A methodology for ranking of customer segments by their suitability for Distributed Energy Resources applications

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Abstract

A massive implementation of Distributed Energy Resources (DER) requires the development of innovative approaches to identify, based on the energy market requirements, fast-track options for such implementation. These approaches should assess the potential for DER of the different customer segments and simulate DER adoption for those with highest potential, in order to evaluate accurately the impact of this implementation on the different energy actors. This paper introduces a methodology to asses the DER implementation potential of customer segments, based on a multicriteria analysis, considering DER as including Distributed Generation (DG), Distributed Storage (DS) and Local Trading Strategies[1] (LTS). Application of the methodology to commercial sector for DG installation, considering different motivations (cogeneration, renewable, emergency generator and peaking power) and the obtained results for five different segments in this sector are presented.

Keywords

Distributed energy resources, distributed generation, demand segmentation, segment ranking.

1. Introduction

The benefits of DER implementation [1] include reduction in greenhouse gas emissions and improvements in the reliability of the whole power system, by countering existing distribution constraints, deferring distribution upgrades and reducing the need for additional transmission capacity.

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1 *Local Trading Strategies (LTS) are defined as trading mechanisms for an optimized management of customer energy consumption and/or production through the interaction with the supply mechanisms and markets in which end-users play an active role.*

All these benefits justify the on going research efforts to find innovative approaches, based on energy market requirements, to facilitate the large scale penetration of DER in Europe [2]. In these approaches, once the demand segmentation [3], according to energy end use criteria, has been completed, a ranking of the typical customer in each segment will be needed in order to select the most suitable ones for DER implementation. Final decision on the segment to select as fast track option will be based on additional studies: physically-based modelling of the involved energy processes, estimated market size for the segments and its impact on the different energy actors: customer, distributors, regulators, generators, etc.
In this paper, we are presenting a methodology to rank those customer segments by analyzing its suitability for DER implementation. This ranking implies to consider the suitability for DG (distributed generation), DS (distributed storage) or LTS (local trading strategies). The methodology here described is only focused on assessing DG implementation potential according to main customer motivations (cogeneration, renewable, emergency generator and peaking power), but it can be directly extrapolated to the other two categories: DS and LTS.
Paper is organized as follows: the developed methodology for segment ranking is described in detail in section 2; examples of its application to the commercial sector are presented in section 3, and main conclusions are presented in a final section.

2. Methodology

The developed customer segment ranking methodology is based on the general approach depicted at the scheme of the figure 1. It is based on the consideration of a set of factors needed to account for all the features that are relevant for DER implementation. These factors are quantified through a variable that evaluates the corresponding factor for the segment under consideration. A relationship, either analytical or numerical, should be defined to relate the variable with the potential for each of the factors. Once these assignments have been completed for all the factors, a DER suitability function $\boldsymbol{A_k}$ can be introduced. This function should provide a normalised value in the range (0,1), where higher value indicates higher suitability. The deduced values for $\boldsymbol{A_k}$ are used to rank the segments. This function $\boldsymbol{A_k}$ is computed as the weighted average of the segment potential for each of the considered factors:

