers (Section A) – add here any additions to on-site electricity production from renewables such as PV or the electricity component of biomass CHP; and select the type of fossil fuel derived electricity it is substituted (2a). The capacity should be installed for self-consumption; any electricity produced onsite and fed into the electricity grid can instead be entered into the power sector worksheet (WS6).
   b. Renewable heating/cooling (Section B) – add here additions to onsite renewable energy technology for heating/cooling generation (see below) that replace conventional technologies which use electricity from the mains/grid (reductions automatically added to power worksheet) (2b)
3. **Heat generation** – add here additions to on-site heat generation from renewable technologies (3a) for all temperature levels of process heat. Also select the type of fossil fuel technology substituted (column R).
   a. **Autoproducers (fuels)** – add here the use of biodiesel if substituting autoproduer diesel (for electricity production, but included here because it is a fuel substitution) (3b). Also the CHP heat component of an autoproduer CHP plant is automatically calculated here based on the amount of electricity entered into cell C10 (using the IEA convention to partition fuels input to the CHP plants and assuming power-to-heat ratio of 0.3)
   b. **Bio-based feedstocks** – Additions of bio-based feedstocks used in production of chemicals and polymers (3c) and the fossil feedstock they are substituting can be entered here. However feedstocks are excluded from TFEC, therefore also from the cost-supply curve. Please discuss use of these options with IRENA before use.

Fig. 6

	2030	Substitution of primary fuels: new capacity	Renewable energy capacity installed	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Capacity	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost
	INDUSTRY SECTOR													
	Electricity:	(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)
	A) Autoproducers (substitution of electricity production)													
2a	Autoproducers (PV)		0.0	0	16	30	100	1400	14	0.000	0.013	100	16,339	32
2a	Autoproducers, CHP electricity part (biomass)		0.0	Primary_biomass_	50	25	10000	320	8	27	0	58	4736709	30
2b	B) Renewable heating/cooling													
2b	Solar cooling		0.0	0	10	25	500	1060	16	0.000	0.013	100	66,777	42
	Total (excluding A)	0												
	Heat generation:	(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)
3a	Solar thermal		0.0	0	10	25	500	656	10	0.000	0.013	100	41,493	26
3a	Geothermal		0.0	0	55	42	100	1500	38	0.000	0.072	100	19,529	11
3a	Biomass boilers		0.0	Primary_biomass_	85	25	500	580	15	30.461	0.054	88	281,715	21
3a	Biomass gasification		0.0	Primary_biomass_	80	25	500	2000	50	28.669	0.054	88	363,529	29
3a	Charcoal		0.0	0	0	0	0	0	0	0.000	0.000	100	0	10
			0.0	0	0	0	0	0	0	0.000	0.000	0	0	0
			0.0	0	0	0	0	0	0	0.000	0	0	0	0
			0.0	0	0	0	0	0	0	0.000	0	0	0	0
			0.0	0	0	0	0	0	0	0.000	0	0	0	0
	A) Autoproducers (fuels)													
3b	Autoproducers (Biodiesel)		0.0	Biodiesel	50	25	100	200	4	21.024	0.013	75	58,880	37
3b	Autoproducers, CHP heat part (biomass)	0	0	Primary_biomass_	90	25	32000	204	5.1	56.7648	0.054	50	29702860.1	32.7036518
	Total	0												

2030	Total substituted fossil fuel	Total substituted electricity
INDUSTRY SECTOR		
Electricity:	(PJ/yr)	(PJ/yr)
Natural gas	0.0	0.0
Coal	0.0	0.0
Electricity		0.0
Total (excluding A and B)	0	0
Heat generation:	(PJ/yr)	(PJ/yr)
Coal (steam boiler)	0.0	0.0
Petroleum products (steam boiler)	0.0	0.0
Natural gas (steam boiler)	0.0	0.0
Coal (furnace)	0.0	0.0
Coking coal	0.0	0.0
Natural gas (furnace)	0.0	0.0
Petroleum products (furnace)	0.0	0.0
	0.0	0.0
	0.0	0.0
Autoproducer diesel	0.0	0.0
Coal (steam boiler)	0.0	0.0
Total	0	0.000

WS4 – Buildings Sector (Fig. 7)

1. In this worksheet the substitution process for the building sector will take place. As in all sectoral worksheets, the process entails entering energy substitution potentials. PLEASE NOTE: these totals should be "additional added" as described in point 8 of the substitution process description.
2. **Electricity:**
    a. Autoproducers (Section A) – add here (2) any additions to on-site electricity production from renewables such as PV or mini-hydro (or other technologies can be added to the section WS2a/b). This electricity is intended to replace electricity drawn from the grid.
3. **District heating**:
    a. Autoproducers (Section A) – add here (3) any additional on-site district heating production that replaces fossil fuel based district heat. Select the type of fossil fuel based district heat in column R. Autoproduction district heat is rare and should not be confused with WS7 (examples may include village biomass community heating).
4. **Space and water heating/cooling and cooking (electrification)** – add here (4a) any added renewable space and water heating/cooling and cooking (4b) technologies which use electricity as the main energy source and select the type of fossil fuel technology substituted in column R. The increase in electricity demand will be transferred to the power sector.
5. **Space and water heating/cooling (RE technologies)**- add here (5) any added renewable space and water heating/cooling technologies based on RE fuels or solar resources and select the type of fossil fuel technology substituted in column R.
6. **Space and water heating/cooling (de-electrification)**- add here (6) any added renewable space and water heating/cooling technologies based on RE fuels or solar resources that substitute electricity based technologies (air conditioning, electric water heating).
7. **Access to modern biomass (space heating)**- add here (7) any added renewable space or water heating technology based on RE fuels or solar resources that substitute the use of traditional biomass. This will result in a reduction in traditional biomass use.
8. **Autoproducers (biodiesel)**- add here (8) the use of biodiesel if substituting autoproducer diesel (for electricity production, but included here because it is a fuel substitution)
9. **Fuels for Cooking (RE):** add here (9) the use of RE fuels for cooking that substitute fossil fuel based cooking
10. **Access to modern biomass (cooking):** add here (10) the use of RE fuels for cooking that substitute traditional biomass based cooking. This will result in a reduction in traditional biomass use. This can also include "cooking biomass (solid)", i.e. modern biomass cookstoves, which use traditional biomass, but which are also more efficient, resulting still in a reduction of traditional biomass use, but an increase in modern biomass use in cooking.

