Energy Planning Tool: new modeling of interventions

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1. Tyoes of intervention

Three basic types of intervention are considered in the Energy Planning Tool:

1) Energy substitution

Through an energy substitution, a conventional or improved technology of the reference system is replaced by a clean or specific technology including solar cookers.

2) Energy efficiency improvement

With this type of basic intervention, a conventional technology of the reference system is replaced by an improved one that uses the same fuel but with an improved efficiency.

3) Cash-based interventions

The aim is to provide poor households with subsidies to improve their energy cost affordability.

An energy intervention may be a combination of any basic interventions. To make easy the formalization of the intervention model, the following specifications are considered.

1.1Type of fuels

The following fuels are considered and categorized as it is showed in table 1.

Table 1: typology of fuels in the Energy planning tool

Index: k	Name	Category
1	Wood	Traditional
2	Charcoal	Traditional
3	Pellet	Alternative
4	Ethanol	Alternative
5	Kerosene	Alternative
6	LPG	Alternative
7	Biogas	Alternative
8	Electricity	Specific
9	Solar	Specific

In further versions of the tool, the renewability of the fuels will be considered as well taking into account their supply chains. In the present version, the boundary of the energy system is the use site.

1.2 Type of cookstove

Twenty types of cookstove are considered in the present version of the tool. They presented and categorized in table 2. Five categories are considered. Conventional cookstoves use wood or charcoal with low efficiency. Improved cookstoves used wood and charcoal as well. Several types of fuels supply clean stoves including pellets of biomass, kerosene, Liquefied natural gas, bioethanol, and biogas. The category “specific” includes “Electricity” and Thermal solar. Electric stoves are considered as clean in the boundary of the system in this version of the tool. However in further versions, their cleanness depends on the supply chain of the electricity. “Thermal solar” is also a clean technology but its modeling is different compared to other stoves since due to the availability of the source, they cannot replace the reference cookstoves with equal numbers of units. Their models have not been included in the present Proof-of-Concept.

Table 2: Typology of cookstove.

Index: j	Name	Fuel used	Category of cookstove
1	Traditional stove - three stones with pot or alternatives	Wood	Conventional
2	Traditional stove - three stones with pot or alternatives	Charcoal	Conventional
3	Basic cooking stove made out of clay	Wood	Conventional
4	Basic cooking stove made out of clay	Charcoal	Conventional
5	Cookstove made with fired clay (ceramic)	Wood	Conventional
6	Cookstove made with fired clay (ceramic)	Charcoal	Conventional
7	Improved stove from metal fueled with side feeder	Wood	Improved
8	Improved stove from metal fueled with side feeder	Charcoal	Improved
9	Improved stove from metal that is batch loaded	Wood	Improved
10	Improved stove from metal that is batch loaded	Charcoal	Improved
11	Gasifier Stove built for burning pellets	Pellets	Clean
12	Cook stove for ethanol / kerosene combustion	Ethanol	Clean
13	Cook stove for ethanol / kerosene combustion	Kerosene	Clean
14	Cook stove for burning gas (LPG, biogas)	LPG	Clean
15	Cook stove for burning gas (LPG, biogas)	Biogas	Clean
16	Modern Cook Stoves - Induction Electric Cooker	Electricity	Electric
17	Solar panel cookers (Example: CooKit made of cardboard and foil)	Solar	Thermal solar
18	Solar box cookers / Sun oven (Example: All American Sun Oven)	Solar	Thermal solar
19	Parabolic solar cookers (Example: AlSol 1.4)	Solar	Thermal solar
20	Evacuated tube solar cookers (Example: SLiCK SM70)	Solar	Thermal solar

2. Formalization for Energy substitution and Energy efficiency improvement interventions

To be general, we consider the case of an intervention that combines Energy substitution and Energy efficiency improvement. Let t_0 the first year of intervention and t_e the intervention end year. Other variables are defined as follows:

A: set of subscripts of the new improved (j=imp) or substitute cooker(j=clc); card (A) may equal 0, 1, or 2

$\eta_{r,i,j,k,t}$; number of cookstoves per 10-household of type j, using fuel k, by households of Quality of life level (QLL) i, in the reference scenario r and year t; that is the technology matrix of the reference scenario defined by the specialist (Input)

$\eta_{rnew,i,j,k,t}$: number of cookstoves per 10-household of type j, using fuel k, by households of Quality of life level (QLL) i, in the new reference case rnew and year t; considering interventions up to year (t-1); these interventions change the reference; these changes must to be considered when investigating the year t. That is why a new reference case must be defined for year t.

