Personal Energy Administration Kiosk application:
an ICT-ecosystem for Energy Savings
through Behavioural Change, Flexible Tariffs and Fun
Contract No 695945

Deliverable D5.4.
Roll-out planning toolkit

Prepared by Leire Bastida and Ana Moja (Tecnalia)

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V1.0	01/02/2019	Final additions based on comments received	Final version
V2.0	31.10.2019	Final version	Integration of comments from PO and monitors

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1 General Information of the Deliverable

Table 1: D5.4 General Information

Title	Roll-out planning toolkit
Description	The design and development of a toolkit (composed of a set of algorithms and data) including a guidebook so any energy utility can assess the expected costs and benefits of using and deploying PEAKapp.
Deadline	M34 – December 2018
Leader	TECNALIA
Partners Involved	Tecnalia (8), ELDER (2), RTDS (2)
Steps covered	All

2 Introduction

There is a need for providing a roll-out planning toolkit allowing decision makers within electricity retailing companies to retrieve all information required to judge the roll-out in terms of social acceptance, commercial viability and system/environmental impact for their company of implementing and deploying the PEAKapp solution.

From the costs perspective, this deliverable details what hardware and software equipment of an electricity company is required to host the ICT-to-Human ecosystem, what the administrative processes are being necessary for its operation, and what resources need to be dedicated during the implementation phase and then during the normal operation.

From the benefits perspective, the outcome from Deliverables 4.1 and 4.2 will serve as basis to assess achievable effects on customer loyalty, customers' willingness to pay, and the other quantifiable effects and expectation of field-test participants.

This deliverable will provide the design and development of the roll-out toolkit (composed of a set of algorithms and data) including a user manual so any energy utility can assess the expected costs and benefits of using and deploying PEAKapp.

The toolkit can be downloaded from: http://www.peakapp.eu/public-deliverables/

3 Methodology for the Cost-Benefit Analysis

Smart Grids are a key component of the European strategy toward a low-carbon energy future and a significant number of investments need to be mobilized for deploying solutions such as PEAKapp. Therefore, the analysis of short term costs and long-term benefits allocation among different stakeholders, mainly for decision makers within electricity retailing companies, is a precondition for reducing uncertainties and incentivize investments.

In order to design and implement a roll-out planning toolkit focused on the PEAKapp solution we will use as basis the Reference Report on “Guidelines for conducting cost-benefit analysis of Smart Grid projects”, co-authored by DG ENER and JRC [JRC 2012] [EU 2012]. This report provides a step by step Cost-benefit Assessment (CBA) framework based on the work performed by EPRI (Electric Power Research Institute), where several additions and modifications to fit the European context have been done. Besides, this assessment framework, which includes economic and qualitative appraisals, is a collaboration between the EC and the US Department of Energy (DoE) in the framework of the EU-US Energy Council.

This CBA framework recognizes that the impact of Smart Grid projects goes beyond what can be captured in monetary terms; so, this approach integrates an economic analysis (monetary appraisal of costs and benefits on behalf of society) and a qualitative impact analysis (non-monetary appraisal of non-quantifiable impacts and externalities, e.g. social impacts, contribution to policy goals) as detailed in Figure 1.

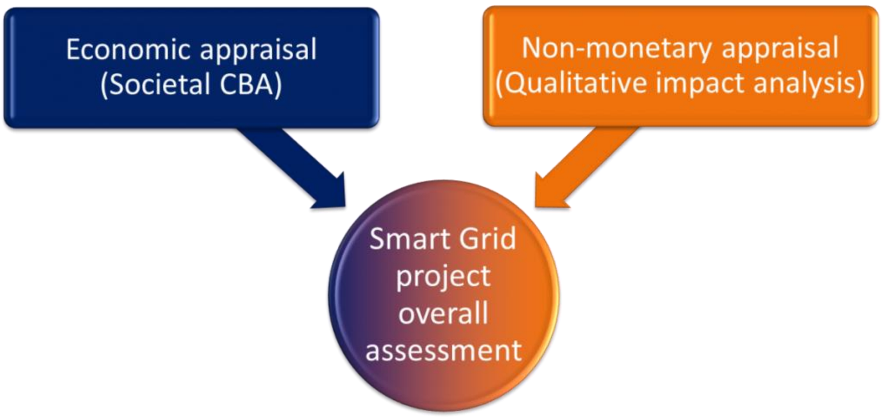


Figure 1 – Assessment framework for Smart Grid projects

For an easy usage, the CBA framework is structured into a set of 10 guidelines (see figure 2) to tailor assumptions to local conditions, to identify and monetize benefits and costs, and to perform sensitivity analysis of most critical variables. It also provides guidance in the identification of externalities and social impacts that can result from the implementation of Smart Grid projects but that cannot be easily monetized and factored into the cost benefit computation.

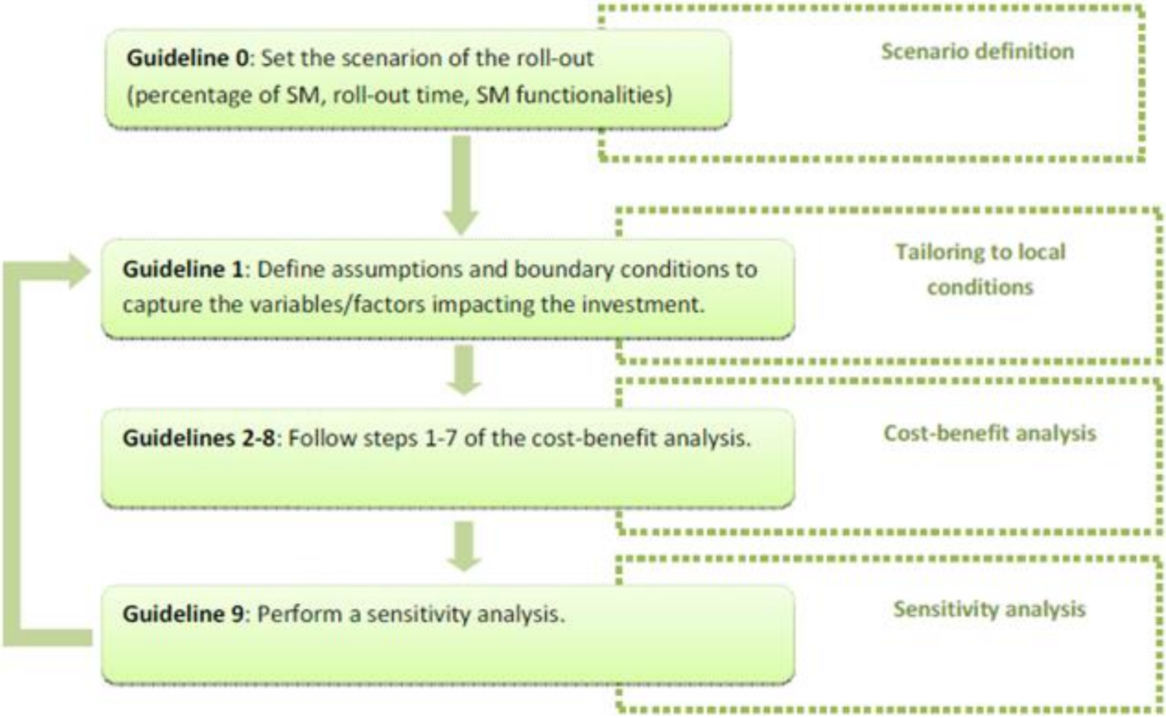


Figure 2 – CBA framework Guidelines

4 Roll-out planning toolkit: CBA

4.1 Guideline 0: Define the scenario

We will use the two scenarios based on the percentage of end-users to be targeted with PEAKapp, the roll-out time and the number of PEAKapp functionalities considered:

- **Scenario 0: "Business as Usual (BaU)" with no PEAKapp solution**. This scenario is focused on the current situation of the energy utility. It assumes that no PEAKapp deployment will be required in the CBA time horizon. This scenario is also labelled as "Do nothing and nothing happens" and can be seem as the **baseline scenario**.
- **Scenario 1: "PEAKapp adoption"**. This scenario assumes that the energy utilities will make available the PEAKapp solution for all their smart meters users by 2020. The PEAKapp solution is provided with the agreed set of common minimum assets based on the type of end-user.

Table 2 - Basis scenarios to consider for the CBA

Scenario	Extension of roll-out (percentage of consumers)	Roll-out time (years)	Number of PEAKapp assets
Scenario 0	-	-	-
Scenario 1	100%	5	3 assets as the whole PEAKapp solution (see section 4.4. for more details)

4.2 Guideline 1: Tailor to local conditions

It is important to define assumptions and set critical parameters because different geographies and contexts (political, economic and cultural) will determine the impacts on the quantification of benefits and costs. For doing so, in this section we provide the following information:

1. Identify the main parameters in order to define the local conditions of the roll-out.
2. Define the assumptions based on the local conditions influence
3. Substantiate the validity of those assumptions using data sources.

Here is a list of non-exhaustive variables to be considered as potential factors having an impact (positive or negative) on the roll-out:

Table 3 - List of potential variables to be considered during the "Tailor to local conditions" step

Variables/data to be set/collected in the case of utilities	Unit/Metric
Projected variation of energy consumption	%
Projected variation of energy price	%
Peak load transfer	%
Electricity losses at transmission and distribution level	%
Estimated non-supplied minutes	Number of minutes

Value of lost load; value of supply	€/kWh
Discount rate	%
Hardware costs (e.g. smart meters, etc.)	€
Number of smart metering systems to be installed	Number of systems
Installation costs for smart metering system	€
Licensing costs for using PEAKapp	€
Deployment schedule of PEAKapp	Number of PEAKapp users/year
Life expectancy of smart metering system	Number of years
Meter reading costs	€/year
Telecommunication success rate	%
Inflation rate	%
Cost reduction associated with technology maturity	%
Implementation schedule	Number of smart meters/year
Carbon costs	€/ton

After an analysis and discussion with utilities' partners, where it is remarked that smart meter roll-out happens regardless of the project solution, the list of variables to be considered as potential factors for PEAKapp are:

Table 4 - List of variables to be considered in PEAKapp

Nº	Variables/data to be set/collected in the case of utilities	Description	Unit/Metric
V1	Number of customers	Average annual number of residential customers.	Number
V2	Growth rate of customers	Estimated rate of potential new customers.	%
V3	Customer energy prices/rates	Amount of money that customer paid for the energy consumed.	€/kWh
V4	Projected variation of energy prices	Estimated annual increase/decrease of energy prices.	%
V5	Projected variation of energy consumption (demand growth)	Estimated annual increase/decrease of energy consumption at residential level.	%
V6	Inflation rate	Estimated annual increase/decrease in the general price level of goods and services.	%
V7	Customer care cost	Average amount of money related to call centre service per customer.	€/year
V8	Estimated non-supplied minutes	Projected average annual number of unserved minutes for a typical residential customer during an outage event.	Number of minutes
V9	Value of lost load; value of supply	Annual average amount of money per kWh of load not served.	€/kWh
V10	Average annual customer electricity usage	Average annual electricity usage of a single typical residential customer.	kWh
V11	Number of meter tamper detections at residential level	Total annual number of residential meter tampering cases that have been detected and confirmed as theft attempts.	Number

V12	Average duration of theft	Projected average annual theft rate of time for a typical residential customer during a theft event.	%
V13	Difference between peak and off-peak generation	Average annual amount of money per MWh of the margin between peak and off-peak prices.	€/MWh
V14	Estimated peak load transfer	Average annual rate of electricity usage that is shifted from peak times to off-peak times.	%
V15	CO^2 emissions	Average annual CO^2 emissions from central generating sources.	tons/year
V16	Value of CO^2 emissions	Average value of CO^2 emissions based on market	€/tons
V17	Discount rate	*Interest rate used in discounted cash flow analysis to get the present value of future cash flows* [JRC 2012].	%

4.3 Guideline 2: Review and describe the technologies, elements and goals of the scenario (CBA step 1)

PEAKapp will provide an ICT-to-Human ecosystem 2.0 to trigger lasting energy savings through behavioural change, enable increased consumption of clean and low-priced electricity from the spot market to household customers, connect customers to social networks, motivate them through serious gaming and to boost the efficacy of Smart Home building energy management systems by integrating their functionalities into the PEAKapp solution.

The ICT-to-Human ecosystem 2.0 is designed to be hosted by electricity retail companies, which offer it to their customers and in return gain customer loyalty, service fees or a platform to promote their other energy efficiency services, such as individualised energy audits or contracting of efficient appliances.

