TOTAL COST OF OWNERSHIP (TCO) tool

General

The TCO tool is intended to be used in the very early stages of the design process where its results can have an effect on the design, which is drastically reduced in later stages of the design. Although the absolute TCO values are estimates, they do provide the opportunity to compare the relative values of different design options. In addition, users of the tool will get an insight in the relationship between costs for construction (or mortgage), energy use and maintenance and how these costs can be affected by changing the design, e.g. by selecting a low energy building, which will increase investment costs but decrease the annual energy costs.

The TCO (Total Cost of Ownership) of a building project is determined by means of Life Cycle Costing (LCC), summing the initial (investment) and running costs (energy and maintenance) over a period determined by the user, e.g. 30 years. This calculation yields the 'Future value'. Alternatively, the lower earning power of future money can be taken into account by calculating the NPV or Net Present Value. The latter is the most commonly used method of economic evaluation.

In case the home owner takes a loan with a bank, the mortgage costs are calculated based on an annuity or a linear mortgage. A final choice in the calculation of the TCO has to be made in terms of expected energy price development (pessimistic, neutral, optimistic). This percentage is added to the historic price development (given per country).

Figure 1 below illustrates the results for a particular case, comparing a low energy ambition (according to the building code)and a high energy ambition version.

	Low energy ambition	High energy ambition
Total net mortgage (interest+redemption)	€ 414,969	€ 512,132
Total energy	€ 224,860	€ 82,160
Total maintenance	€ 15,000	€ 15,600
Total Cost of Ownership	€ 654,828	€ 609,892

Figure 1: TCO consisting of mortgage (bases a linear mortgage), energy costs and maintenance costs over a period of 60 years

Investment and mortgage

Since the TCO tool is intended for CSO (Collective Self-Organized) housing projects, it distinguishes between individually owned buildings and communal buildings. Apportionment of the cost of the communal building can be done evenly over the households, on the basis of m^2 of individual buildings or on the size of the households. Currently, only the first option is implemented.

Building costs

For the individual buildings, the TCO tool calculates the construction cost based on the gross floor area and multiplies it with a default price per m^2. The latter depends on the building typology (terraced house, semi detached, detached house or apartment). For the communal building, the TCO tool calculates the construction

cost based on the type of functionality of the rooms (living, kitchen, parking, playing, office, meeting) by taking the gross floor area and multiplying it with a default price per m^2. The cost of each is then multiplied by several factors

1. The cost is increased by a factor representing the energy ambition: high (zero energy), medium (low energy) or low (according to the building code). The factor is 1.2, 1.1 and 1.0 respectively for the communal buildings and 1.25, 1.12 and 1.0 for the individual buildings. Different factors for individual and communal building are possible. These initial factors are based on the first calibration of the tool using case studies.
2. The cost is increased by a factor representing the desired quality level. The factor for high, medium and low quality is 1.2, 1.1 and 1.0 respectively. . Different factors for individual and communal building are possible. These initial factors are based on the first calibration of the tool using case studies.
3. A percentage is added for the costs of architects and advisors and administrative charges (% to be set by the user).
4. A LandscapeMultiplier, depending of the location of the project in a capital/urban/rural region: 1.3, 1.0 and 0.8 respectively. The tool has not been calibrated for these factors yet.
5. Finally, the resulting cost is multiplied by a Price level index that varies from country to country with the price level for Europe (EU28) set to 100%.

Installation costs

The installation costs are made up of the individual heating installation and a share in the cost of the collective renewable energy installation. Current options for the latter include PhotoVoltaic (PV) panels, generating electricity and solar collectors, generating heat. The size of the renewable energy installation is expressed as a percentage of the energy demand, with a default (but adaptable) value determined by the energy ambition. For low, medium and high energy ambition options, the default percentage is 0%, 50% and 100% respectively. These percentages can be overruled by the user by providing a desired area (in m^2) of PV panels or solar collectors.