$\Delta\eta_{i,j,k,t}$: cumulative reduction of number of conventional and improved cookstoves j added from year t_0 to year(t-1); i= 1, …,I; j= 1, …,Jr; t= t_0, ….., t_e

$\Delta\eta i,j,k,t = \sum_{t0}^{t-1} \delta\eta i,j,k,t$ I = 1, …,I; i= 1, …I; j = 1, Jr; t= t_0 …., t_e

I: maximum subscript of targeted QLL; Jr: maximum subscript of cookstoves to replace; t= t_0 …., t_e

$\delta\eta i,j,k,t$: Reduction of number of conventional or improved cookstove j in year t; i= 1, …,I; j= 1, …,Jr; t= t_0 …., t_e

$\eta_{rnew,i,j,k,t}$ = Max (($\eta_{r,i,j,k,t}$ - $\Delta\eta_{i,j,k,t}$) ; 0), i= 1, …,I; j= 1, …,Jr; t= t_0 …., t_e

If $\eta_{rnewi,j,k,t}$ = 0, then $\Delta\eta_{i,j+1,k,t}$ = $\Delta\eta_{i,j+1,k,t}$ + ($\Delta\eta_{i,j,k,t}$ - $\eta_{ri,j,k,t}$), i= 1, …,I, j= 1, …,Jr-1, t= t_0 …., t_e

$O\eta_{i,j,k,t}$:Objective of the number of cookstoves (to replace) per 10-household of type j, using fuel k, by households of Quality of life level (QLL) i, in year t (Input); i= 1, …,I; j= 1, …,Jr; t= t_0 …., t_e

$\eta_{i,j,k,t}$ = Min ($O\eta_{i,j,k,t}$; $\eta_{rnewi,j,k,}$); i= 1, …,I; j= 1, …,Jr; t= t= t_0 …., t_e

$\delta\eta i,j,k,t$ = Max (($\eta_{i,j,k,t}$ - $O\eta_{i,j,k,t}$) ; 0); i= 1, …,;, j= 1, …,Jr; t= t_0 …., t_e

$\Delta\eta i,j,k,t+1 = \Delta\eta i,j,k,t + \delta\eta i,j,k,t$; i= 1, …,I, j= 1, …,Jr, t= t_0 …., t_e -1

Let $Allsub_{i,t}$[%] : the allocation of the replacements $\delta\eta i,j,k,t$ to the substitute clean cooker (Input), the additional substitute clean cooker number of that technology in year t is:

$(\sum_{j=1}^{Jr} \delta\eta i,j,k,t) * Allsubi_{,t}/100$; i= 1, …,I; j= 1, …,Jr; t= t_0 …., t_e

then,

$\eta_{i,j=cl,k,t} = \eta_{ri,j=cl,k,t} + (\sum_{j=1}^{Jr} \delta\eta i,j,k,t) * Allsubi,t/100$; i= 1, …,I; j= 1, …,Jr; t= t_0 …., t_e

The additional improved substitute cookstoves number in year t is:

$(\sum_{j=1}^{Jr} \delta\eta i,j,k,t) * (1-Allsub_{i,t})/100$; i= 1, …,I; j= 1, …,Jr; t= t_0 …., t_e

then,

$\eta_{,i,j=imp,k,t} = \eta_{ri,j=imp,k,t-} + (\sum_{j=1}^{Jr} \delta\eta i,j,k,t) * (1-Allsub_{i,t})/100$; i= 1, …,I; j= 1, …,Jr; t= t_0 …., t_e

$\eta_{i,j=cl,k,t}$: number of clean cookstoves per 10-households for the targeted QLL i, and the year t of the intervention period (output)

$\eta_{i,j=imp,k,t}$: number of improved cookstoves per 10-households for the targeted QLL i, and the year t of the intervention period (output)