The following figure shows the technical description of the PEAKapp architecture:

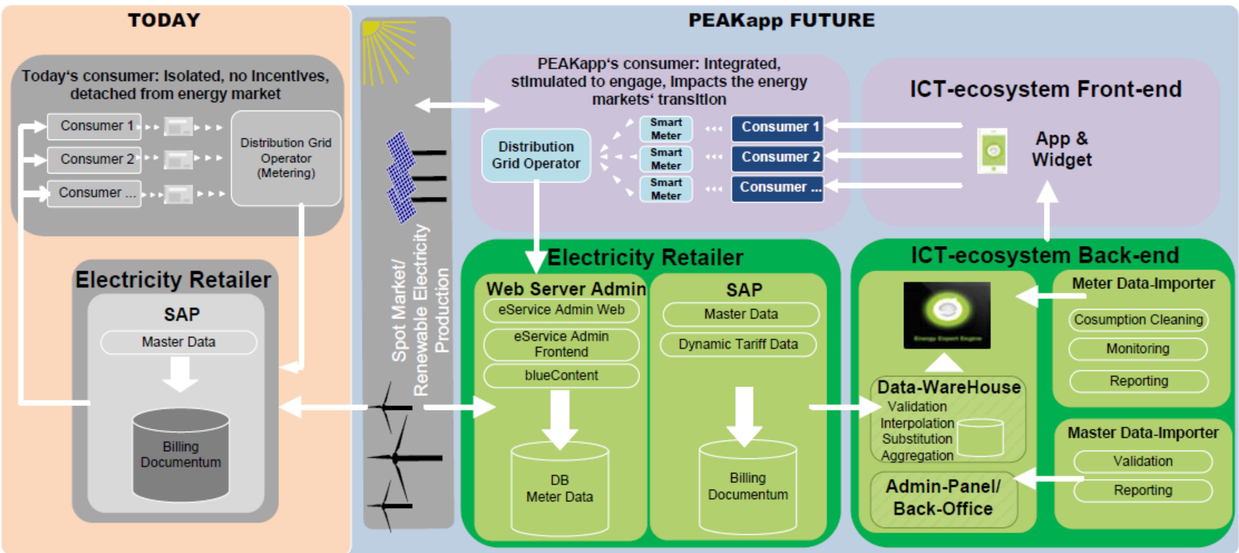


Figure 3 – Technical description of the architecture of the ICT-to-Human ecosystem

The main components of the system are:

- **Data Collection Framework**: A standardized and open interface framework to import meter-data like consumption data and meter reading of different energy types, as well as to import master-data like user-data and tariff-data. It supports a wide range of interface solutions and data formats because data from different sources comes together in the EEE [D2.1].
- **Data Warehouse**: An optimised central database for analytical purposes, which receives data from several, normally heterogeneous sources from the Data Collection Framework and afterwards brings them together and compresses them [D2.1].
- **Energy Expert Engine – EEE**: Summarizes, analyses and visualizes the smart meter data on a PC, tablet or smart phone. It is supported by the Data Collector and a Data Warehouse [D2.1].
- **Backend Processing Unit:** The PEAKapp is based on classic client-server architecture. The client in this case is the PEAKapp smartphone app front-end communicating with the JEE application located on a server reachable over the World Wide Web [D2.2].
- **Front-end system**: A top notch rich HTML5, CSS3 and JavaScript application. It can be wrapped with Apache Cordova, an open source mobile application development framework, enabling programmers to develop a platform independent application without losing native smartphone functionality such as Geolocation and Notifications [D2.2].

The features of the PEAKapp result in following benefits for the users:

- **Optimize energy consumption**: all relevant key data at a glance, compare to your own average or previous period and get detailed analysis and forecasts
- **Saving costs**: get informed in case of expected debit in annual payment period
- **Save energy**: get informed in case of exceeding your consumption limit
- **Compare to other households**: see how efficient your household is compared to other households in your surrounding environment
- **Serious Game**: get to know your daily consumption and learn, how much energy appliances use
- **Notifications**: stay informed about attractive offers and activities from your utility
- **Discount offers**: consume electricity if it is cheap, for instance in times of high renewable energy consumption
- **Illustrating energy records; Protecting the environment**: Environmental analogies helps you to better assess your energy usage, for example, the CO2 output generated by energy consumption is set in relation to the number of kilometres for a car journey.

4.4 Guideline 3: Map assets on to functionalities (CBA step 2)

Based on the components of the PEAKapp system, the following table provides a list of assets considered when assessing cost and benefits of PEAKapp project.

Table 5 - List of PEAKapp assets

Asset nº	Asset name	Description
1	Smart metering connection technologies	Equipment and technologies installed at consumers that records energy consumption and communicates that information at least daily back to the utility for monitoring and billing. The technologies from PEAKapp operate from a central server station and it stores the incoming consumption data of the households retrieved from their smart meters, stores, forwards and manages the dynamic electricity prices, handles all requests sent from the households to the system, handles all messages that the provider sends to the customers, and interconnects the households amongst each other. This asset includes the **Data Collection Framework** and the **Data Warehouse**.
2	Energy Expert Engine – EEE	The highly flexible Energy Expert Engine application summarizes, analyses and visualizes the smart meter data on a PC, tablet or smart phone. The multi-compatible interface enables the connection with a range of AMR and EDM systems, customer databases and billing systems. Digital energy consumption data is initially prepared in the EEE. Additional data, such as environmental indicators, are subsequently included in the calculations and are supported by the Data Collector and a Data Warehouse. Datasets are linked and interpreted in line with the requirements of energy consumers on the basis of algorithms and heuristics.
3	Customer Portal	This includes the **Backend processing unit** and the **Front-end system**. This asset integrates the JEE application as well as the Game Server. The PEAKapp is based on classic client-server architecture. The client in this case is the PEAKapp smartphone app front-end communicating with the JEE application located on a server reachable over the World Wide Web. The PEAKapp front-end is a top notch rich HTML5, CSS3 and JavaScript application. It can be wrapped with Apache Cordova, an open source mobile application development framework, enabling programmers to develop a platform independent application without losing native smartphone functionality such as Geolocation and Notifications.

Now, we have to map each asset with the functionalities to provide enhanced capabilities provided by the PEAKapp solution. For doing so, we will use as basis the 33 standardised functionalities [EU 2010] for Smart Grid projects that are (potentially) activated by the assets.

The next table shows that mapping, where the dots in the cells represent the functionalities provided by the PEAKapp project and which assets activate them.

Table 6 - Mapping of assets-functionalities

Assets	Services and Functionalities										
	D. Better planning of future network investment	E. Improving market functioning and customer service						F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management			
	17. Better models of DG, storage, flexible loads, ancillary services	20. Participation of all connected generators in the electricity market	21. Participation of VPPs and aggregators in the electricity market	22. Facilitate consumer participation in the electricity market	25. Support the adoption of intelligent home / facilities automation and smart devices	26. Provide to grid users individual advance notice for planned interruptions	27. Improve customer level reporting in occasion of interruptions	28. Sufficient frequency of meter readings	30. Consumption/injection data and price signals by different means	31. Improve energy usage information	32. Improve information on energy sources
Smart metering connection		X	X	X	X			X	X	X	X
Energy Expert Engine	X	X	X	X	X	X	X		X	X	X
Customer Portal				X		X	X		X	X	X

4.5 Guideline 4: Map functionalities on to benefits (CBA step 3)

The purpose of this second mapping is to link the functionalities considered in previous step with the benefits they provide. This mapping only includes the functionalities provided by the project's assets, as identified in the previous step.

For the definition of the benefits, we can use as reference the 22 Smart Grid benefits put forwards by the EPRI methodology [EPRI 2010] [JRC 2012]. Here is the list tailored to PEAKapp:

Table 7 - List of PEAKapp benefits

Group	Category	Benefits
Economic	Theft Reduction	Reduced Electricity Theft (Utilities)
	Electricity Cost Savings	Reduced Electricity Cost (Consumer)
	Consumer Satisfaction	Increased Consumer Satisfaction (Utilities, Consumers)
	Other	Reduced Call Centre Cost (Utilities)
Reliability	Power Interruptions	Reduced Sustained Outages (Consumer)
Environmental	Air Emissions	Reduced CO^2 Emissions (Society)

According to [JRC 2012], the description of each of those benefits is as follows:

- **Reduced Electricity Theft**: Smart meters can typically detect tampering. Moreover, a meter data management system can analyse customer usage to identify patterns that could indicate diversion.
- **Reduced Electricity Cost**: The functions listed could help alter customer usage patterns (demand response with price signals or direct load control) or help reduce the cost of electricity during peak times through either production (DG) or storage. In our case, we will analyse this benefit from the peak load transfer perspective.
- **Increased Consumer Satisfaction**: Increased use of smart meters and connected PEAKapp use enhances the customer's feeling of satisfaction which may result in tariff incentives for utility company. This benefit will be measured using questionnaires.
- **Reduced Call Centre Cost**: Functions that enable a reduction in the customer claims using the call centres regarding billing or inaccurate meter readings.
- **Reduced Sustained Outages**: Reduces the likelihood that there will be an outage and allows the system to be reconfigured on the fly to help in restoring service to as many customers as possible. A sustained outage is one lasting > 5 minutes, excluding major outages and wide-scale outages. The benefit to consumers is based on the value of service (VOS).
- **Reduced CO^2 Emissions**: Functions that provide this benefit can improve performance in many aspects for end-users. These improvements translate into a reduction in CO^2 emissions produced by fossil-based electricity generators.

Now, we have to map each benefit with the functionalities. The next table shows that mapping, where the dots in the cells represent the functionalities provided by the PEAKapp project and which benefits are addressed.

Table 8 - Mapping of benefits-functionalities

Benefits	Functionalities										
	17. Better models of DG, storage, flexible loads, ancillary services	20. Participation of all connected generators in the electricity market	21. Participation of VPPs and aggregators in the electricity market	22. Facilitate consumer participation in the electricity market	25. Support the adoption of intelligent home / facilities automation and smart devices	26. Provide to grid users individual advance notice for planned interruptions	27. Improve customer level reporting in occasion of interruptions	28. Sufficient frequency of meter readings	30. Consumption/injection data and price signals by different means	31. Improve energy usage information	32. Improve information on energy sources
Reduced Electricity Theft	X							X			
Reduced Electricity Cost				X	X			X			
Reduced Call Centre Cost						X	X				
Increased Consumer Satisfaction					X	X				X	X
Reduced Sustained Outages	X	X				X	X			X	X
Reduced CO^2 Emissions	X			X	X			X	X	X	X

4.6 Guideline 5: Establish the baseline and project data (CBA step 4)

The definition of the baseline scenario provides a set of formal data about the grid status when the PEAKapp solution is not taken place (this means, assuming a “no build” scenario). This baseline scenario, which must be defined by the user, will be used to compare against in order to determine the improvement of using the PEAKapp technology in the grid. The Section 4.1 defined the two scenarios we will be used: scenario 0 (baseline) will be the current smart grid without the PEAKapp technology and scenario 1 will assume that the user has already deployed a smart grid, which is a requirement for PEAKapp deployment.

The identification of the required baseline and project data is defined in Table 4. And for their collection, we will use historical data (data is relatively stable over the deployment period), which in some cases will be adjusted using forecasts (data is expected to vary over short time periods [EPRI 2010]). To calculate the benefits, the toolkit needs to collect the baseline data from the user based on a five-year projection. Besides, we also need some additional data about the PEAKapp project usage (for at least one year). The following table summarises all the data required.

Table 9 - Baseline and Project data in PEAKapp

Baseline and Project data	Historical / Forecasted metric	Related benefits
Number of customers	H	Reduced Electricity Theft, Reduced Call Centre Cost
Growth rate of customers	H	Reduced Electricity Theft, Reduced Call Centre Cost
Customer energy prices/rates	H	Reduced Electricity Theft
Projected variation of energy prices	F	Reduced Electricity Theft
Projected variation of energy consumption (demand growth)	F	Reduced Electricity Theft, Reduced Electricity Cost, Reduced Call Centre Cost, Reduced Sustained Outages, Reduced CO^2 Emission
Inflation rate	F	Reduced Electricity Cost, Reduced Call Centre Cost, Reduced Sustained Outages
Customer care cost	H	Reduced Call Centre Cost
Estimated non-supplied minutes	H	Reduced Sustained Outages
Value of lost load; value of supply	F	Reduced Sustained Outages
Average annual customer electricity usage	H	Reduced Electricity Theft
Number of meter tamper detections at residential level	H	Reduced Electricity Theft
Average duration of theft	H	Reduced Electricity Theft
Difference between peak and off-peak generation	H	Reduced Electricity Cost
Estimated peak load transfer	F	Reduced Electricity Cost
CO^2 emissions	H	Reduced CO^2 Emission
Value of CO2 emission	F	Reduced CO^2 Emission
Discount rate	H	Used for the sensitive analysis

In the case the user provides less than five-year projection of project data, the toolkit will automatically defer it by interpolating the missing data with the trend in the baseline data. For example, if the baseline values for 2020 and 2021 are 100 and 130, respectively; and the project value for year 2020 is 40, the tool would interpolate 52 as value for the missing 2021 project data (30% higher).