Fig. 7

	2030	Substitution of primary fuels: new	Renewable energy capacity installed	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Capacity	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost	2030	Total substituted fossil fuel	Total substituted electricity	Fossil fuel capacity substituted
	BUILDINGS SECTOR														**BUILDINGS SECTOR**			
	Electricity:	(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJe)	Electricity:	(PJ/yr)	(PJ/yr)	(MW)
	A) Autoproducers (substitution of electricity production)																	
2	PV		0	0	16	30	100	1400	14	0	0	100	16339	32	Electricity		0	0.0
2	Mini-hydro		0	0	50	40	50	4000	80	0	0	100	24496	31	Electricity		0	0.0
	Total	0													Total		0	
	District heating:	(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)	District heating:	(PJ/yr)	(PJ/yr)	(MW)
	A) Autoproducers (substitution of heat production)																	
3	Biomass		0.0	Primary_biomass_	30	25	100	600	15	12.614	0.072	75	28,541	30	Space heating: petroleum products (boiler)	0	0.000	0.0
3	Geothermal		0.0	0	40	25	100	1500	38	0.000	0.050	100	20,622	16	Space heating: coal (boiler)	0	0.000	0.0
3	Waste-to-energy		0.0	Municipal_waste	85	25	100	800	20	59.568	0.050	45	23,074	9	Space heating: natural gas (boiler)	0	0.000	0.0
	Total	0													Total	0	0.00	
	Space and water heating/cooling and cooking (electrification):	(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)	Space and water heating/cooling:	(PJ/yr)	(PJ/yr)	(MW)
	Space heating and cooling:														Space heating and cooling:			
4a	Space cooling: Air conditioner		0	0	15	14	12	572	14	0	2	90	2620	46	Space heating: petroleum products (boiler)	0.00	0.000	0.0
4a	Space cooling: With seasonal cold		0	0	50	25	15	5000	125	0	4	400	10152	60	Space heating: natural gas (boiler)	0.00	0.000	0.0
4a	Space cooling: Air conditioning heat		0	0	50	25	10	1500	38	0	4	400	4765	30	Space heating: coal (boiler)	0.00	0.000	0.0
4a	Space heating: With seasonal storage		0	0	50	25	25	5000	125	0	4	350	16921	60	Space heating: petroleum products (boiler)	0.00	0.000	0.0
4a	Space heating: Geothermal heat pumps		0	0	50	15	12	1500	38	0	5	350	6571	35	Space heating: natural gas (boiler)	0.00	0.000	0.0
4a	Space heating: Air-to-Air heat pumps		0	0	50	15	12	780	20	0	5	350	5219	28	Space heating: natural gas (boiler)	0.00	0.000	0.0
4a	Space heating: Electricity		0	0	10	10	23	346	9	0	1	90	2753	38	Space heating: coal (boiler)	0.00	0.000	0.0
4a	Water heating: Electricity		0	0	10	10	23	346	9	0	1	90	2753	38	Water heating: natural gas (boiler)	0.00	0.000	0.0
			0	0	0	0	0	0	0	0	0	0	0	0		0.00	0.000	0.0
			0	0	0	0	0	0	0	0	0	0	0	0		0.00	0.000	0.0
	Cooking:														Cooking:			
4b	Cooking electricity		0	0	10	10	7	24	1	0	4	75	2194	94	Cooking LPG/kerosene	0.000	0.000	0.0
4b	Cooking electricity		0	0	10	10	7	24	1	0	4	75	2194	94	Cooking natural gas	0.000	0.000	0.0
	Total	0													Total	0	0.00	
	Space and water heating/cooling (RE technologies):	(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)	Space and water heating/cooling:	(PJ/yr)	(PJ/yr)	(MW)
	Water heating: Biomass		0.0	Primary_biomass_	30	15	20	600	15	12	0	80	5684	30	Water heating: natural gas (boiler)	0	0.000	0.0
5	Water heating: Solar		0.0	0	12	20	82	1200	30	0	0	100	14303	46	Water heating: natural gas (boiler)	0	0.000	0.0
5	Space heating: Solar		0.0	0	12	20	5	1200	30	0	0	100	872	46	Space heating: petroleum products (boiler)	0	0.000	0.0
5	Space heating: Biogas		0.0	Biomass_residues_	50	15	50	600	15	20	0	80	10781	14	Space heating: natural gas (boiler)	0	0.000	0.0
5	Space heating: Pellet burners		0.0	Primary_biomass_	30	15	20	774	19	11	0	85	6009	32	Space heating: coal (boiler)	0	0.000	0.0
			0.0	0	0	0	0	0	0	0	0	0	0	0		0	0.000	0.0
			0.0	0	0	0	0	0	0	0	0	0	0	0		0	0.000	0.0
	Space and water heating/cooling (de-electrification)														Space and water heatings/cooling: Electricity			
6	Space Cooling: Solar		0.0	0	12	20	5	1350	34	0	0	100	979	52	Space cooling: electricity		0	0.0
6	Water heating: Solar		0.0	0	12	20	82	1200	30	0	0	100	14303	46	Water heating: electricity		0	0.0
			0.0	0	0	0	0	0	0	0	0	0	0	0			0	0.0
	Access to modern biomass:														Access to modern biomass:			
7	Space heating: Solar		0.0	0	12	20	5	1200	30	0	0	100	869	46	Space & Water heating: traditional biomass	0	0.000	0.0
7	Space heating: Pellet burners		0.0	Primary_biomass_	30	15	20	774	19	11	0	85	5149	27	Space & Water heating: traditional biomass	0	0.000	0.0
	Autoproducers:														Autoproducers:			
8	Biodiesel		0.0	Biodiesel	50	25	1	300	8	19.710	0.013	80	574	36	Diesel	0	0.000	0.0
	Total	0													Total	0	0.000	
	Fuels for cooking:	(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(kW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%, eff)	(USD/yr)	(USD/GJth)	Fuels for cooking:	(PJ/yr)	(PJ/yr)	(MW)
9	Cooking biogas (from AD)		0.0	Biomass_residues_	10	25	9	39	1	7	0	48	402	14	Cooking natural gas	0.000	0.000	0.0
9	Cooking biomass (solid)		0.0	Primary_biomass_	10	20	5	15	0	11	0	30	841	53	Cooking LPG/kerosene	0.000	0.000	0.0
9	Cooking bioethanol		0.0	_generation_bioeth	10	20	5	10	0	6	0	50	796	50	Cooking LPG/kerosene	0.000	0.000	0.0
			0.0	0	0	0	0	0	0	0	0	0	0	0		0.000	0.000	0.0
			0.0	0	0	0	0	0	0	0	0	0	0	0		0.000	0.000	0.0
	Access to modern biomass:														Access to modern biomass:			
10	Cooking biogas (from AD)		0.0	Biomass_residues_	10	25	9	39	1	6.570	0.000	48	343	12	Cooking traditional biomass	0.000	0.000	0.0
10	Cooking biomass (solid)		0.0	Primary_biomass_	10	20	5	15	0	10.512	0.000	30	641	41	Cooking traditional biomass	0.000	0.000	0.0
10	Cooking bioethanol		0.0	_generation_bioeth	10	20	5	10	0	6.307	0.000	50	701	44	Cooking traditional biomass	0.000	0.000	0.0