$$A_k = \sum_f \delta_f \cdot a_{k,f} \qquad \textbf{(1)}$$

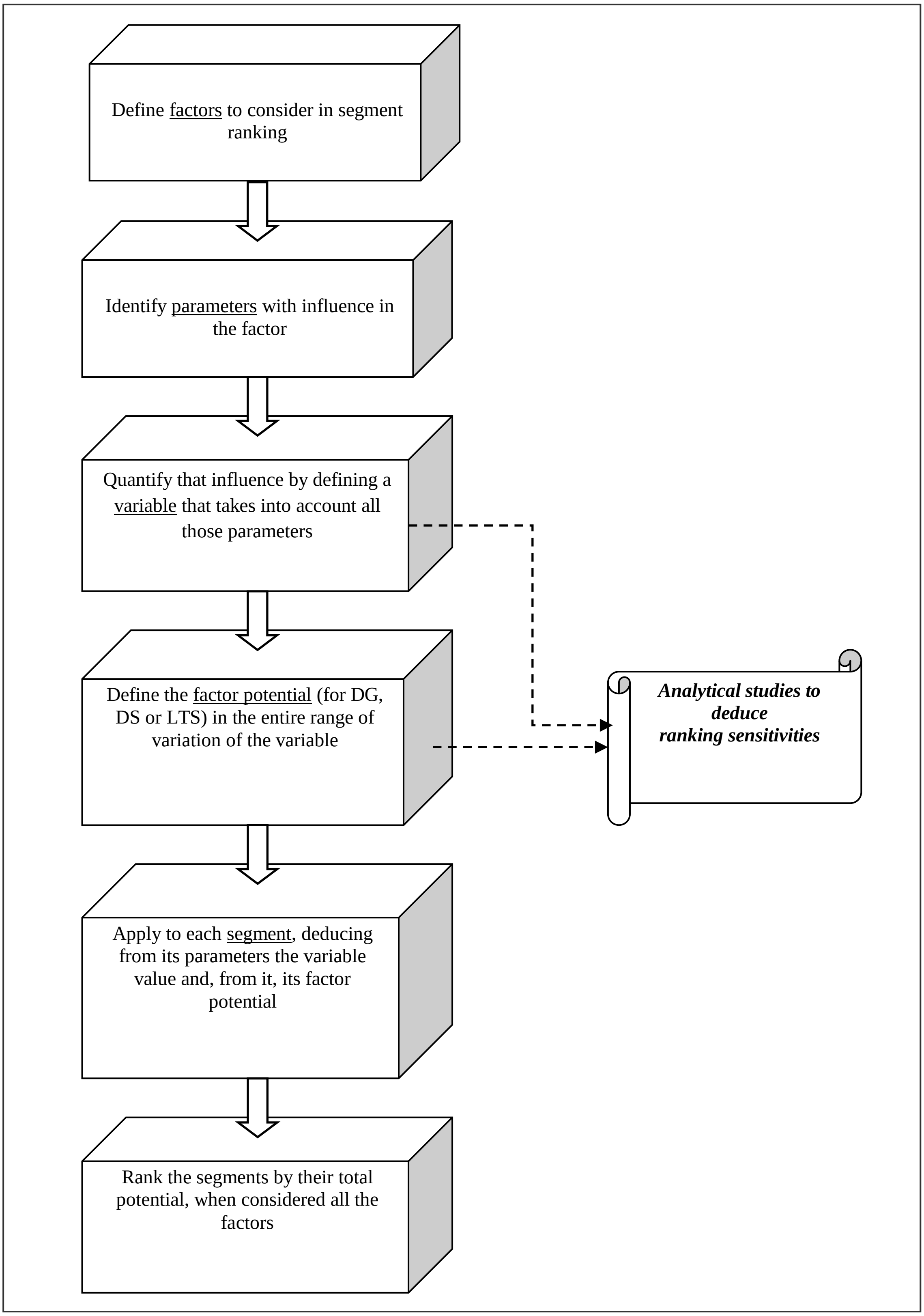

Figure 1: General approach for DER suitability ranking of demand segments

Where $\boldsymbol{f}$ indicates each factor to be taken into account, $\boldsymbol{a_{k,f}}$ is the potential (always in the range 0 to 1) of this segment in relation to this particular factor and $\boldsymbol{\delta_f}$ is the factor weight assigned in the scenario considered for the ranking procedure.

To evaluate $\boldsymbol{a_{k,f}}$ a two steps process is necessary. The first step addresses the scenario definition and the second one corresponds to the analysis, using that scenario, of each of the segments under consideration.