4.7 Guideline 6: Monetise the benefits (CBA step 5)

Based on the identified benefits (and both the baseline and project data (see Table 9), this step is in charge of collecting and reporting the data for the quantification and monetisation of the benefits. In general [JRC 2012], the monetary value of a benefit can be calculated as:

$$\textbf{Value (€) = [Status]}_{\text{Baseline (Scenario 0)}} - \textbf{[Status]}_{\text{PEAKapp (Scenario 1)}}$$

In order to monetise the benefits, here is the formula we have used and the rationale behind the benefit calculation [JRC 2012]:

Table 10 - Monetisation of benefits

Benefits	Formulae	Rationale
Reduced Electricity Theft	Value (€) = [Number of meter tamper detections at residential level * Average annual customer electricity usage * Average duration of theft *Average energy prices]	The average energy rate is calculated using as basis the customer energy prices and the projected variation.
Reduced Electricity Cost	Value (€) = [Difference between peak and non-peak generation* Estimated peak load transfer]	The savings in electricity is based on peak load transfer. The provision of real-time consumption information to users is expected to motivate them not only to save energy but also to shift their consumption to off-peak periods.
Reduced Call Centre Cost	Value (€) = [Number of customers * Customer care cost]	The reduction in the costs for the call centre is based on a reduction of customer claims related to billing, energy consumption or inaccurate meter readings.
Reduced Sustained Outages	Value (€) = [Projected variation of energy consumption * Estimated non-supplied minutes * Value of lost load; value of supply]	The value of lost load represents an estimated cost per kWh of electricity not supplied. And it is often set as a reference by national regulators.
Reduced CO2 Emissions	Value (€) = [Projected variation of energy consumption * CO2 emissions from central generating sources * Value of CO2 emission]	Avoided emissions should be entered as negative numbers.

4.8 Guideline 7: Identify and quantify the costs (CBA step 6)

Collecting information on the roll-out's costs is necessary for determining its return on the investment. The next table shows the type of costs to be tracked for roll-out and to be estimated for the baseline. Here is the list tailored to PEAKapp:

Table 11 - List of PEAKapp costs

Nº	Category	Type of cost to be tracked for roll-out and to be estimated for baseline Unit: €/year
C9	OPEX	IT set-up and maintenance costs (this includes the set-up of the server to host back-end processing unit of PEAKapp)
C10		Network management and front-end costs
C11		Communication/data transfer costs (incl. GPRS, Radio Communications, etc)
C19		Call centre/customer care

C25	Other	Licensing costs for using PEAKapp* *(in the scenario 0, this cost will be 0)*

4.9 Guideline 8: Compare costs and benefits (CBA step 7)

Once costs and benefits have been estimated, we need to compare them in order to evaluate the cost-effectiveness of the PEAKapp deployment. For doing so, we will use three common methods:

- **Annual comparison**: This method provides a comparison per year.
- **Cumulative comparison**: This method presents costs and benefits cumulatively over time, for example per year. This provides insights about when benefits will exceed costs.
- **Net present value (NPV)**: This method consists of calculating the monetary value now of the project's future cash flow. For doing so, the steps are to subtract the present value cost schedule from the present value total benefits schedule; to discount these annual net benefit amounts and then to sum up the discounted values.

The NPV is calculated as follows:

$$\sum_{t=0}^{n} \frac{R_t}{(1+i)^t}$$

Where, *t* is the time of the cash flow; *i* is the discount rate; R_t is the net cash flow (cash inflows minus cash outflow at time *t*); n is the total number of years considered.

4.10 Guideline 9: Perform a sensitive analysis

Apart from the standard analysis of the inputs, it is optional to perform a sensitivity analysis for benefits calculations, which indicates to what extent the benefits are affected by variations in the input parameters. In this case, the user controls the sensitivity range for each input by setting the low and high ranges for each input to explore uncertainty. This implies to provide a high and low ranges for each of the inputs from table 9.

5 Roll-out toolkit: Digital support

In our case, we will provide a software tool as a digital support for utilities to calculate the costs and benefits of using PEAKapp solution. The tool has been developed as an Excel file "*PEAKapp_Roll-out_toolkit_v1.0.xlsm*". The tool will help utilities to understand the impact of the investments on using PEAKapp. The tool can be used in two ways:

1. To have an estimation about the expected benefits and costs with a projected hypothetical one-year scenario deploying PEAKapp. The resulting insights provided can be used to justify a future PEAKapp investment.
2. To compare benefits and costs with real-word data after the deployment of PEAKapp during some years while having a deeper understanding of the value of using PEAKapp.

The final result provided by the tool is a set of charts and tables summarizing the analysis performed. This tool follows the different steps identified in the methodology and guide the user in the data collection process to tailor each analysis to the characteristics of each utility.

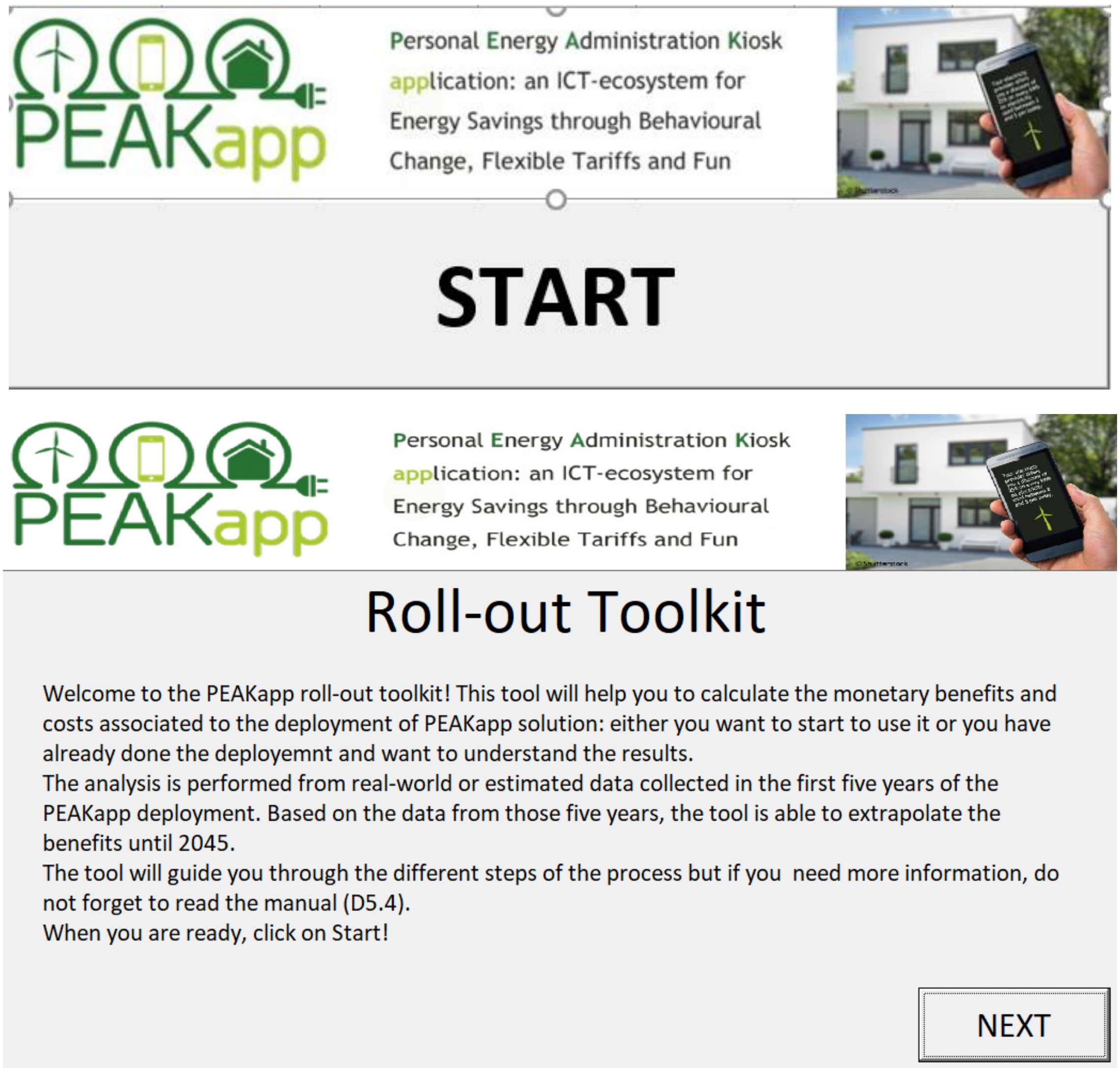


Figure 4 – Main Screen of the Roll-Out toolkit

First, the tool asks for some **general information** about the PEAKapp project, such as:

- Name of the utility that will be implementing the PEAKapp deployment.
- Name of the PEAKapp deployment project, using a unique name in case several analyses wants to be performed and saved.
- Start year referring to the first year that the project began to operate. This year will be used as the starting year for calculating the costs and benefits. The format should be YYYY.
- Country (optional) where the PEAKapp deployment will be performed.

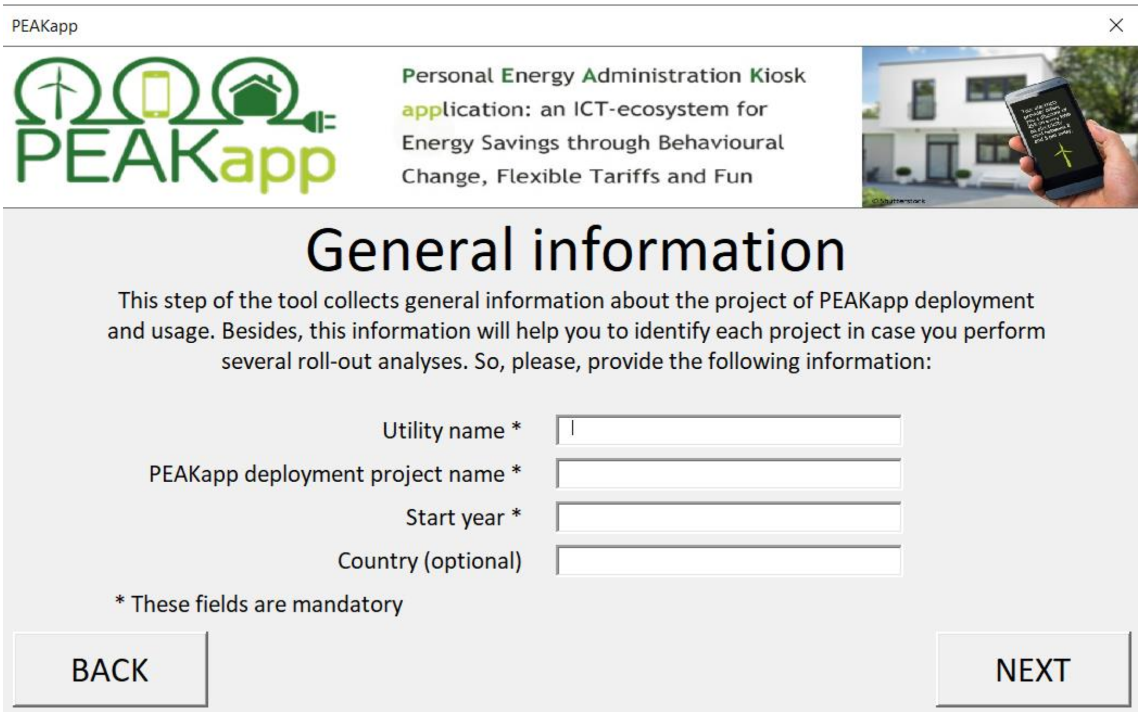
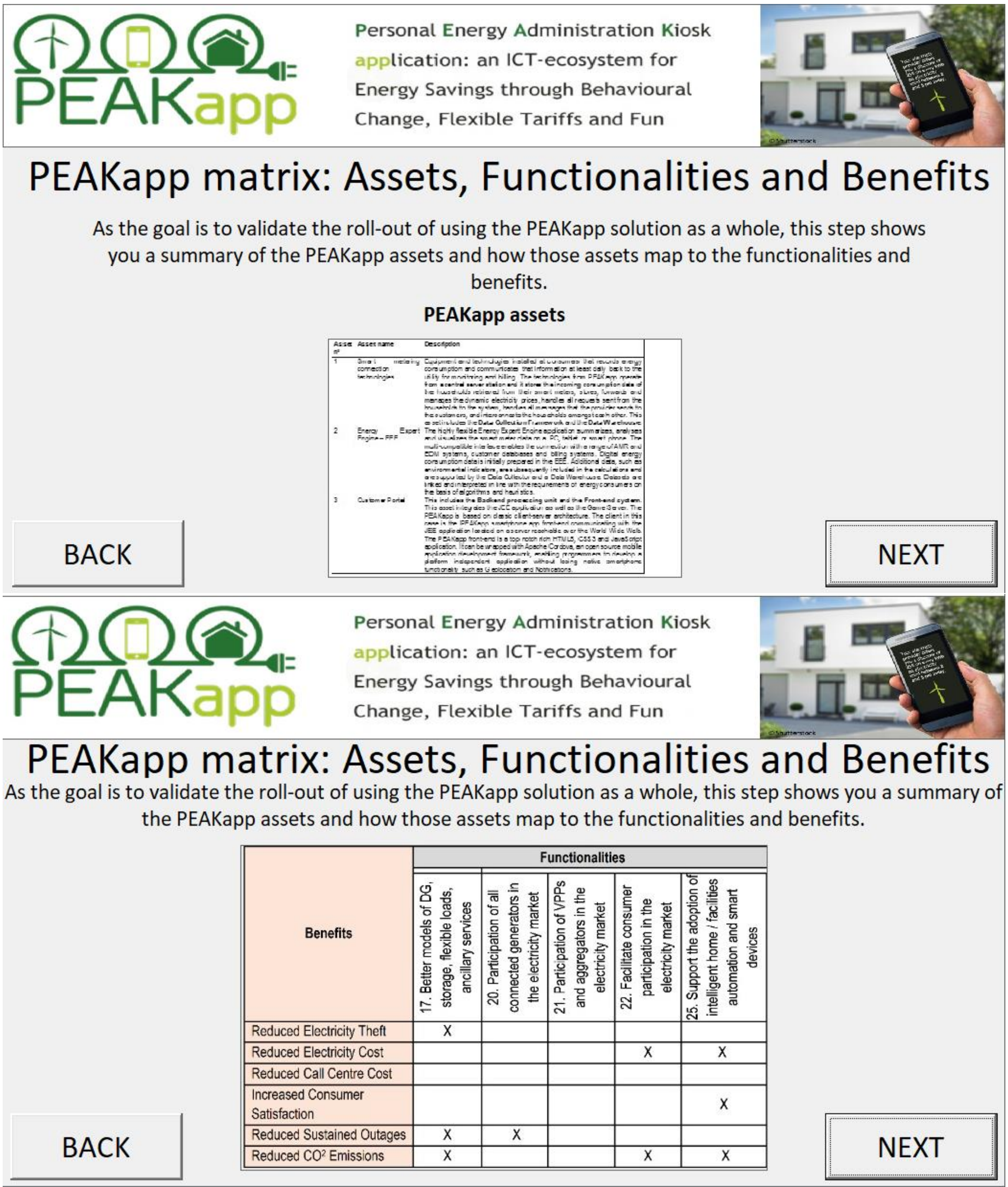


Figure 5 – General Information Screen

As the goal is to validate the roll-out of using the PEAKapp solution as a whole, the tool will show the user a summary of the PEAKapp **assets** and how those assets map to the **functionalities** and **benefits** (Guideline 2, 3, 4).