WS5 – Transport Sector (Fig. 8)

1. In this worksheet the substitution process for the transport sector will take place. As in all sectoral worksheets, the process entails entering energy substitution potentials. PLEASE NOTE: these totals should be "additional added" as described in point 8 of the substitution process description.
2. **Renewable fuels** – add here (2) any RE fuels (first/second generation bioethanol, biodiesel, hydrogen, etc.) based on transport type (passenger road, freight road, freight rail, aviation, etc) and the type of fossil fuel being substituted which is usually the petroleum-based equivalent.
    a. PLEASE NOTE: for blended fuels, please calculate the amount of renewable fuel used in the blending requirement and enter this value as the renewable fuel – for example if blending requirement is 10% and a total of 100 PJs will be consumed by gasoline cars, then enter 10 PJs of second generation bioethanol
3. **Electrification** – add here (3) any electricity power vehicles and the fossil fuel technology being substituted. The increased electricity demand is automatically added to the power worksheet (WS6) but the production source has not yet been defined (a later step in WS6).
    a. PLEASE NOTE: for plug-in hybrids, please calculate the portion of distance traveled on electricity and enter the equivalent PJ amount, the remainder passenger or tonne kilometers can be petrol based (no action required) or RE fuel based (entered as a technology option in the RE fuels section).
4. **Structural changes towards electrification** (modal shift) – add here any structural changes that reduce fossil fuel consumption and add to electricity demand in various transportation modes. Select the structural shift (4) and the fossil fuel technology impacted (column R). This added electricity demand is handled as describe above later in WS6.

PLEASE NOTE: If you do not know the amount of energy for a particular technology, in column E the "total activity from renewable technology vehicles" is provided in either billion passenger or tonne km/year. If you do not know the total capacity, rather the number of units (automobiles for example), please multiply the number of units by the average unit distance to arrive at the total capacity, and adapt the values in PJ to arrive at the total capacity you have estimated.