Mortgage

We assume that the individual owner has to take a loan with a bank for the building cost and installation cost, having the options of taking a linear mortgage (the cheapest option in terms of TCO) or an annuity mortgage (with lower *initial* costs). In case the home owner can deduct part of the interest paid (not the redemption) from his income, an average fiscal deductible percentage can be introduced to calculate the net mortgage. To calculate the total gross mortgage, this percentage should be set to 0 (zero). Costs can be calculated as NPVs (discounting future costs) or as future costs (without discounting).

Annual costs

Energy costs

For the *individual* building, the energy demand distinguishes between electricity demand and heating demand. The latter is divided into space heating, DHW (domestic hot water) and cooking.

Space heating demand is determined by the areas of external floor, external roof and external façade. The climate is taking into account by applying a factor based on HDD (Heating Degree Days), varying per country.

DHW consumption is determined by the number of people in the household, heat demand for cooking is a fixed value.

Electricity consumption stems mainly from appliances and is determined by the number of people in the household (with smaller contributions of electricity consumption for space cooling and ventilation).

Renewable energy generated by PV panels and solar collectors is calculated by the default percentage representing the energy ambition (0%, 50% and 100% of energy demand covered by renewable generation). Alternatively, the area of solar collectors or PV panels can be manually entered, in which case the default % covered is overridden.

The renewable energy generated is subtracted from the energy demand and the remaining energy is taken from the grid. The energy bill is calculated using gas and electricity prices that vary per country.

The energy demand (in gas and electricity consumption) of the *communal* building is determined by a fixed value per m^2 depending on the functionality (underground parking, kitchen, living, playing, office, meeting) and an energy use factor depending on the energy ambition. The climate is taking into account by applying a factor based on HDD (Heating Degree Days) to the heat demand.

As in the case of individual dwellings, the renewable energy generated by PV panels and solar collectors is subtracted from the energy demand and the remaining energy is taken from the grid. The energy bill, calculated using gas and electricity prices that vary per country, is divided over the households.

Maintenance costs

Both for the individual buildings and the communal building, the maintenance costs are calculated by taking the external roof area and the external facade area and multiplying each with a default price per m^2, that depends on the building typology. The costs are then multiplied by the country factor.

Output

The sheet ‘detail_output shows the investment costs, annual energy costs and annual maintenance costs, distinguishing between costs for the land, the individual and the communal building. It also gives the overall TCO as shown in Figure 1. Scenarios in calculating the TCO include: Pessimistic/Neutral/Optimistic energy price development, Future/Present Value and Linear/Annuity mortgage (12 possible combinations). In addition, more detailed output is given in the form of monthly expenses, illustrated in

Figure 2 for the 12 different scenarios

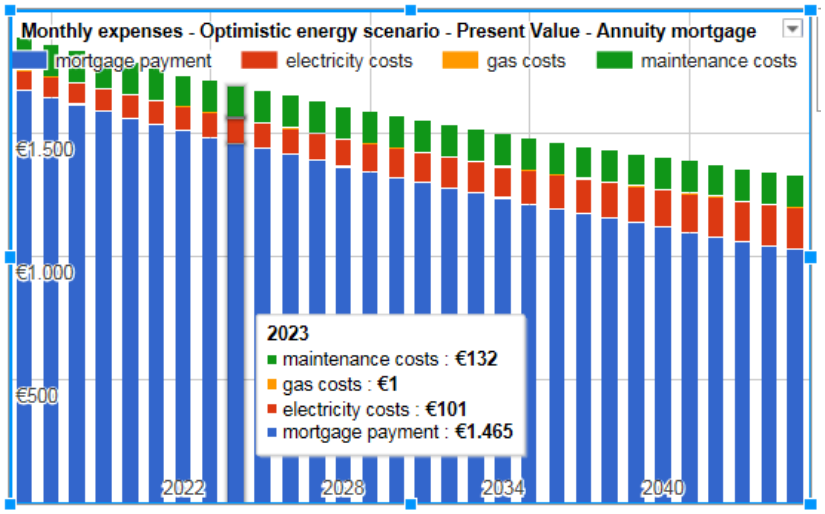

Figure 2: example of output of the TCO tool for an end-user for an optimistic energy scenario (lower increase in energy prices than the increase derived from on historic data) as the Present Value of monthly expenses, based on an annuity mortgage.