Benefits	Functionalities: 17. Better models of DG, storage, flexible loads, ancillary services	20. Participation of all connected generators in the electricity market	21. Participation of VPPs and aggregators in the electricity market	22. Facilitate consumer participation in the electricity market	25. Support the adoption of intelligent home / facilities automation and smart devices
Reduced Electricity Theft	X				
Reduced Electricity Cost				X	X
Reduced Call Centre Cost					
Increased Consumer Satisfaction					X
Reduced Sustained Outages	X	X			
Reduced CO² Emissions	X			X	X

Figure 6 – Summary of PEAKapp assets and matrix

Then, based on the assets and associated benefits, the tool requires user to **enter the values of the variables** identified in Table 9 from **baseline scenario and, at least, one estimation from scenario 1** (Guideline 5,6). The tool will ensure that the inputs are provided in the correct format for calculating the benefits.

- The first input requested is the Customer electricity rates, which includes the number of customer and the related electricity prices. The tool only includes the residential customer segment due to the PEAKapp purpose. Customer electricity prices must be the average energy rate. This input is always requested independently of the selected benefits because it is needed for the calculation of the benefits.

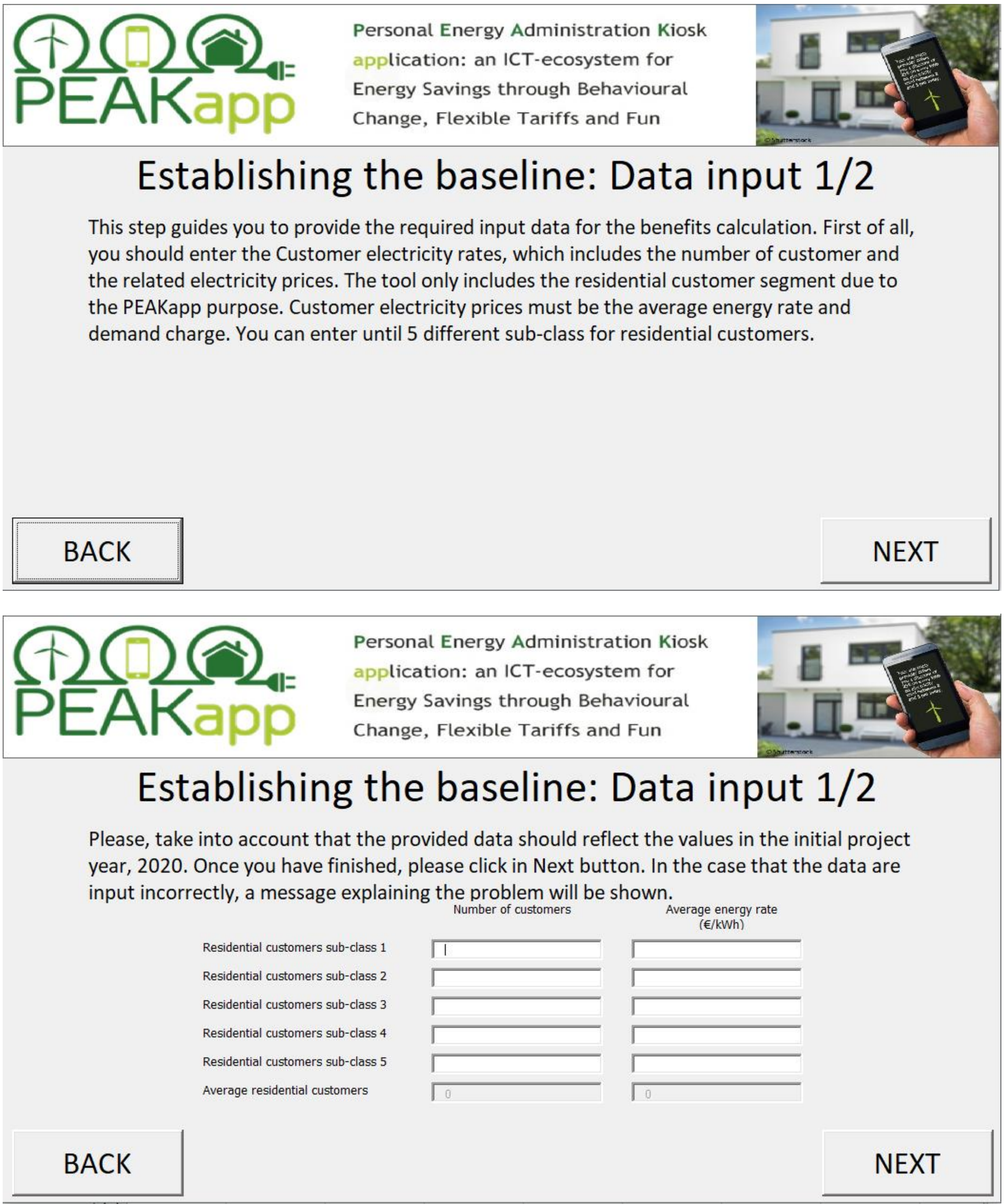
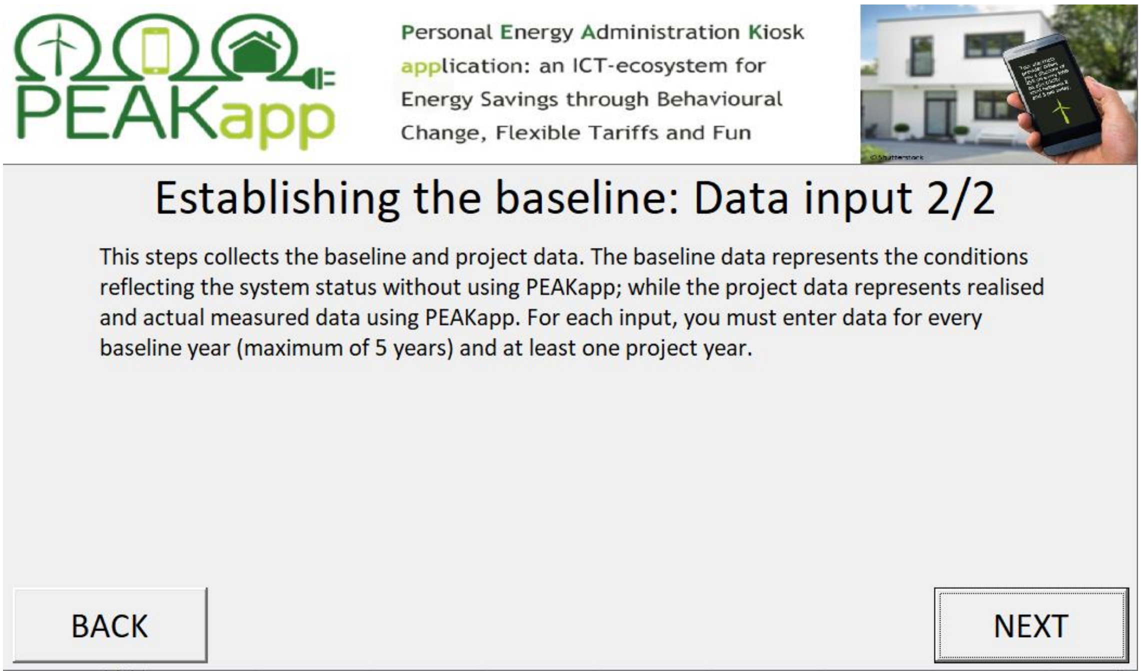
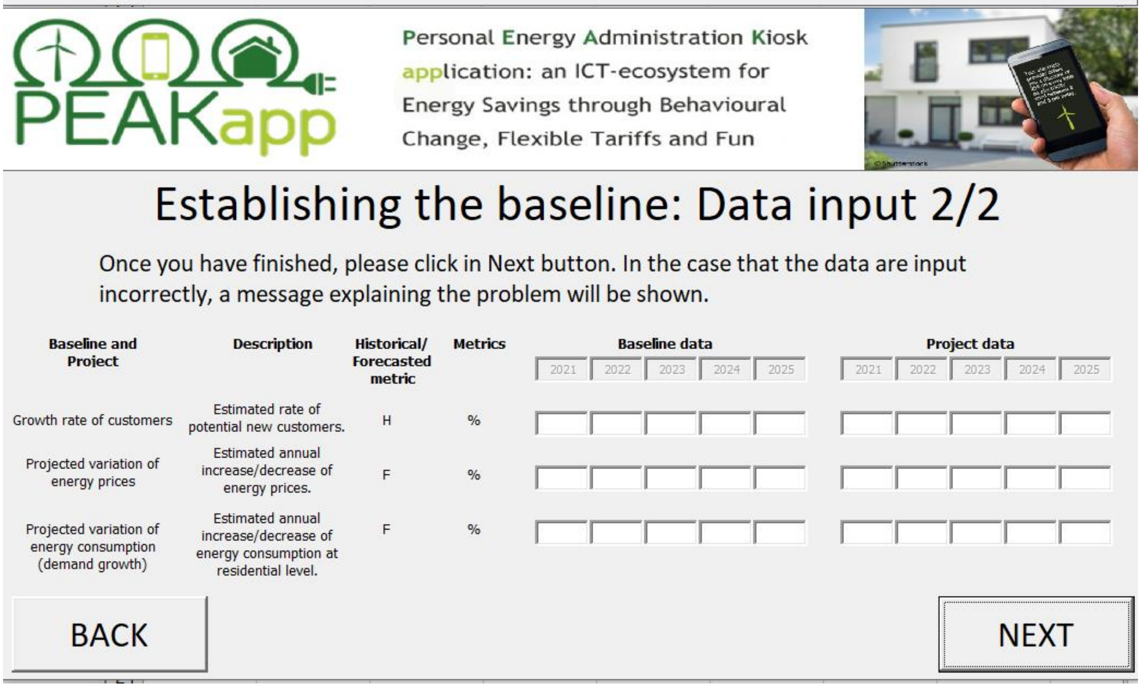
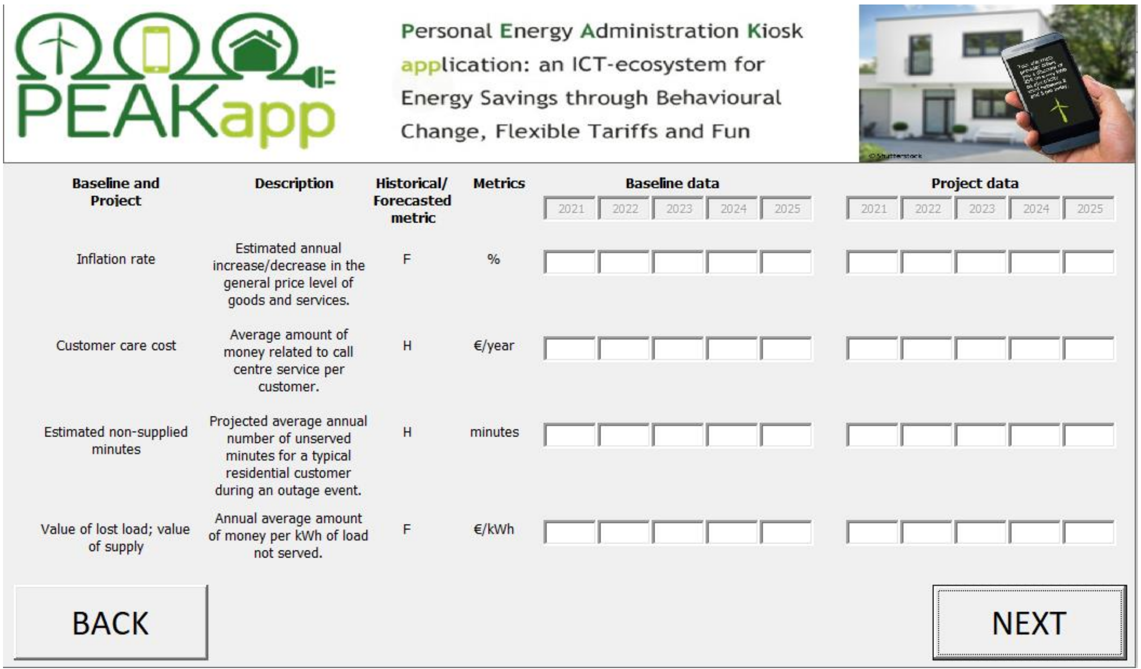


Figure 7 – Customer electricity rates screen

- Then, the baseline and project data are requested for each input defined in Table 9. There are two types of values that are required for any input: "Baseline" values and "Project" values. The baseline data represents the conditions reflecting the system status without using PEAKapp (in our case, scenario 0); while the project data represents realised and actual measured data using PEAKapp (in our case, scenario 1). For each input, the user must enter data for every baseline year (maximum of 5 years) and at least one project year.