Fig. 8

2030	Substitution of primary fuels: new capacity	Total activity from renewable technology vehicles	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Unit activity of renewable technology vehicle	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost
TRANSPORT SECTOR													
Renewable fuels:	(PJ/yr)	(bln. port km/yr)	(-)	(%, cap)	(years)	(port km/yr/vehicle)	(USD / vehicle)	(USD / vehicle / yr)	(MJf/port km)	(MJe/port km)	(%)	(USD/yr)	(USD/port-km)
First generation bioethanol (passenger road vehicles)		0.0	generation_bioe	0	12	15000	28000	2800	1.640	0.000	0	7524	1
Second generation bioethanol (passenger ro	10.0	6.1	_generation_bio	0	12	15000	28000	2800	1.640	0.000	0	7721	1
Biodiesel (passenger road vehicles)		0.0	Biodiesel	0	12	15000	30000	3000	1.540	0.000	0	8027	1
Biodiesel (public road vehicles)		0.0	Biodiesel	0	25	60000	100000	10000	0.520	0.000	0	21859	0
Biodiesel (freight road vehicles)		0.0	Biodiesel	0	35	110000	120000	12000	1.150	0.000	0	27858	0
Biodiesel (passenger rail)		0.0	Biodiesel	0	35	500000	500000	50000	1.040	0.000	0	115885	0
Biodiesel (freight rail)		0.0	Biodiesel	0	35	500000	350000	35000	0.540	0.000	0	78581	0
Biodiesel (freight navigation)		0.0	Biodiesel	0	35	500000	800000	80000	0.210	0.000	0	165787	0
Biomethane (passenger road vehicles)		0.0	Biomethane	0	12	15000	30000	3000	1.770	0.000	0	7987	1
Biomethane (public road vehicles)		0.0	Biomethane	0	25	60000	40000	4000	0.600	0.000	0	9199	0
Biomethane (freight road vehicles)		0.0	Biomethane	0	35	100000	150000	15000	1.350	0.000	0	33523	0
Hydrogen (passenger road vehicles)		0.0	Hydrogen	0	12	15000	30000	3000	1.410	0.000	0	8037	1
Hydrogen (public road vehicles)		0.0	Hydrogen	0	25	60000	40000	4000	0.780	0.000	0	9811	0
Hydrogen (freight road vehicles)		0.0	Hydrogen	0	35	100000	150000	15000	1.750	0.000	0	35803	0
Biofuels (passenger aviation)		0.0	Biokerosene	0	30	1000000	50000000	5000000	5.520	0.000	0	10607562	11
Biofuels (freight aviation)		0.0	generation bioet	0	30	1000000	50000000	5000000	32.400	0.000	0	12085962	12
		0.0	0	0	0	0	0	0	0.000	0.000	0	0	0
Total	10												
Electrification:	(PJ/yr)	(bln. port km/yr)	(-)	(%, cap)	(years)	(port km/yr/vehicle)	(USD / vehicle)	(USD / vehicle / yr)	(MJf/port km)	(MJe/port km)	(%)	(USD/yr)	(USD/port-km)
Plug-in hybrid (passenger road vehicles)		0.0	0	0	12	15000	35000	3500	0.000	0.980	0	9658	1
Plug-in hybrid (public road vehicles)		0.0	0	0	15	15000	125000	12500	0.000	0.250	0	29195	2
Plug-in hybrid (light-freight road vehicles)		0.0	0	0	15	60000	80000	8000	0.000	1.360	0	24185	0
Battery electric (passenger road vehicles)		0.0	0	0	12	15000	45000	4500	0.000	0.690	0	11823	1
Battery electric (public road vehicles)		0.0	0	0	15	15000	135000	13500	0.000	0.160	0	31416	2
Battery electric (light-freight road vehicles)		0.0	0	0	15	60000	100000	10000	0.000	1.110	0	27772	0
		0.0	0	0	0	0	0	0	0.000	0.000	0	0	0
Total	0												
Structural changes towards electrification:	(PJ/yr)	(bln. port km/yr)	(-)	(%, cap)	(years)	(port km/yr/vehicle)	(USD / vehicle)	(USD / vehicle / yr)	(MJf/port km)	(MJe/port km)	(%)	(USD/yr)	(USD/port-km)
City tram for passenger road vehicles		0.0	0	0	35	500000	500000	50000	0.000	0.370	0	114692	0
High speed train for passenger aviation		0.0	0	0	35	500000	500000	50000	0.000	0.370	0	114692	0
Long range train for freight road		0.0	0	0	35	500000	350000	35000	0.000	0.115	0	75284	0
Train electrification		0.0	0	0	35	500000	500000	50000	0.000	0.370	0	114692	0
Train electrification		0.0	0	0	35	500000	500000	50000	0.000	0.370	0	114692	0
		0.0	0	0	0	0	0	0	0.000	0.000	0	0	0
		0.0	0	0	0	0	0	0	0.000	0.000	0	0	0
Total	0												
Total	0												

2030	Total substituted fossil fuel
TRANSPORT SECTOR	
Fossil fuels:	(PJ/yr)
Petroleum products (passenger road vehicles)	0.0
Petroleum products (passenger road vehicles)	9.8
Petroleum products (passenger road vehicles -	0.0
Petroleum products (public road vehicles)	0.0
Petroleum products (freight road vehicles)	0.0
Petroleum products (passenger rail)	0.0
Petroleum products (freight rail)	0.0
Petroleum products (freight navigation)	0.0
Natural gas (passenger road vehicles)	0.0
Natural gas (public road vehicles)	0.0
Natural gas (freight road vehicles)	0.0
Petroleum products (passenger road vehicles)	0.0
Petroleum products (public road vehicles)	0.0
Petroleum products (freight road vehicles)	0.0
Petroleum products (passenger aviation)	0.0
Petroleum products (freight aviation)	0.0
	0.0
Total	10
Fossil fuels:	(PJ/yr)
Petroleum products (passenger road vehicles)	0.0
Petroleum products (public road vehicles)	0.0
Petroleum products (light-freight road vehicles)	0.0
Petroleum products (passenger road vehicles)	0.0
Petroleum products (public road vehicles)	0.0
Petroleum products (light-freight road vehicles)	0.0
	0.0
Total	0
Fossil fuels:	(PJ/yr)
Petroleum products (passenger road vehicles)	0.0
Petroleum products (passenger road vehicles)	0.0
Petroleum products (freight road vehicles)	0.0
Petroleum products (passenger rail)	0.0
Petroleum products (freight rail)	0.0
	0.0
	0.0
Total	0
	10

WS6 – Power Sector (Fig. 9)

1. In this worksheet the substitution process for the power sector will take place. As in all sectoral worksheets, the process entails entering energy substitution potentials. PLEASE NOTE: these totals should be "additional added" as described in point 8 of the substitution process description.
2. Main activity (Section A) – add here based on technology (2) any additions to renewable electricity production in PJ and select the type of fossil fuel being substituted (column R). If only the capacity increases are known (reference column E), enter the PJ amounts into column C until the desired number of MW_e is reached.
3. Autoproducers (Section B) –This is the sum of additional electricity produced in the industry and buildings sectors by renewable sources (3). In those original tables, comparison was made with a type of conventional energy which could potentially be substituted in order to come up with an average incremental cost which will be displayed in the cost supply curve, thus the costs are assigned to the end-use sectors. For this reason, in this table only the energy total (in PJ/yr) has been imported and this sum is automatically added to the renewable energy total - nothing else has to be done.
4. "Additional Main activity plants" (Section C) – is the total PJ/yr amount of energy demand increase as a result of electrification in the industry, buildings and transport sectors. This additional amount of energy must be accounted for in the power system's generation capacity and be assigned to a renewable technology or group of technologies. Therefore the country expert should:
    a. Select technology(ies) and enter PJ amounts (4a) which equal the sum of the net amount of additional mains activity (4b)
5. Lastly, the amount of PJ entered for each renewable energy technology in the "additional main activity" section (4a) must be subtracted from the corresponding technology in the "main activity" section (Section A) as to avoid double counting.