Worksheets in the Excel version of the TCO tool

The Tool is composed of a number of worksheets:

location_input

This sheet allows to give input for project data. Default values for location (country) specific data such as discount factor (inflation), consumer electricity price and natural gas price, price development of electricity and natural gas are taken from the list in sheet 'lists'.

household_input

Input can be given for the size of the household, the type and size of the individual dwelling, energy ambition etc. This allows the calculation of building costs, energy cost and maintenance cost for the individual dwelling.

collective_input

Input can be given for the type and size of the communal building, energy ambition etc. This allows the calculation of building costs, energy cost and maintenance cost for the communal building.

detail_output

This sheet shows the investment costs, annual energy costs and annual maintenance costs, distinguishing between costs for the land, the individual and the communal building. It also gives the overall TCO as shown in Figure 1 as well as more detailed output in the form of monthly expenses, illustrated in

Figure 2 for different scenarios.

Lists

This sheet shows the indices, prices, price development and heating degree days (HDD) per EU country. Source are shown, mostly from Eurostat.

List of countries	Price level index	Inflation (HICP)	gas price	price development	electricity price	price developmen	heating degree da
Country	Index (year=2012)		€/MJ gas		€/kWh		
Europe (EU28 = 100)	100	1.022	0.018	1.044	0.200	1.048	3066.7193
Albania	47.7				0.116	1.002	
Austria	116.2	1.020	0.021	1.057	0.208	1.032	3377.2928
Belgium	97.9	1.022	0.018	1.030	0.217	1.022	2637.9684
Bosnia and Herzegovina	33.2		0.015	1.142	0.080	1.028	
Bulgaria	38.2	1.046	0.014	1.094	0.092	1.056	2527.7053
Croatia	43.6	1.026	0.013	1.085	0.137	1.070	2368.4282
Cyprus	67.2	1.020			0.276	1.104	684.1523
Czech Republic	65.3	1.023	0.018	1.084	0.153	1.037	3354.9912
Denmark	152	1.018	0.031	1.056	0.300	1.027	3194.0038
Estonia	70.6	1.041	0.015	1.099	0.135	1.109	4191.52
Finland	121	1.019			0.158	1.054	5482.9606
Former Yugoslav Repub	29.6				0.081		
France	121.3	1.018	0.019	1.056	0.147	1.040	2326.7578
Germany (until 1990 for	133.3	1.017	0.018	1.009	0.292	1.063	3015.3919
Greece	67.7	1.025	0.021		0.156	1.084	1554.9179
Hungary	49.8	1.046	0.012	1.021	0.140	0.983	2747.1284
Iceland	175.2	1.058			0.105	0.949	3991.9356
Ireland	78.7	1.013	0.018	1.050	0.230	1.058	2723.6499
Italy	76.9	1.020	0.023	1.050	0.229	1.026	1816.3884
Latvia	56	1.050	0.014	1.163	0.138	1.108	4034.4455
Lithuania	57.2	1.034	0.017	1.137	0.137	1.099	3854.0254
Luxembourg	113.2	1.026	0.017	1.031	0.167	1.000	2938.1005
Malta	60.1	1.022			0.170	1.143	463.9874
Montenegro	45.1				0.102	1.084	
Netherlands	123.5	1.017	0.023	1.029	0.192	1.017	2644.5453
Norway	196.6	1.015			0.191	1.040	5392.3801
Poland	56.9	1.027	0.013	1.026	0.148	1.038	3394.1783
Portugal	54.7	1.018	0.023	1.064	0.208	1.072	1259.2362
Romania	36.2	1.065	0.008	0.972	0.132	1.051	2939.6925
Serbia	35.2						
Slovakia	64.3	1.030	0.014	1.033	0.170	1.037	3255.9315
Slovenia	61.5	1.027	0.019	1.049	0.161	1.071	2861.9343
Spain	72.6	1.024	0.020	1.056	0.223	1.104	1773.404
Sweden	182.7	1.014	0.034	1.051	0.210	1.054	5148.3571
Switzerland	191.5	1.004					3356.5657
Turkey	34.9	1.090	0.011	1.061	0.150	1.089	2544.5283
United Kingdom	86.1	1.026	0.015	1.064	0.174	1.039	2926.0181

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Explanation of (input) fields in TCO tool

The screenshots below provide additional information for the input fields.