PEAKapp
Personal Energy Administration Kiosk application: an ICT-ecosystem for Energy Savings through Behavioural Change, Flexible Tariffs and Fun
Establishing the baseline: Data input 2/2
This steps collects the baseline and project data. The baseline data represents the conditions reflecting the system status without using PEAKapp; while the project data represents realised and actual measured data using PEAKapp. For each input, you must enter data for every baseline year (maximum of 5 years) and at least one project year.
BACK
NEXT


PEAKapp
Personal Energy Administration Kiosk application: an ICT-ecosystem for Energy Savings through Behavioural Change, Flexible Tariffs and Fun
Establishing the baseline: Data input 2/2
Once you have finished, please click in Next button. In the case that the data are input incorrectly, a message explaining the problem will be shown.
Baseline and Project
Description
Historical/ Forecasted metric
Metrics
Baseline data
2021 2022 2023 2024 2025
Project data
2021 2022 2023 2024 2025
Growth rate of customers
Estimated rate of potential new customers.
H
%
Projected variation of energy prices
Estimated annual increase/decrease of energy prices.
F
%
Projected variation of energy consumption (demand growth)
Estimated annual increase/decrease of energy consumption at residential level.
F
%
BACK
NEXT



PEAKapp

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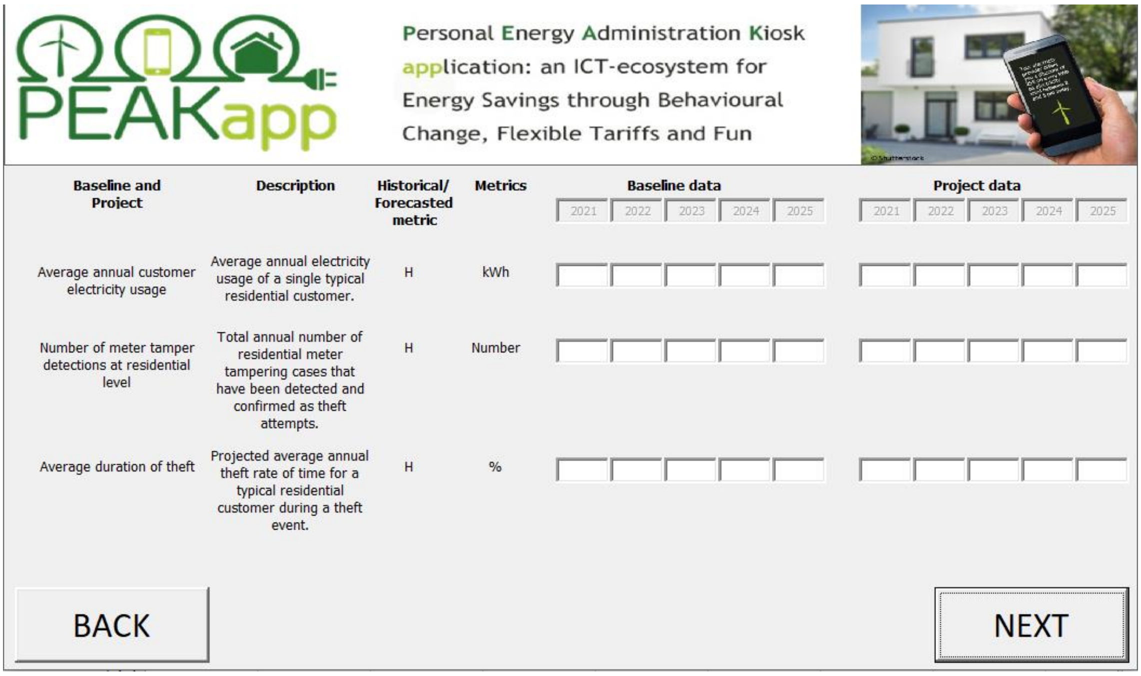
Baseline and Project	Description	Historical/ Forecasted metric	Metrics	Baseline data					Project data				
				2021	2022	2023	2024	2025	2021	2022	2023	2024	2025
Inflation rate	Estimated annual increase/decrease in the general price level of goods and services.	F	%										
Customer care cost	Average amount of money related to call centre service per customer.	H	€/year										
Estimated non-supplied minutes	Projected average annual number of unserved minutes for a typical residential customer during an outage event.	H	minutes										
Value of lost load; value of supply	Annual average amount of money per kWh of load not served.	F	€/kWh										

BACK NEXT



PEAKapp

Personal Energy Administration Kiosk application: an ICT-ecosystem for Energy Savings through Behavioural Change, Flexible Tariffs and Fun

Baseline and Project	Description	Historical/ Forecasted metric	Metrics	Baseline data					Project data				
				2021	2022	2023	2024	2025	2021	2022	2023	2024	2025
Average annual customer electricity usage	Average annual electricity usage of a single typical residential customer.	H	kWh										
Number of meter tamper detections at residential level	Total annual number of residential meter tampering cases that have been detected and confirmed as theft attempts.	H	Number										
Average duration of theft	Projected average annual theft rate of time for a typical residential customer during a theft event.	H	%										

BACK NEXT

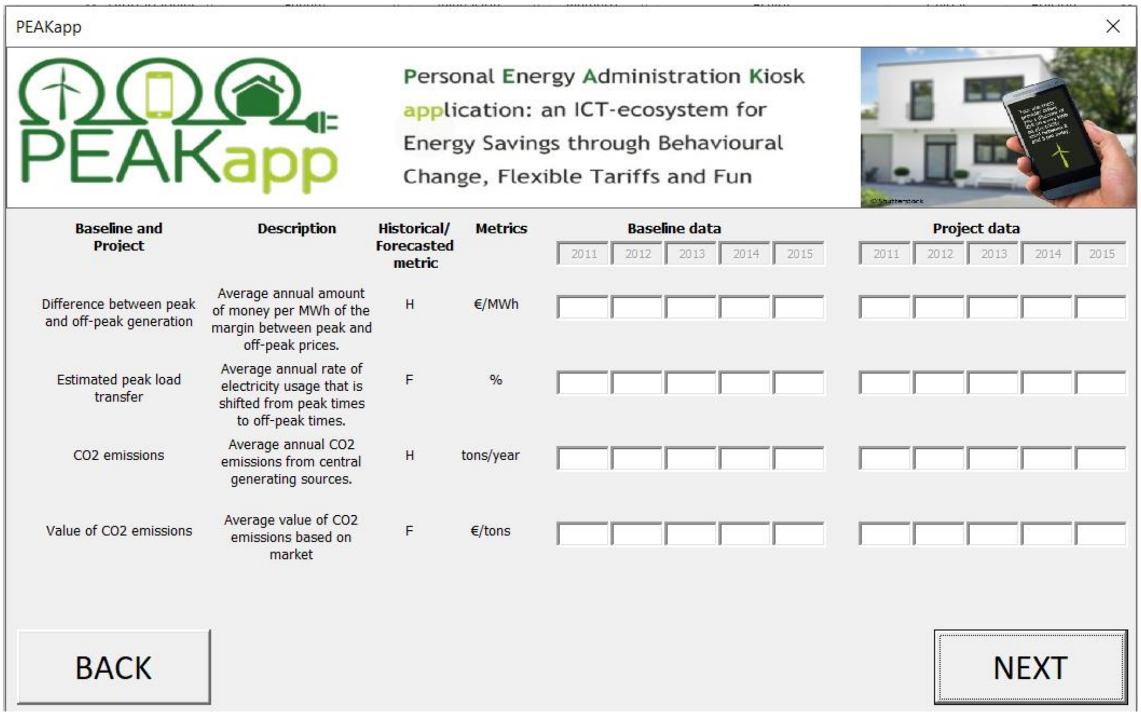


Figure 8 – Baseline and Project data input screen

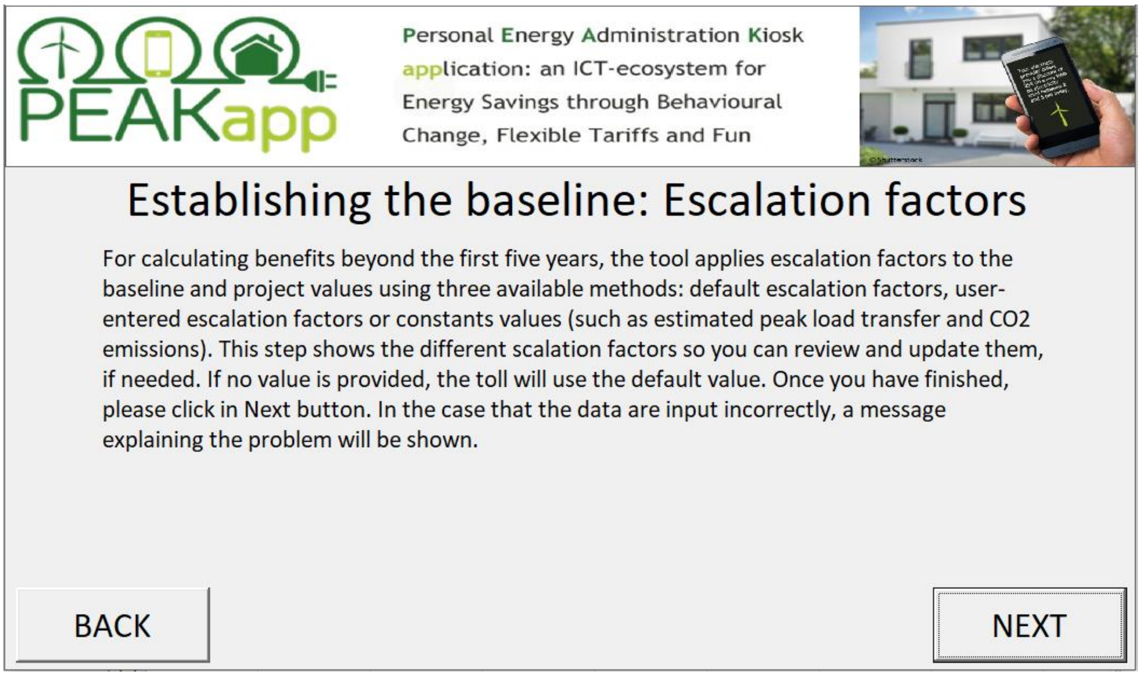
- Finally, for calculating benefits beyond the first five years, the tool applies escalation factors to the baseline and project values using three available methods: default escalation factors, user-entered escalation factors or constants values (this last case affects to three variables: average duration of theft, estimated peak load transfer and CO^2 emissions). In the case of an input is affected by two or more escalation factors, the sum of those escalation factors will be applied. All factors can be reviewed and updated by the user.

Table 12 - Escalation factors

Escalation Factors	Description	Default value	Baseline and Project Data affected
Population growth factor	Represents the customer population growth in the deployment area.	3.7%[1]	Number of customers, Growth rate of customers, Projected variation of energy consumption, Number of meter tamper detections at residential level, Customer care cost, Difference between peak and non-peak generation
Load growth factor	Represents the electricity load growth in the deployment area.	4.4%[2] [3]	Estimated non-supplied minutes, Value of lost load; value of supply
Economic inflation factor	Represents the economic inflation in the deployment area.	2.6%[4]	Inflation rate, Customer energy prices/rates, Projected variation of energy prices
Final year of benefits	Represents the year that the baseline scenario reaches the project scenario. This means, the	2045	Affects the Benefits are calculated until the year 2045. However, the user can change the

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php/People_in_the_EU_-_population_projections#Population_projections
[2] https://docstore.entsoe.eu/Documents/Publications/Statistics/Factsheet/entsoe_sfs_2017.pdf
[3] https://docstore.entsoe.eu/Documents/Publications/Statistics/electricity_in_europe/entsoe_electricity_in_europe_2016_web.pdf
[4] https://data.oecd.org/price/inflation-forecast.htm

	time period over which the projected benefits will decline to zero.		year that determines when benefits decline to zero.