Fig. 9

	B	C	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T
	Renewable Energy Technology														Conventional Fossil Fuel & Nuclear Technology		
	2020	Power production: new capacity	Renewable energy capacity installed	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Total capacity	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost	2020	Total substituted fossil fuel	Total substituted electricity
	POWER SECTOR														POWER SECTOR		
		(PJ/yr)	(MW)	(-)	(%, cap)	(years)	(MW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%)	(USD/yr)	(USD/GJe)		(PJ/yr)	(PJ/yr)
	A) Main activity														A) Main activity		
	Hydro (Small)		0	0	50	40	0	4000	80	0.000	0.013	100	24487	31	Coal	0	0.000
	Hydro (Large)		0	0	50	60	100	1500	30	0.000	0.013	100	18119426	11	Coal	0	0.000
	Wind onshore		0	0	38	30	100	1840	74	0.000	0.013	100	26948582	22	Coal	0	0.000
	Wind efficient		0	0	42	30	100	2200	99	0.000	0.013	100	33307435	25	Coal	0	0.000
	Wind offshore		0	0	48	30	50	2870	158	0.000	0.013	100	23149872	31	Coal	0	0.000
	Solar PV (Residential/Commercial)		0	0	16	30	0	1400	14	0.000	0.013	100	16321	32	Coal	0	0.000
	Solar PV (Utility)		0	0	18	30	1	1000	10	0.000	0.013	100	116779	21	Coal	0	0.000
	Solar CSP PT no storage		0	0	35	35	50	6250	63	0.000	0.013	100	35563033	64	Coal	0	0.000
2	Solar CSP PT storage		0	0	40	35	50	8150	245	0.000	0.013	100	54513555	86	Coal	0	0.000
	Solar CSP ST storage		0	0	70	30	20	10000	100	0.000	0.013	100	23229850	53	Coal	0	0.000
	Biomass co-firing (retrofit)		0	rimary_biomass_	70	40	200	500	13	58.093	0.054	38	152748257	35	Coal	0	0.000
	Biomass steam cycle		0	rimary_biomass_	80	25	50	2750	69	66.392	0.054	38	58570557	46	Coal	0	0.000
	Biomass (gasification CC)		0	rimary_biomass_	85	25	15	3500	88	67.014	0.054	40	19203844	48	Coal	0	0.000
	Biomass Fixed-bed Gasifer		0	rimary_biomass_	80	25	1	1100	28	168.192	0.054	15	2169989	86	Coal	0	0.000
	Biomass Anaerobic Digester		0	rimary_biomass_	85	25	1	3300	83	76.587	0.054	35	684052	51	Coal	0	0.000
	Landfill gas ICE		0	Municipal_waste	80	25	1	1350	34	78.840	0.054	32	132158	10	Coal	0	0.000
	Geothermal		0	0	80	50	25	3100	124	0.000	0.072	10	11016586	17	Coal	0	0.000
	Tide, wave, ocean		0	0	90	25	5	3350	67	0.000	0.072	100	2200315	16	Coal	0	0.000
			0	0	0	0	0	0	0	0.000	0.000	0	0	0		0	0.000
3	B) Autoproducers (add. capacity from other sectors)														B) Autoproducers (add. capacity from other sectors)		
	Autoproducers	0.0										100			Costs assigned to the other sectors		
	C) Additional main activity plants to supply net additional demand from other sectors (distribute across different technologies below)	100	4b												C) Additional main activity plants to supply net additional demand from other sectors		
4a	Wind onshore		0	0	38	30	100	1840	74	0.000	0.013	100	26948582	22	Coal	0	0.000
	Hydro (Large)		0	0	50	60	100	1500	30	0.000	0.013	100	18119426	11	Coal	0	0.000
	Solar PV (Utility)		0	0	18	30	1	1000	10	0.000	0.013	100	116779	21	Coal	0	0.000
			0	0	0	0	0	0	0	0.000	0.000	0	0	0	Coal	0	0.000

WS7 – Heat Sector (Fig. 10)

1. In this worksheet the substitution process for the heat sector will take place. As in all sectoral worksheets, the process entails entering energy substitution potentials. PLEASE NOTE: these totals should be "additional added" as described in point 8 of the substitution process description.
2. For clarification: the energy for this sectoral worksheet includes district heating plants for its main activity and as autoproducers. Any heat produced and consumed onsite should be entered into the buildings or industry sectors (in terms of the primary fuels consumed to generate this heat).
3. Main activity (Section A) – add here (3) any additions to renewable district heat in PJ and select the type of fossil fuel being substituted. If only the capacity increases are known, reference column E and enter the PJ amounts into column C until the desired number of megawatt thermal (MW_{th}) is reached.
4. Autoproducers (Section B) – (4) is the sum of district heat produced in the buildings sectors by renewable sources. In those original tables, a substitution comparison was made with the type of fossil energy to come up with an incremental cost which will be displayed in the cost supply curve thus the costs are assigned to the building sector. For this reason, in this table only the energy total (in PJ/yr) has been imported and this sum is automatically added to the renewable energy total - nothing else has to be done.

*** PLEASE NOTE: In addition to main activity and autoproducer power and district heating plants which exist to produce electricity or heat only, there are also combined heat and power (CHP) plants. The detailed assessment of CHPs is excluded from the REmap tool. Their "additional potential" for renewable-based electricity and heat generation is estimated as a function of the power and heat sector developments. For this purpose, the fuels used in CHPs for electricity and heat production are partitioned based on the IEA methodology. This methodology considers the efficiencies of separate power (total of main activity & autoproducer) and heat (total of main activity & autoproducer) plants. In a subsequent step, identical rate of fossil fuel substitution in the power sector is applied to the fossil fuels used for power generation in CHPs. The same step is applied for the heat sector as well.