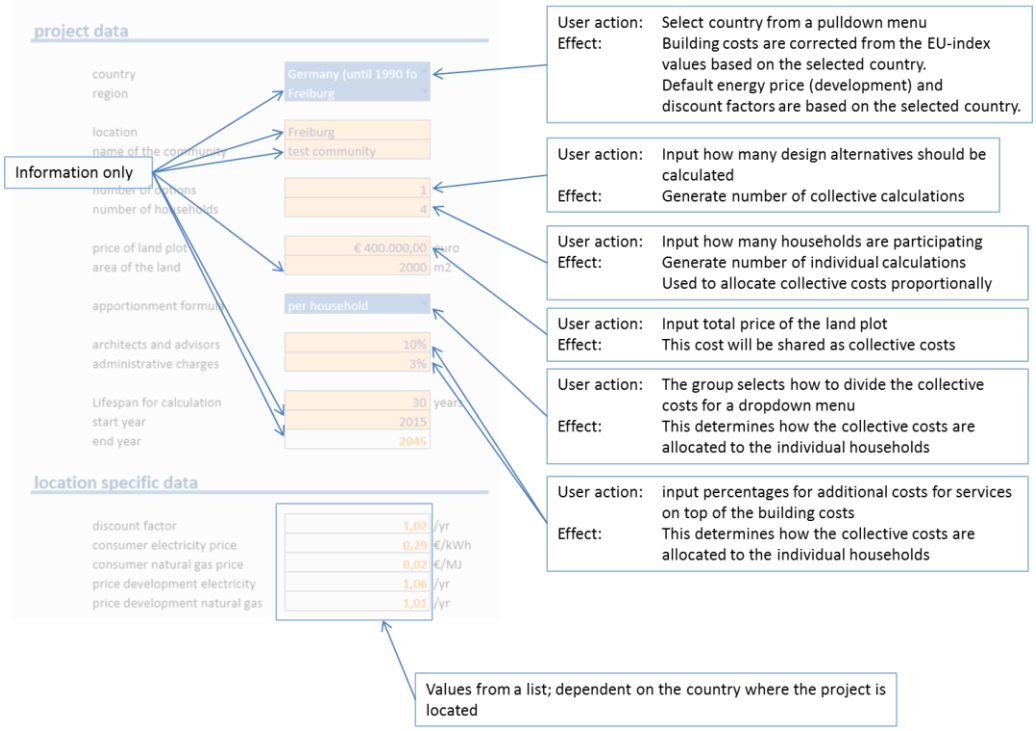

Figure 3.Project data (worksheet 'location_input') with explanation of (input) fields in the TCO tool