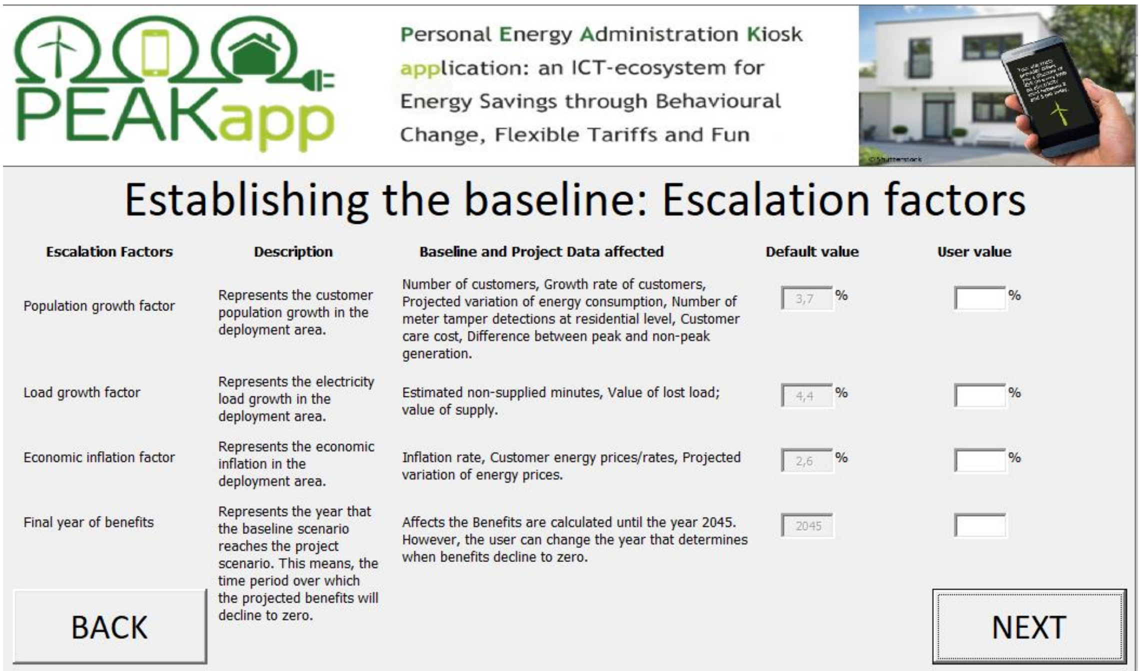


Figure 9 – Escalation factors screen

In the case of sensitivity analysis, the user has to set the low and high ranges for each input to explore uncertainty.

After calculating the benefits, we have to collect information on the **roll-out's costs** for determining the cost-effectiveness of the PEAKapp deployment and the return of investment (Guideline 7). For doing so, the user has to enter the costs detailed in the table 11 so the tool can calculate the net present value (NPV). Besides, the tool will ask for the discount rate and the initial and final spending years.

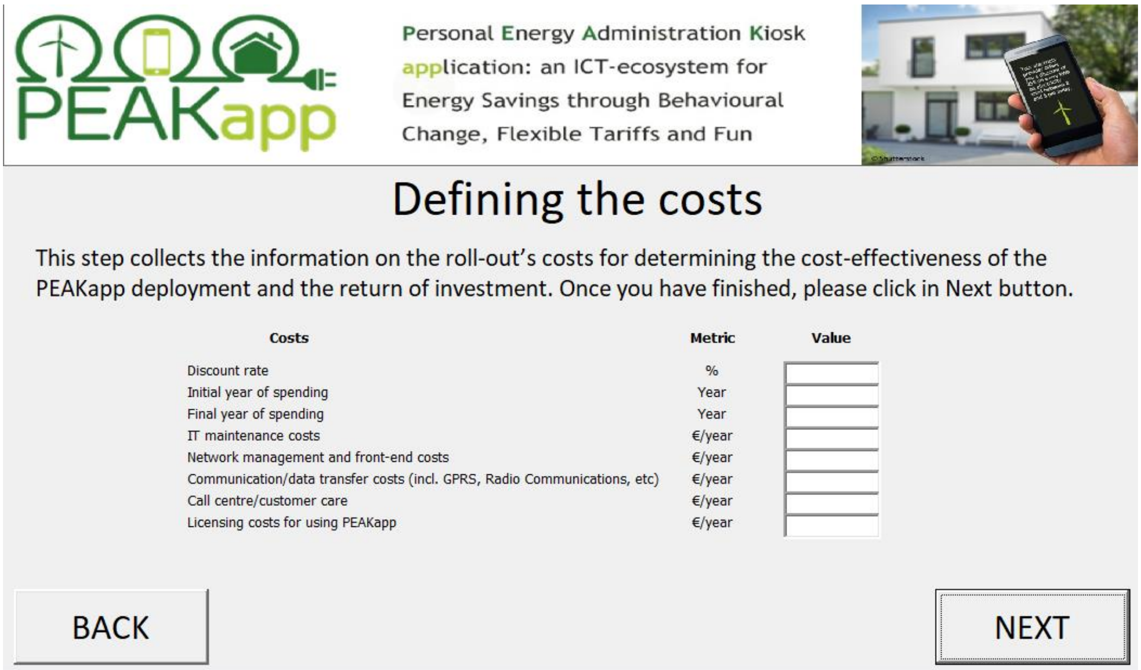
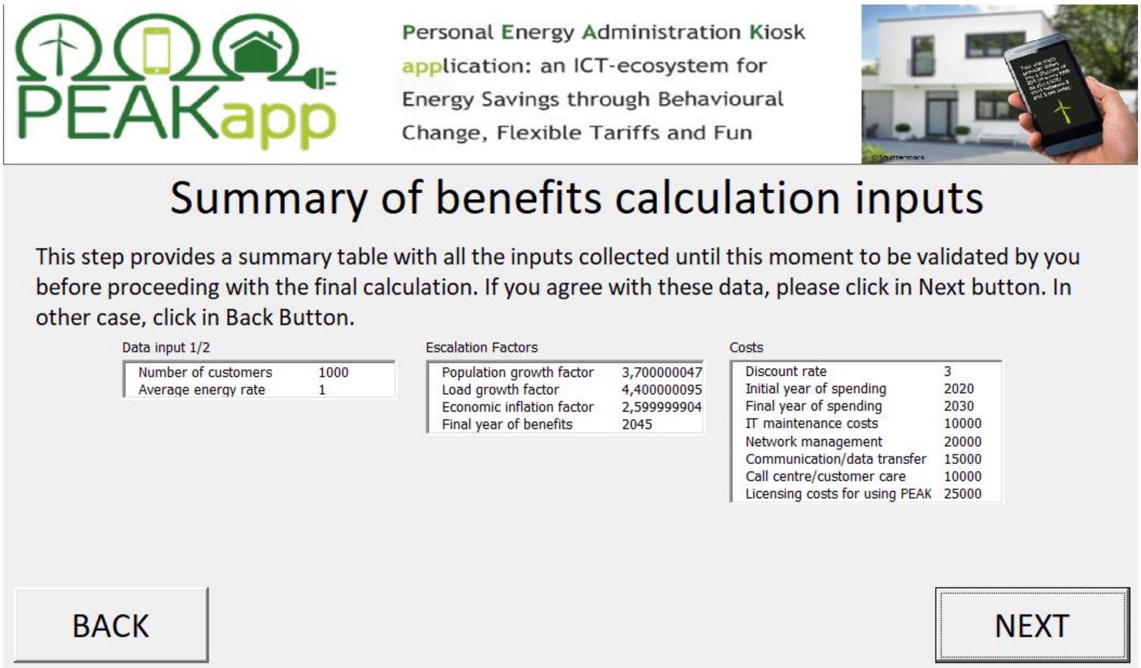


Figure 10 – Costs input screen

A final summary table will be shown with all the inputs collected until that moment to be validated by the user before proceeding with the final calculation.



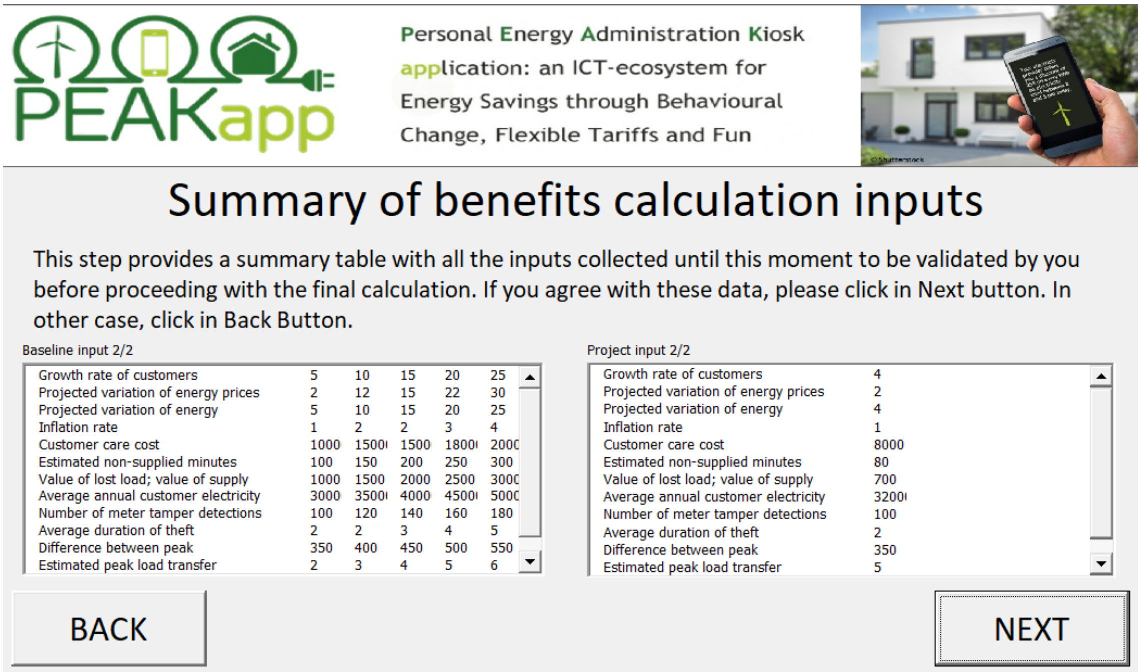


Figure 11 – Final summary screen

Then, the tool performs the **cost-benefit analysis** (Guideline 8).

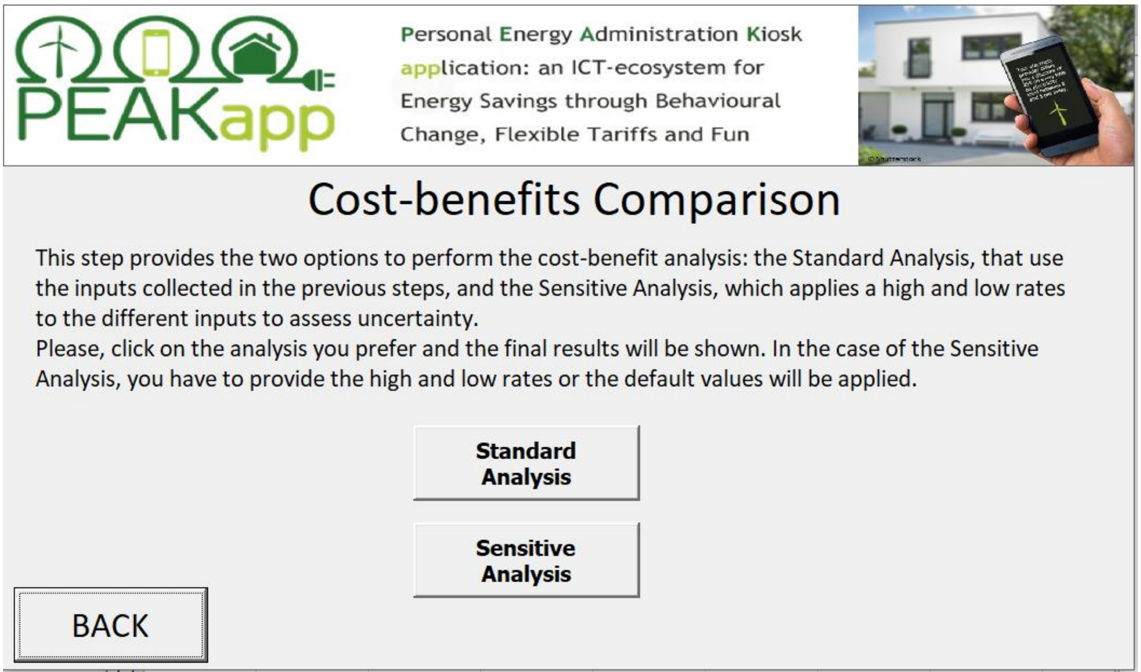


Figure 12 – Cost-benefit analysis screen

The analysis can be done using those inputs (called ***Standard Analysis***). The final results are presented in two ways:

- **Benefit and costs values**: A table with the annual benefits and costs, a second table with the cumulative benefit and costs values and a chart with the analysis of the benefits per category using nominal terms.