Fig. 10

B	C	E	F	G	H	I	J	K	L	M	N	O	P
Renewable Energy Technology													
2030	Heat production: new capacity	Renewable energy capacity	Main fuel type (excl. Electricity)	Capacity factor	Lifetime	Capacity or production volume	Overnight Cap. Cost	O&M Costs	Fuel demand	Power demand	Conversion efficiency	Total annualized costs	Production cost
HEAT SECTOR	(PJ/yr)												
		(MW)	(-)	(%, cap)	(years)	(MW)	(USD/kW)	(USD/kW/yr)	(GJf/kW/yr)	(GJe/kW/yr)	(%)	(USD/yr)	(USD/GJth)
A) Main activity													
Solar thermal		0	0	10	25	1	1200	12	0.000	0.013	100	145077	46
Biomass waste-to-energy		0	Municipal_waste	29	25	1	600	15	18.291	0.054	50	121433	13
Biomass steam cycle		0	rimary_biomass_	45	25	1	1500	38	18.922	0.054	75	505463	36
Geothermal		0	0	50	25	1	800	40	0.000	0.072	100	133134	8
		0	0	0	0	0	0	0	0.000	0.000	0	0	0
		0	0	0	0	0	0	0	0.000	0.000	0	0	0
		0	0	0	0	0	0	0	0.000	0.000	0	0	0
B) Autoproducers (add. capacity from other sectors)													
Distric heating plants	0.0										#DIV/0!		

R	S	T
Conventional Fossil Fuel Technology		
2030	Total substituted fossil fuel	Total substituted electricity
HEAT SETOR	(PJ/yr)	(PJ/yr)
	(%, cap)	(years)
A) Main activity		
Petroleum products	0	0.000
Coal	0	0.000
Coal	0	0.000
Natural gas	0	0.000
	0	0.000
	0	0.000
	0	0.000
B) Autoproducers (add. capacity from other sectors)		
Costs assigned to the other sectors		

WS8 – Summary (Fig. 11)

Fig. 11

A) SUMMARY ENERGY BALANCES

2020		Fossil fuels	Renewables	Electricity	Heat	Total
		(PJ/yr)	(PJ/yr)	(PJ/yr)	(PJ/yr)	(PJ/yr)
INDUSTRY	Reference	690	99	300	0	1,088
	REMAP Options	690	99	300	0	1,088
BUILDINGS (traditional biomass as fossil fuel)	Reference	229	71	522	0	822
	REMAP Options	229	71	522	0	822
TRANSPORT	Reference	1,258	12	16	0	1,286
	REMAP Options	1,258	12	16	0	1,286
POWER	Reference	-2,176	-137	932	0	-1,382
	REMAP Options	-2,176	-137	932	0	-1,382
HEAT	Reference	0	0	0	0	0
	REMAP Options	0	0	0	0	0
TOTAL FINAL CONSUMPTION	Reference	2,178	181	838	0	3,196
	REMAP Options	2,178	181	838	0	3,196

2030		Fossil fuels	Renewables	Electricity	Heat	Total
		(PJ/yr)	(PJ/yr)	(PJ/yr)	(PJ/yr)	(PJ/yr)
INDUSTRY	Reference	747	115	320	0	1,181
	REMAP Options	747	115	320	0	1,181
BUILDINGS (traditional biomass as fossil fuel)	Reference	248	73	574	0	894
	REMAP Options	248	73	574	0	894
TRANSPORT	Reference	1,350	12	17	0	1,379
	REMAP Options	1,350	12	17	0	1,379
POWER	Reference	-1,849	-311	942	0	-1,218
	REMAP Options	-1,849	-311	942	0	-1,218
HEAT	Reference	0	0	0	0	0
	REMAP Options	0	0	0	0	0
TOTAL FINAL CONSUMPTION	Reference	2,345	199	910	0	3,454
	REMAP Options	2,345	199	910	0	3,454

CURVE REMAP OPTIONS 1

CURVE REMAP OPTIONS 2

B) SUMMARY SHEET

		Reference case			REMAP Options	
SECTORS	Explanations	2010	2020	2030	2020	2030
		(%)	(%)	(%)	(%)	(%)
INDUSTRY	Renewable share (excl. electricity, heat)	9.7%	12.5%	13.3%	12.5%	13.3%
	Renewable share (incl. electricity, heat)	9.5%	12.4%	15.3%	13.1%	15.9%
BUILDINGS (excl. traditional biomass)	Renewable share (excl. electricity, heat)	24.4%	23.6%	22.7%	23.6%	22.7%
	Renewable share (incl. electricity, heat)	14.6%	16.4%	21.4%	18.0%	22.9%
TRANSPORT	Renewable share (excl. electricity, heat)	1.0%	0.9%	0.9%	0.9%	0.9%
	Renewable share (incl. electricity, heat)	1.1%	1.1%	1.1%	1.1%	1.1%
	Electricity share	1.1%	1.2%	1.2%	1.2%	1.2%
ELECTRICITY: Total	Renewable share in generation (incl. CHP)	8.9%	12.2%	20.7%	14.8%	23.1%
HEAT: Total	Renewable share in generation (incl. CHP)	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	Renewable share (excl. electricity, heat)	7.3%	7.7%	7.8%	7.7%	7.8%
	Renewable share (incl. electricity, heat)	7.7%	8.9%	11.2%	9.6%	11.8%

C) SUPPLY CURVE

	Reference case			REMAP Options		Total	Average incremental cost		
RE TECHNOLOGY OPTIONS	2010	2020	2030	2020	2030	2020, 2030	2020	2030	Weighted avg.
	(PJ/yr)	(PJ/yr)	(PJ/yr)	(PJ/yr)	(PJ/yr)	(PJ/yr)	(USD/GJ)	(USD/GJ)	(USD/GJ)
INDUSTRY									