1.1 Scenario definition

The first step to evaluate $\boldsymbol{a_{k,f}}$ is the definition of the scenario to consider for DER implementation. This process is common <u>for all the segments</u> and made only once at the beginning of the process. It includes the following actions:

a) Selection of the factors to be taken into account in the evaluation of the DER suitability of the segments.

b) Introduction of a variable $\boldsymbol{v_f}$ to quantify, after an analysis of all the elements affecting the factor, the factor importance for a segment. This variable could be directly one of the parameters obtained from the data of a specific parameter describing the segment or deduced from elaboration of one or several of those parameters.

c) Definition of the factor potential $\boldsymbol{a_f(v_f)}$, normalized to the range [0,1] for the entire range of variation of the chosen variable, either by an analytical dependence or an approximate histogram. This definition should be based on previous knowledge or studies regarding DER applications.

d) Assignment of weights $\boldsymbol{\delta_f}$ to each factor in the ranking procedure. These weights take into account the importance of the factor in relation to the specific DER under consideration and should be normalised in order to facilitate that the final value obtained for the function $\boldsymbol{A}$ will be a direct indication of the DER suitability percentage,

1.2 Segment analysis

The second step is the segment analysis, <u>specific for each segment</u> and applied as many times as segments considered in the ranking, includes the following actions:

e) Calculation, using definition introduced at (b) and the basic data of the segment, of the value of the variable for the segment $\boldsymbol{k}$: $\boldsymbol{v_{k,f}}$

f) Using this value of the variable, the corresponding value for $\boldsymbol{a_{k,f}}$ is deduced from the factor potential defined at (c)

g) Calculation of the DER suitability $\boldsymbol{A_k}$ of the segment by the addition of all the obtained potentials, weighted in accordance with the considered scenario.

h) Ordering of the segments based on their final $\boldsymbol{A_k}$ values.

Next paragraphs clarify this methodology by applying it to a specific case of DER implementation, which is DG: Distributed Generation. The process would be essentially the same for the other two cases of DER: DS and LTS.

3. Application to DG ranking

3.1 Factors for DG ranking

The first step in any application of the proposed ranking methodology is the selection of the factors to be taken into account in this ranking. These factors are selected based on a set of considerations related to energy consumption and technological aspects [4][5]. The most significant ones are:

1. Use of electricity along low system load periods is more convenient than using it when the system is heavily loaded. This may result in economic and environmental benefits. Obviously, the corresponding utilization factor has opposite importance for DG and DS.
2. The more intensive the use of electricity by the customer, the best to implement DG.
3. Uniformity in the use of the energy favours a higher utilization of any DG.
4. Simultaneous requirements of electrical and thermal energy, especially if these requirements are coincident along the time, are also a positive fact for DG.
5. Flexibility in the use of the energy is a key factor in the implementation of DG solutions.
6. Reliability requirements in the supply, as well as the connection possibilities to the electricity and gas grids, may be strong issues when deploying DG.
7. When implementing any equipment for DG, its utilization, in term of hours/year has to be significant (no lower than 2000, being 4000 a desirable target).
8. According to the present technological availability for cogeneration, the higher is the rated power of the installed unit, the higher is its efficiency and the lower is its specific costs ($/kW).

Table 1: Factors to consider in DG ranking

Factor	***Variable***	***Factor potential***
Power size	$P_{avg} = \frac{\text{Annual electricity consumption(kWh)}}{\text{8760h/year}}$	$Adg, ps = 0.13 \cdot Ln(P_{avg})$
Utilization	t_{OP} (hours) per year	$Adg, u = 1 - \exp[(t_{op}/4000)^2]$
Thermal demand regularity	$Reg_{TH} = \min(TH_S, TH_W)/\max(TH_S, TH_W)$	$Adg, regth = 0,5 \cdot (1 + Reg_{TH}{}^2)$
Electric to thermal demand ratio	$R = \int_0^{24} P_E(t)dt / \int_0^{24} P_{TH}(t)dt$	$Adg, r = 3 \cdot \exp\left(-\frac{R}{2}\right) \cdot \left(1.28 - \exp\left(-\frac{(R-0.5)}{2}\right)\right)$
Thermal demand coincidence	$ETC = \left[1 + \frac{\sum_{i=1}^{96}\left(P_E(i) - \overline{P_E}\right)\left(P_{TH}(i) - \overline{P_{TH}}\right)}{\sqrt{\left[\sum_{i=1}^{96}\left(P_E(i) - 0.85 \cdot \overline{P_E}\right)^2\right]\left[\sum_{i=1}^{96}\left(P_{TH}(i) - 0.85 \cdot \overline{P_{TH}}\right)^2\right]}}\right] \times \frac{1}{2}$	$Adg, coinc = ETC$
Load factor	$LF = \frac{1}{365}\sum_{i=1}^{365}\frac{P_{avg_i}}{P_{peak_i}}$	$Adg, lf = 1.5 \cdot LF - 0.5 \cdot LF^2$
Day/night use	$E_{day} = \int_8^{21} P_{Esup}(t)dt / \int_0^{24} P_{Esup}(t)dt$	$Adg, peak = 1.5 \cdot E_{day} - 0.5 \cdot E_{day}{}^2$
Power quality	$S_{PQ} = \frac{\sum_{i=1}^{6} q_i}{6}$	$Adg, q = 1 - \exp\left(-\frac{S_{PQ}}{50}\right)^2$
Power Reliability	$P_R = P_{backup}/P_{avg}$	$Adg, rel = 1 - \exp\left(-\frac{P_R}{30}\right)$
Renewable energy	$P_{RW} = P_{Generation, RW} / P_{avg}$	$Adg, rw = RW$