For t > te , $\eta_{i,j,k,t}$ = $\eta_{i,j,k,te}$, i = 1, ..., I; j= 1, ..., Jr

If i>I, or(j>Jr and j∉A), then $\eta_{i,j,k,t} = \eta_{ri,j,k,t}$

3. Formalization of the cash- based interventions

Let's consider the following variables:

AvgITcosti,t: Average yearly total cost per household of QLL I, in year t [currency] (Output)
Avglincomei,t: Average yearly income per household of QLL, in year t [currency] (Input)
ObjAffordi, t: Objective of the energy cost affordability for households of QLL I [%] (Input)
i: subscript of targeted QQL by the intervention, I = 1,…,I; t= t_0, ….., t_e as defined in section 2

Results
Expenhhi,t: Expenditures of per household I, in yeof QLL iar t, considering the subsidies by donors [currency]
Expendhhi,t = ObjEffordi,t * Avgincomei,t /100
Expenddonori,t : Donor's expenditures per targeted household of QQL i, in year t [currency]
Expenddonori,t = AvgITcosti,t - Expendhhi,t
TExpenddonort : Total yearly expenditures of the donors in year t
TExpenddonori,t= $\sum_{i=1}^{I} NIhhi, t * \text{Expenddonori, t})$
NIhhi,t : Number of households of QLL i

4. Inputs for the interventions

4.1 Energy substitution or/and Energy efficiency improvement (update)

1. Name of the intervention:
2. Name of the new cooker to diffuse
3. First year of the intervention **(must be higher or equal to the first year of the planning period)**
4. Last year of diffusion **(must be lower or equal to the last year of the planning period)**
5. Technologies to replace
6. Targeted QLLs
7. Objectives of number of conventional or improved cooking count per 10-household of each targeted QLL each intervention year
8. Reference values of the technology matrix (Input of the reference scenario)
9. Allocation of replacement of conventional or /and improved cookstoves to the substitute clean cookers [%]

4.2 Input for Cash-based interventions (new)

1) Name of the intervention
2) First year of the intervention (must be higher or equal to the first year of the planning period)
3) Last year of diffusion (must be lower or equal to the last year of the planning period)
4) Targeted QLLs

5) Objective of energy for cooking cost affordability of each targeted QLL each intervention year [%]

5. Outputs of the alternative case with interventions (update of the version of 17 July, 2022)

Results per year of the planning period, QLL, and total, and when relevant, per household

1. Technology matrix of cookstoves after the intervention
2. Useful energy [MJ]
3. Final energy [MJ]
4. Energy efficiency
5. CO2 emission [kg]
6. CO emission [g]
7. Emission of particulate matters [mg]
8. Wood weight
9. Charcoal weight
10. Equivalent wood weight
11. Required biomass area for wood collection (Eucalyptus basis) [ha]
12. Annual income [currency]
13. Annual fixed cost [currency]
14. Annual variable cost [currency]
15. Total annual cost [currency]
16. Total annual discounted cost [currency]
17. Total annual subsidies (expenditures of the donors)
18. Total expenditures of the households
19. Affordability [%]
20. Number of added cookstoves per type of cooker by the intervention
21. Total Number of cookstoves per type of cooker

Key Performance Indicators considering the whole planning period

Please see my specifications of April 20th, 2022, implement them and make it possible to export the results in an Excel file as well.

6. Outputs of the reference case versus alternative case with intervention (update)

Results per year of the planning period, QLL, and total – relative change between the alternative and the reference cases [%] – Radar graphic representation

1. Useful energy
2. Final energy
3. Energy efficiency
4. CO2 emission
5. CO emission
6. Emission of particulate matters
7. Wood weight
8. Charcoal weight
9. Equivalent wood weight
10. Required biomass area for wood collection (Eucalyptus basis)
11. Annual income
12. Annual fixed cost
13. Annual variable cost

14. Total annual cost
15. Total annual discounted cost
16. Total annual subsidies (expenditures of the donors)
17. Total expenditures of the households
18. Affordability
19. Number of cookstoves per type of cooker

Key Performance Indicators considering the whole planning period (relative changes between the two cases)

Please see my specifications of April 20th, 2022, implement them and make it possible to export the results in an Excel file as well.