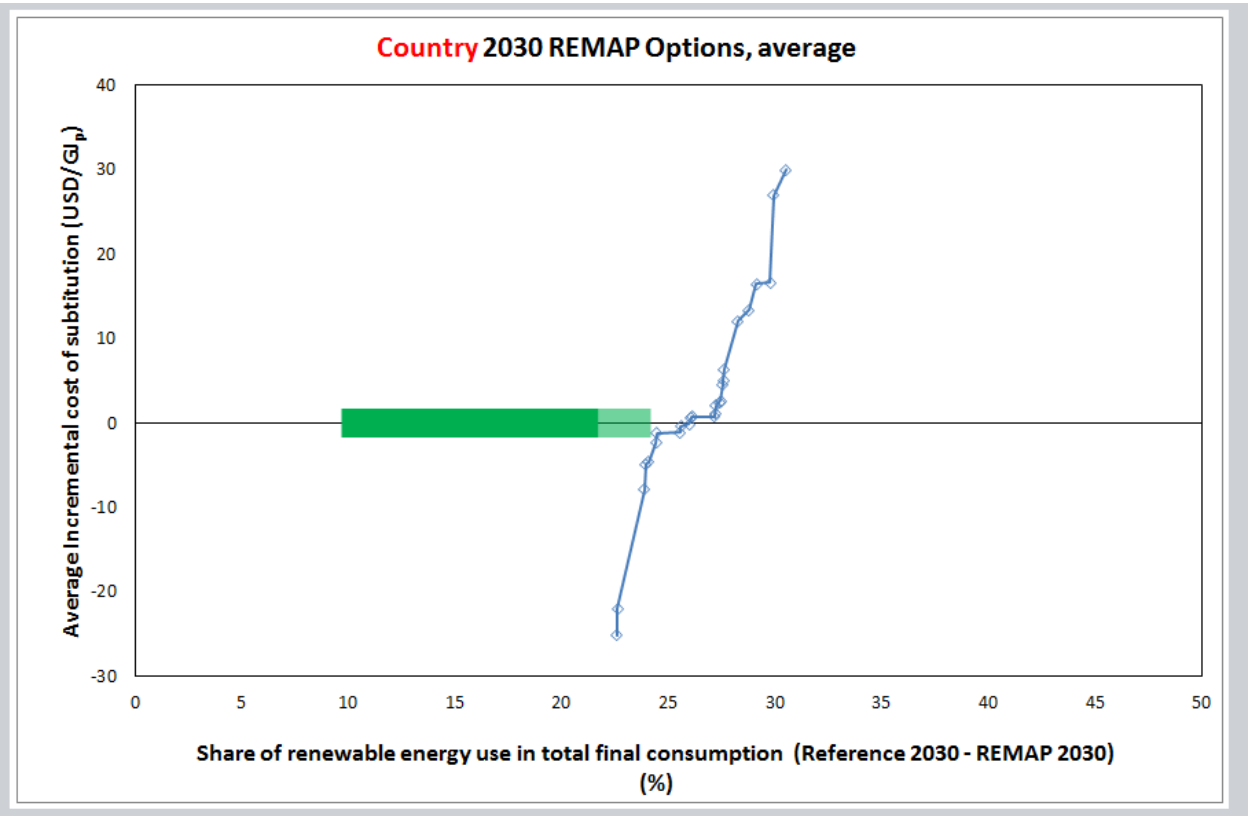
4

1. Worksheet 8 is the summary sheet and requires no inputs. Instead it provides overview of
2. **Summary Energy Balances** (Section A) – Energy use by end-use sector (2) in PJ/yr with a breakdown of fossil fuels, renewables, electricity and heat. Energy use by power and heat sectors (indicated with a minus sign) and the total electricity and heat produced (indicated with a plus sign). The breakdown is displayed for both 2020 and 2030 and provide details for the Reference Case and REmap Options.
3. **Summary Sheet** (Section B) –The share of RE in each sector (3) as well as for the total of all sectors are separately provided for the Reference Case and REmap Options for 2010, 2020 and 2030. The end-use sectors for industry/ buildings/transport provide two breakdowns: one excluding electricity/district heat and one including electricity/district heat. In the latter case, the percent of renewable energy in the electricity or district heat is accounted for. For the power and heat sectors, the shares are estimated based on the amounts of electricity and heat produced, but not the energy used.
4. **Supply Curve** (Section C) – A summary of all technology options (4) selected by the user with a breakdown by sector and their corresponding energy use as well as the average incremental cost of substitution in 2020 and 2030 for the REmap Options are provided. Additionally, the total energy amounts as well as the weighted average incremental cost of substitution are also provided.
5. Curve REmap Options 1 – a macro function (5) that creates the cost-supply curve 1 which plots the technologies for 2020 and 2030 along the curve SEPERATELY.
6. Curve REmap Options 2 - a macro function (6) that creates the cost-supply curve 2 which plots the average weighted cost and total energy amounts for 2020/2030 for each technology as one bar.

Curves 1 & 2: (Fig. 12)

1. Figure 12 shows the result of the of the macro function button #2 on WS8. This plots the total combined energy substitution total for the same technologies as one point, and using the weighted average cost. The macro function button #1 results in the same type of curve, except the 2020 and 2030 technologies are plotted separately based on their energy amounts and costs. The total RE share achieved by REmap Options is identical in both curves
2. The cost-supply curve is a basic visual representation of the substitution process. The starting point for the cost supply curve is the RE share in TFEC according to the Reference Case in 2030. The substitution potential for each renewable energy option (entered in PJ) is translated into an increase in the RE share on top of the Reference Case end point (horizontal x-axis). The cost estimate is the average incremental cost of substitution for each renewable energy technology option based on the difference between performance and cost data of the renewable energy technology option, and the conventional energy technology option that is replaced (vertical y-axis).
3. The dark green bar represents Reference Case renewable energy growth. The start point is the RE share in 2010 in TFEC and the end point is the share in 2030 according to the Reference Case developed in WS0.
4. One of UN Sustainable Energy Access for All (SE4ALL) Initiative goals is to eliminate the use of traditional biomass in inefficient cooking and heating applications. Therefore traditional biomass is not presented in the curve as renewable energy. It is, however presented as the light green bar indicating traditional biomass use in 2030 for the Reference Case. Any substitution of traditional biomass done in the tool is plotted in the curve as modern biomass.