Go back Roll-out Toolkit

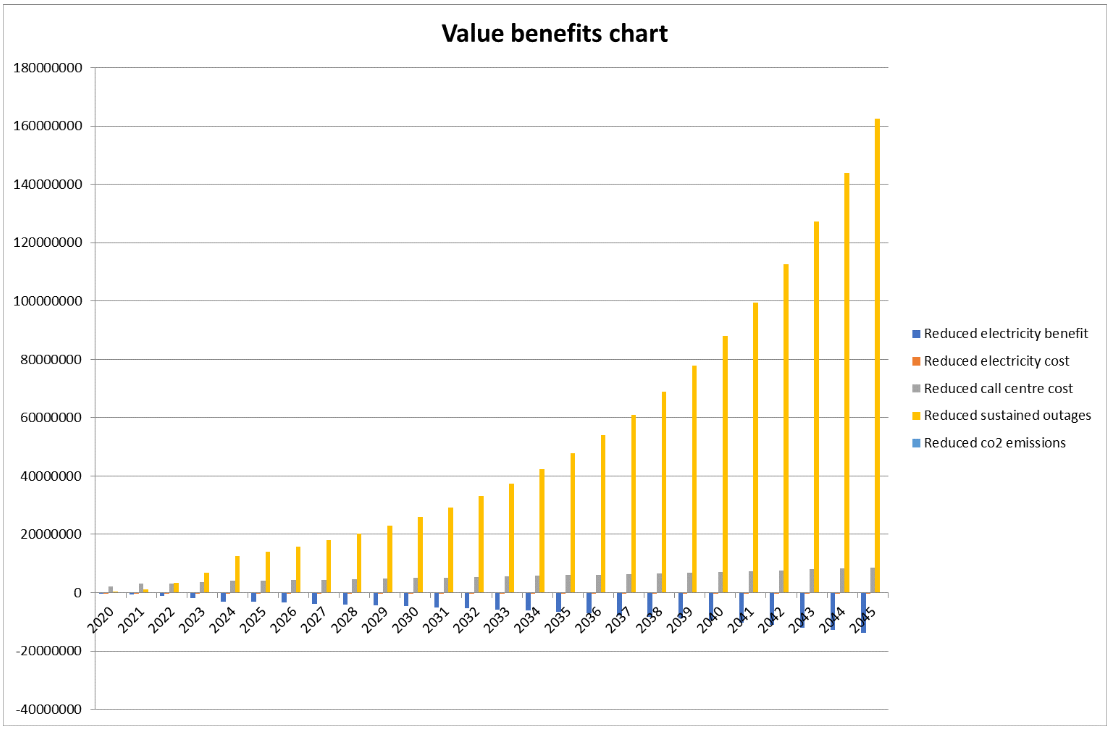
BENEFITS AND COSTS VALUES

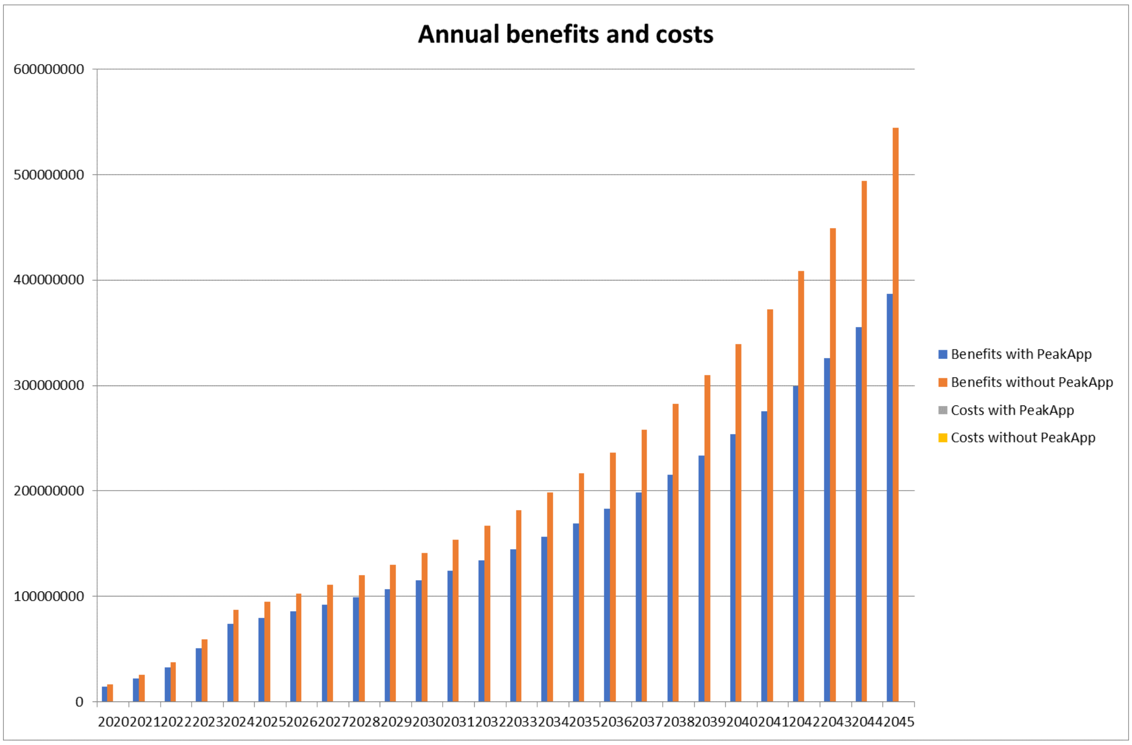
Scenario without PeakApp

Years	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reduced elect	6000000	8400000	16800000	28800000	45000000	48391605	52038832	55960946,8	60178667,4	64714273,4	69591723,6
Reduced elect	700	1200	1800	2500	3300	3422,1	3548,7177	3680,02026	3816,18101	3957,37971	4103,80276
Reduced call c	10000000	15000000	15000000	18000000	20000000	20740000	21507380	22303153,1	23128369,8	23984119,5	24871531,9
Reduced susta	500000	2250000	6000000	12500000	22500000	25430931,8	28743657,4	32487910,7	36719904	41503172,1	46909526,2
Reduced CO2	500	1100	1800	2600	3500	3629,5	3763,7915	3903,05179	4047,46471	4197,22091	4352,51808
Total Benefits	16501200	25652300	37803600	59305100	87506800	94569588,4	102297182	110759594	120034805	130209720	141381238
IT	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Network	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Transfer costs	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Call centre	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Total Costs	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000
Balance	16446200	25597300	37748600	59250100	87451800	94514588,4	102242182	110704594	119979805	130154720	141326238

Scenario with PeakApp

Years	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reduced elect	6400000	8960000	17920000	30720000	48000000	51617712	55508087,4	59691676,5	64190578,6	69028558,3	74231171,8
Reduced elect	1750	3000	4500	6250	8250	8555,25	8871,79426	9200,05065	9540,45253	9893,44928	10259,5069
Reduced call c	8000000	12000000	12000000	14400000	16000000	16592000	17205904	17842522,5	18502695,8	19187295,6	19897225,5
Reduced susta	224000	1008000	2688000	5600000	10080000	11393057,4	12877158,5	14554584	16450517	18593421,1	21015467,7
Reduced CO2	320	704	1152	1664	2240	2322,88	2408,82656	2497,95315	2590,37741	2686,22138	2785,61157





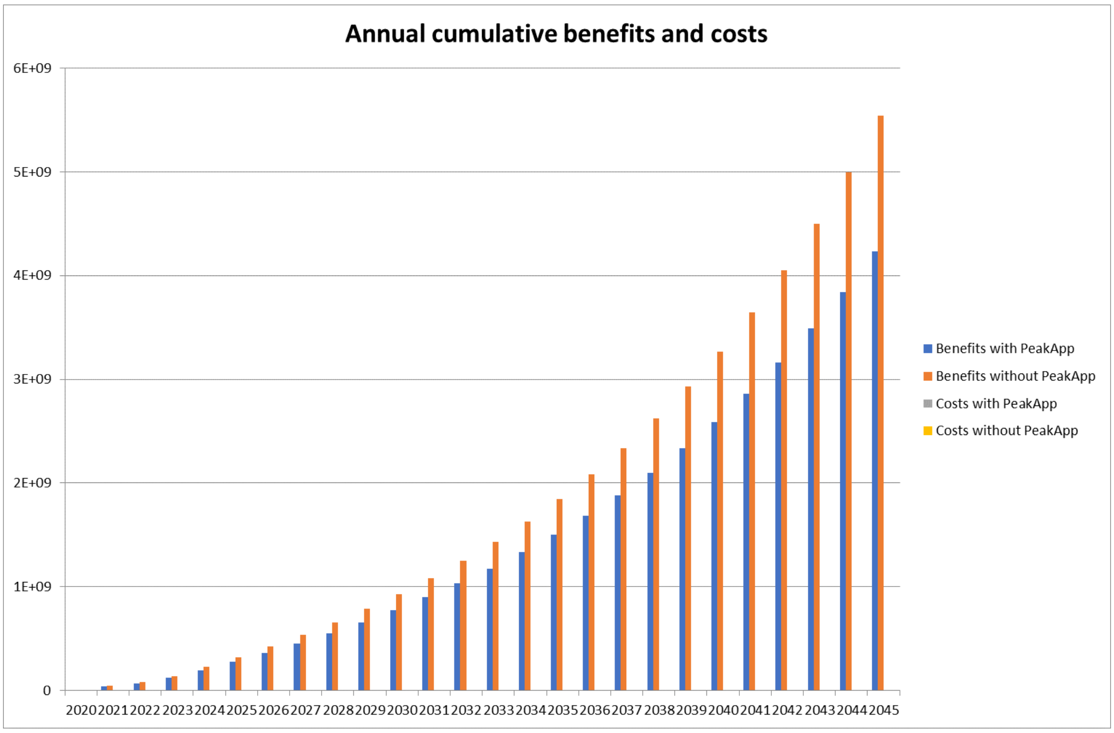


Figure 13 – Standard analysis: Values screen

- **Net Present Value (NPV)**: A table and a chart summarising the benefits and costs in present value terms from annual and cumulative perspectives.

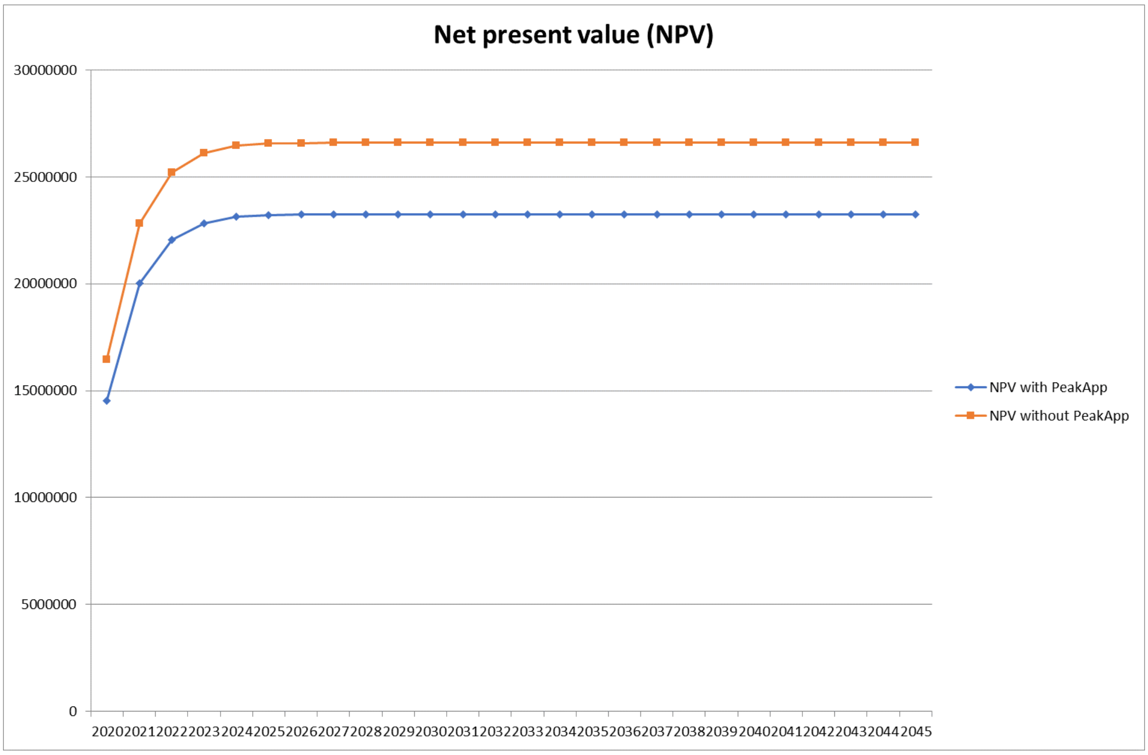


Figure 14 – Standard analysis: NPV screen

As explained in Section 4.10, the tool will also provide the option of performing a sensitive analysis (called ***Sensitive Analysis***) using the high and low sensitives rates associated to the different inputs (Guideline 9).