Table 1 summarises the selected factors for the DG ranking of segments in the commercial sector, together with the variables used to defined them and the their potential as function of the variable values. All of them are detailed in the next paragraphs.

3.2 Variables and DG potentials definition

Next step in the methodology application would be the definition, for each of the selected factors, of the corresponding variable and the dependence on that variable value of the segment potential. This is done for factors at Table 1, by defining for each of them the variable to use and its DG potential dependence. This potential dependence is introduced, based on the available studies and expertise at the utilities and research centres [3], by histograms for $a_{k,f}$ in the entire range of variation of that variable. Analytical expressions are deduced from these histograms to facilitate the ranking studies.

3.2.1 Power size (Adg,ps)

The real size of an installation is an important feature to be taken into account, so we will use $\mathbf{P_{avg}}$, average electrical power based on the annual electricity consumption, as the representative variable for this factor.

$$P_{avg} = \frac{\text{Annual electricity consumption(kWh)}}{\text{8760h/year}} \quad (2)$$

High average power reduces DG installation costs per kW and provides higher efficiency [6][7]. This relation doesn't show a lineal tendency, because for higher power values (1- 10 MW), efficiency and costs remain almost invariable, but for low power values (i.e. < 300 kW) the size can be very important when assigning technical and economic suitability. These kinds of facts justify the dependence for the factor potential for DG shown at histogram in figure 2.1. We can approach analytically this dependence in the range 1 to 1500 kW by:

$$Adg,ps = 0.13 \cdot Ln(P_{avg}) \quad (3)$$

3.2.2 Utilization (Adg,u)

This factor takes into account the annual number of hours of normal activity when main energy consuming processes take place, and will assign higher suitability to higher operating times.

Variable: $\mathbf{t_{OP}}$, operating time, defined as the total number of hours in which the power is higher than a minimum value P_1, where we have used P_1 defined as 0.75 the average power defined by eq. 2.

Most of the cogeneration applications [7] in the commercial and institutional sectors meet the criteria of moderate to high operation times (~ 3000 hours per year), so these values are considered as indicative of a moderate potential. Operation times above 4000 hours per year correspond to high potential and those with use periods in the order of 6000 hours per year, typical for industrial customer or large hospitals, maximum potential will be assigned. Less than 2000 hours of operation, what is not common for the commercial sector, is considered low potential. This potential dependence on utilisation time is plotted at figure 2.2, together with the analytical adjustment, given by:

$$Adg,u = 1 - \exp[(t_{op}/4000)^2] \quad (4)$$

3.2.3 Thermal demand regularity (Adg,regth)

This factor provides an indication of seasonality of the thermal demand during year by comparing winter and summer periods consumptions.