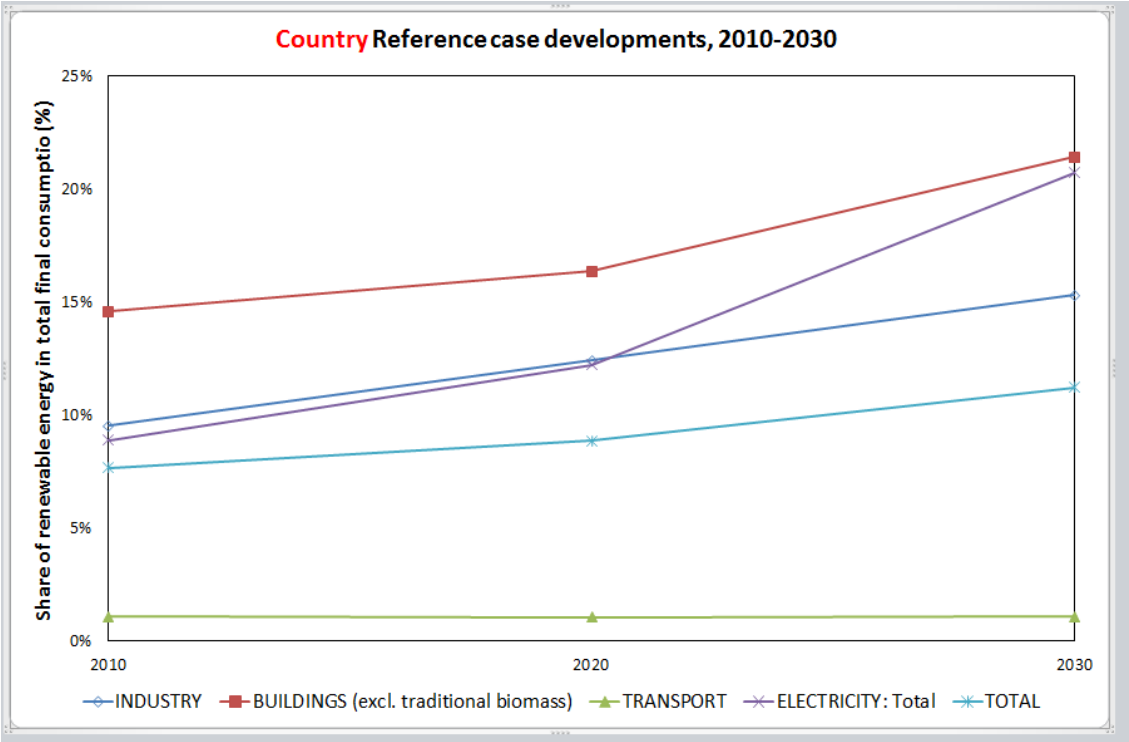
Fig. 12



Curve Reference (Fig. 13):

1. The “curve reference” tab is a simple graph showing Reference Case renewable energy developments from 2010-2030. This curve is based on the Reference Case in WS0 and provides insights into the development of RE share relative to TFEC.

Fig. 13



Progress Checklist:

IRENA suggests national REmap experts to follow the following order when using the REmap tool for the first time:

- ☐ 1. WS0 EB – review the Reference Case energy balances for 2010, 2020 and 2030. 2020 and 2030 projections can be changed by altering the CAGR
- ☐ 2. WS3 Industry – review and update the technology options and energy amounts provided by IRENA 2030 in each subsection (all may not apply). Alter any renewable energy technology option and its energy amount accordingly. Also alter the fossil fuel substituted if necessary (subdivision of the renewable technology to offset various fossil fuels is also possible).
- ☐ 3. WS4 Buildings – review and update the technology options and energy amounts provided by IRENA for 2030 in each subsection (all may not apply). Alter any renewable energy technology option and its energy amount accordingly. Also alter the fossil fuel being substituted if necessary (subdivision of the renewable technology to offset various fossil fuels is also possible).
- ☐ 4. WS5 Transport - review and update the technology options and energy amounts provided by IRENA for 2030 in each subsection (all may not apply). Alter any renewable energy technology option and its energy amount accordingly. Also alter the fossil fuel being substituted if necessary (subdivision of the renewable technology to offset various fossil fuels is also possible).
- ☐ 5. WS6 Power review and update the technology options and energy amounts provided by IRENA for 2030 in each subsection (all may not apply). Alter any renewable energy technology option and its energy amount accordingly. Also note that additional mains activity in section C has to be accounted for in generation capacity.
- ☐ 6. WS7 Heat - review and update the technology options and energy amounts provided by IRENA for 2030 in each subsection (all may not apply). Alter any renewable energy technology option and its energy amount accordingly. Also alter the fossil fuel being substituted if necessary (subdivision of the renewable technology to offset various fossil fuels is also possible).
- ☐ 7. WS1 Country Data – Update the commodity prices and carbon prices. Two copies of the tool would be created at the end of the process, one with national prices including taxes and subsidies and other with prices without taxes and subsidies. OPTIONAL: enter country specific and economic data
- ☐ 8. WS2b Tech List – review the technology list options and cost/performance figures for 2030. Since not all will be used, reference the technologies that were used in the substitution tables for both RE and conventional technologies and “localize” this data to your country.
- ☐ 9. WS8 Summary – review the summary tab and click the “create cost supply curve 2” macro button to see the REmap process results displayed visually.