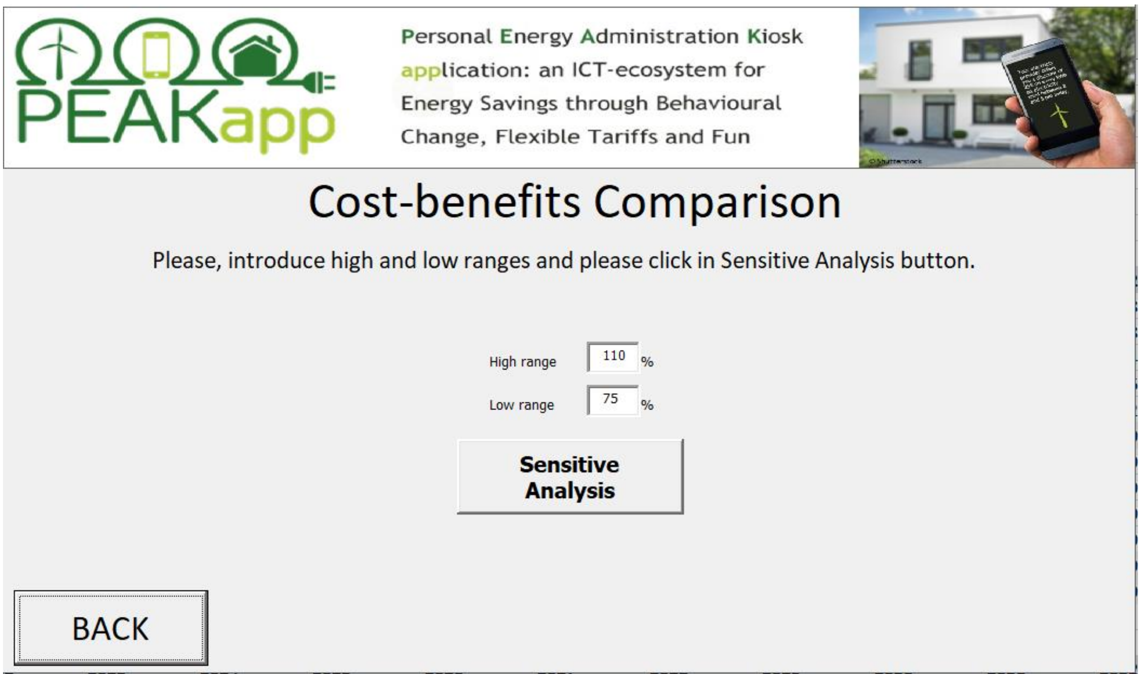


Figure 15 – Sensitive analysis: sensitive rates screen

The final results are presented as:

- **Sensitive charts**: A set of charts comparing the total annual and cumulative gross benefits from standard results with the high and low ranges over the analysis period.

Go back Roll-out Toolkit

BENEFITS VALUES

Low range

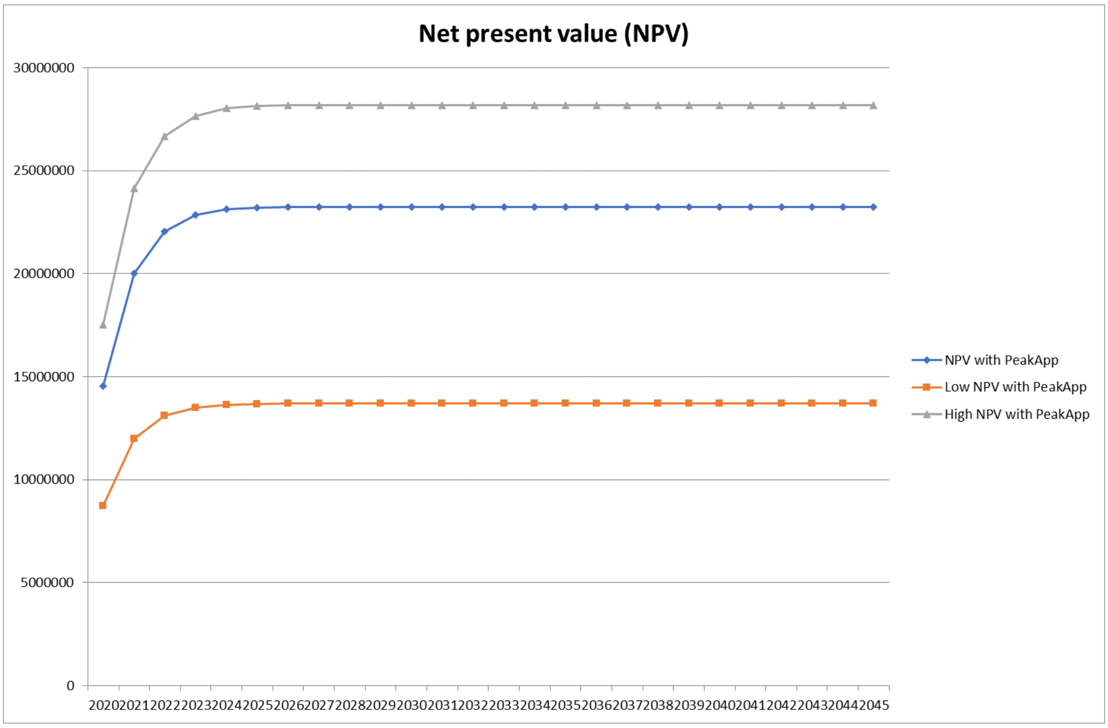
Years	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Reduced electricity theft	2700000	3780000	7560000	12960000	20250000	21776222,3	23417474,4	25182426	27080400,3	29121423,1	31316275,6
Reduced electricity cost	984,375	1687,5	2531,25	3515,625	4640,625	4812,32813	4990,38427	5175,02849	5366,50455	5565,06522	5770,97263
Reduced call centre cost	6000000	9000000	9000000	10800000	12000000	12444000	12904428	13381891,9	13877021,9	14390471,7	14922919,1
Reduced sustained Outages	94500	425250	1134000	2362500	4252500	4806446,11	5432551,25	6140215,12	6940061,85	7844099,53	8865900,45
Reduced CO2 Emissions	180	396	648	936	1260	1306,62	1354,96494	1405,09864	1457,0873	1510,99953	1566,90651
Total Benefits	8795664,38	13207333,5	17697179,3	26126951,6	36508400,6	39032787,3	41760799	44711113,1	47904307,6	51363070,3	55112433,1

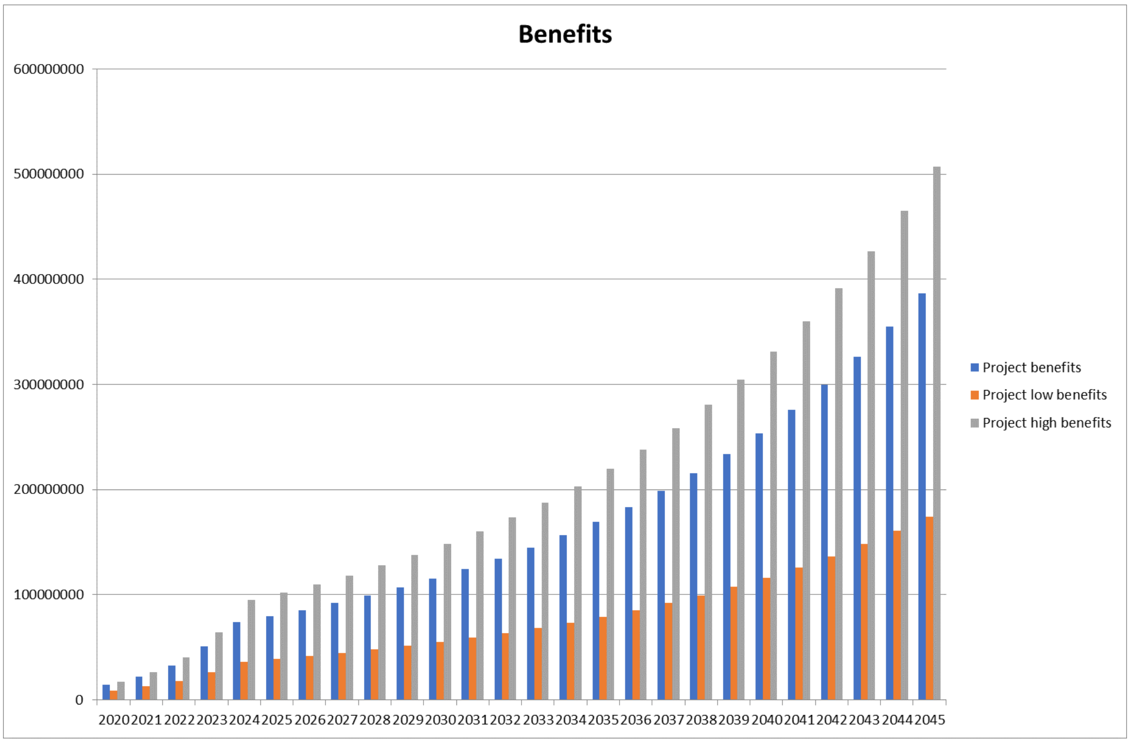
Project with PeakApp

Years	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Reduced electricity theft	6400000	8960000	17920000	30720000	48000000	51617712	55508087,4	59691676,5	64190578,6	69028558,3	74231171,8
Reduced electricity cost	1750	3000	4500	6250	8250	8555,25	8871,79426	9200,05065	9540,45253	9893,44928	10259,5069
Reduced call centre cost	8000000	12000000	12000000	14400000	16000000	16592000	17205904	17842522,5	18502695,8	19187295,6	19897225,5
Reduced sustained Outages	224000	1008000	2688000	5600000	10080000	11393057,4	12877158,5	14554584	16450517	18593421,1	21015467,7
Reduced CO2 Emissions	320	704	1152	1664	2240	2322,88	2408,82656	2497,95315	2590,37741	2686,22138	2785,61157
Total Benefits	14626070	21971704	32613652	50727914	74090490	79613647,6	85602430,6	92100481	99155922,2	106821855	115156910

High range

Years	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Reduced electricity theft	8518400	11925760	23851520	40888320	63888000	68703174,7	73881264,4	79449621,5	85437660,1	91877011,2	98801689,7





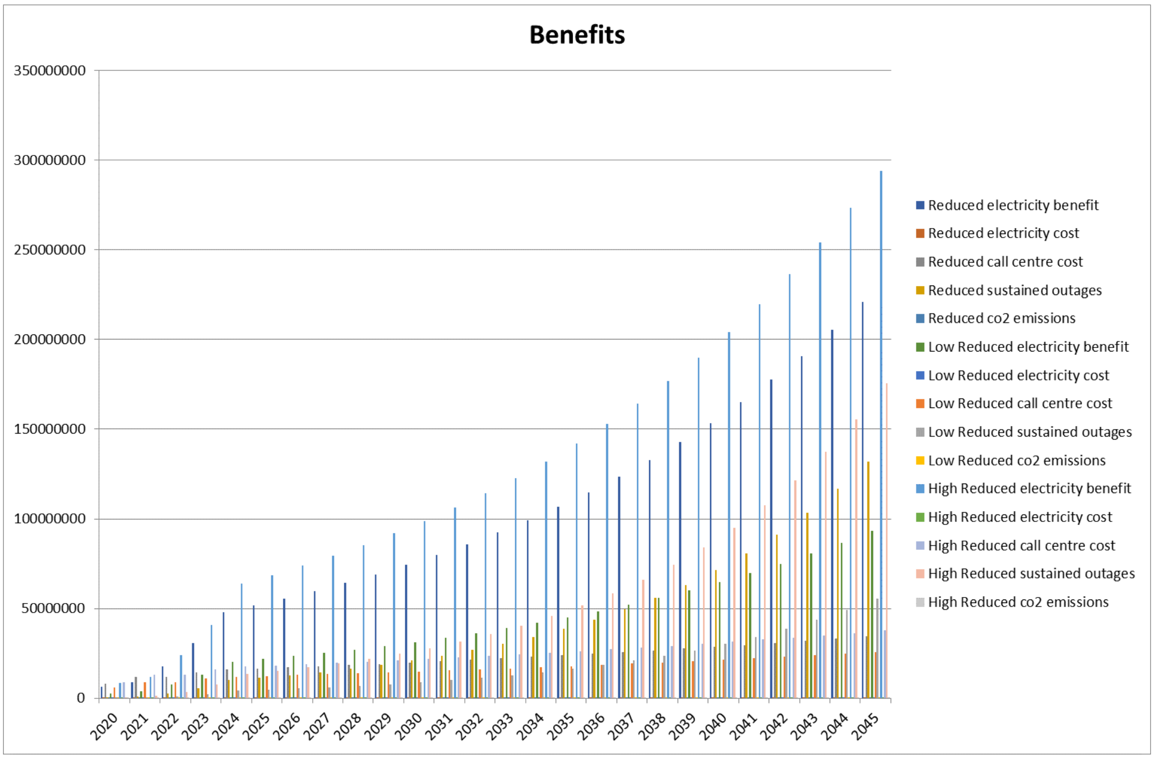


Figure 16 – Sensitive analysis: sensitive charts screen

6 Conclusions

This deliverable provides a detail description of the methodology followed to define the roll-out planning toolkit in order to support decision makers within electricity retailing companies for analysing and understanding the roll-out terms for the deployment of the PEAKapp solution.

The methodology is based on the Reference Report on "Guidelines for conducting cost-benefit analysis of Smart Grid projects", which provides a detailed step by step Cost-benefit Assessment (CBA) framework, which has been adapted to the PEAKapp project requirements.

Based on that methodology, we have implemented a roll-out digital tool which provides a set of charts and tables summarizing the CBA analysis performed. Besides, the tool aims to guide the user in the data collection process to tailor each analysis to the characteristics of each utility and deployment project.

The tool can be used in two ways:

3. To justify a future PEAKapp investment.
4. To compare benefits and costs with real-word data after the deployment of PEAKapp during some years while having a deeper understanding of the value of using PEAKapp.

7 References

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