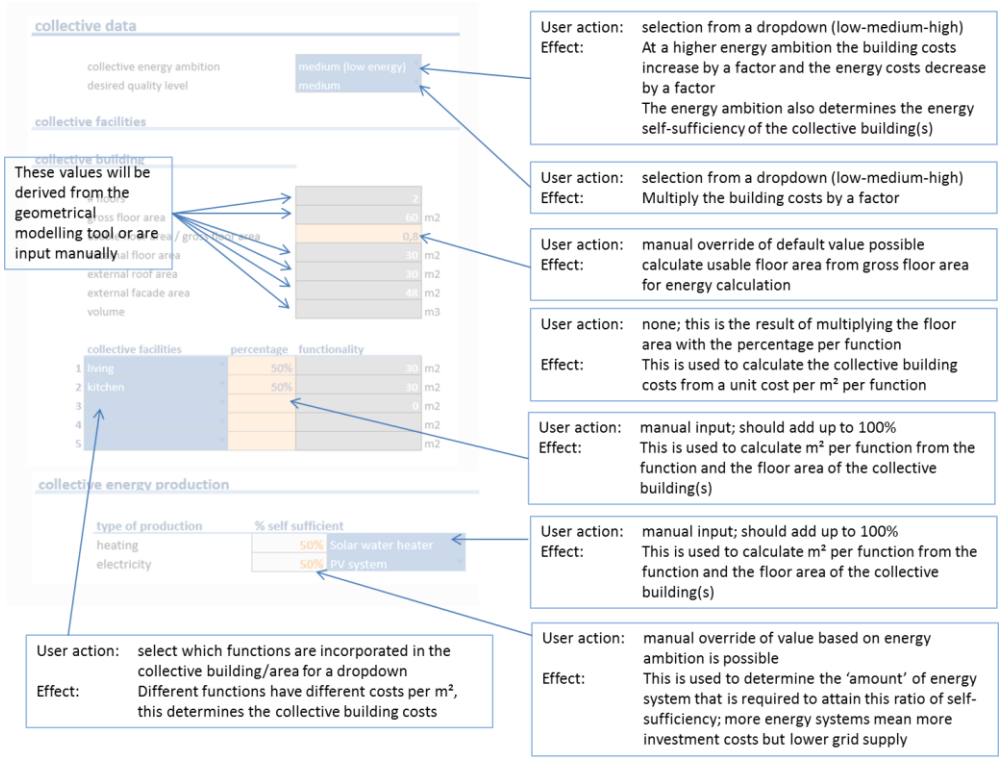

Figure 4.Collective data (worksheet' collective_input') with explanation of (input) fields in the TCO tool

input manually

Figure 5.Individual data worksheet with explanation of (input) fields in the TCO tool

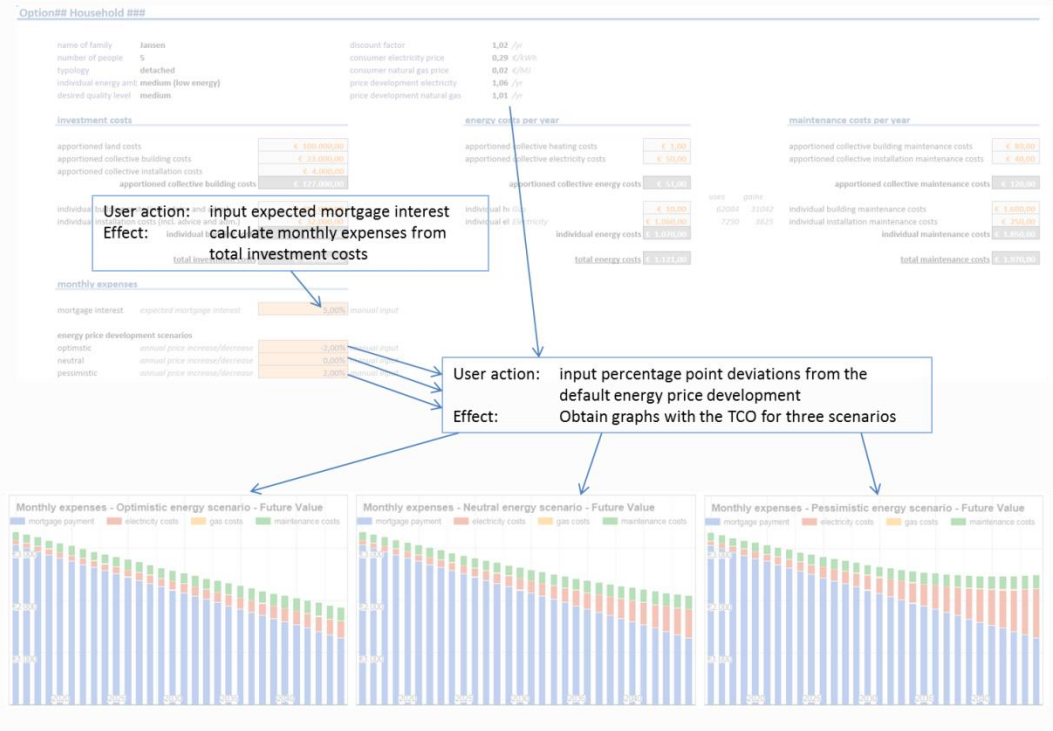

Figure 6.Individual output worksheet with explanation of (input) fields in the TCO tool