Variable: $\mathbf{Reg_{TH}}$, to characterize the ratio between thermal demand during high demand and low demand periods. As space cooling is also considered as a thermal load, higher thermal demand could be found in summer instead of winter (which is the most usual case), in order to cover this possibility the following definition has been considered:

$$\mathrm{Reg_{TH}} = \frac{\min(\mathrm{TH_S}, \mathrm{TH_W})}{\max(\mathrm{TH_S}, \mathrm{TH_W})} \tag{5}$$

Where TH_S is the total thermal demand from April to September and TH_W, the corresponding one from October to March, $\max(TH_S, TH_W)$ is the period of maximum thermal demand and $\min(TH_S, TH_W)$ the period of minimum demand.

High thermal demand regularity, so very high potential, can be considered for Reg_{TH} values above 0.75 what means thermal demand almost constant for the whole year. Values between 0.5 – 0.75 indicate a moderate difference between high/low thermal demand periods, but without severe partial load operation needs for a hypothetic cogeneration unit, so corresponding potential is high. Values below 0.5 indicate high differences between high demand and low demand period meaning shorter annual operating time for the cogeneration unit, severe partial load operation or smaller size, all these facts are not positive so it was considered medium potential.

These considerations result on histogram of figure 2.3, together with the analytical approach, given by:

$$\mathrm{Adg,regth} = 0{,}5 \cdot (1 + \mathrm{Reg_{TH}}^2) \tag{6}$$

3.2.4 Electric to thermal demand ratio (Adg, r)

Variable: **R**, the ratio between electric and thermal power computed using the average electrical and thermal daily load curves, given by:

$$R = \frac{\int_0^{24} P_E(t)dt}{\int_0^{24} P_{TH}(t)dt} \tag{7}$$

This factor will indicate how much the ratio between electric demand and thermal demand of the segment fits with common cogeneration technologies (internal combustion engines, microturbines or fuel cells), normally with values of this ratio from 0.5 to 2.5 so we assign maximum potential. High power-to-heat ratio (above 2.5) indicates low thermal demand so lower potential for cogeneration applications. Low ratios (below 0.5) indicate high thermal demand so the CHP system would be bigger and it would be necessary to sell electricity to the grid so it was considered high potential but not as high as that of ratio from 0.5 to 2.5. We can approach analytically this dependence (figure 2.4) by:

$$Adg,r = 3 \cdot \exp\left(-\frac{R}{2}\right) \cdot \left(1.28 - \exp\left(-\frac{(R-0.5)}{2}\right)\right) \quad (8)$$

3.2.5 Thermal demand coincidence (Adg,coinc)

Variable: **ETC**, computed using the average electrical and thermal daily load curves as defined in the following equation:

$$ETC = \frac{1}{2} \cdot \left[1 + \frac{\sum_{i=1}^{96} \left(P_E(i) - \overline{P_E}\right)\left(P_{TH}(i) - \overline{P_{TH}}\right)}{\sqrt{\left[\sum_{i=1}^{96} \left(P_E(i) - 0.85 \cdot \overline{P_E}\right)^2\right]\left[\sum_{i=1}^{96} \left(P_{TH}(i) - 0.85 \cdot \overline{P_{TH}}\right)^2\right]}} \right] \quad (9)$$

Where P_E and P_{TH} are the average electrical and thermal daily load curves using fifteen minutes as time resolution, so 96 values per day.

This factor will deal with the temporal coincidence and shape similarity between thermal and electrical loads indicating the feasibility of using the waste heat produced by the generation unit. High coincident electric and thermal loads increase the overall efficiency and operating time of the system and allow the installation of higher powers. We can assume a linear dependence, as higher the coincidence, better the possibility to use cogeneration so higher the potential (figure 2.5):

$$Adg,coinc = ETC \quad (10)$$

3.2.6 Load Factor (Adg,lf)

Variable: **LF**, defined as the average annual value of daily load factors of electricity supply, these factors are computed as the ratio of average power (P_{avg}) to maximum power (P_{peak}) for each day:

$$LF = \frac{1}{365}\sum_{i=1}^{365}\frac{P_{avg_i}}{P_{peak_i}} \quad (11)$$

High load factor indicates the capability to cover almost full load when installing a generation system and lower ones corresponds to the need for additional capacity to handle very high peak loads. Load factors above 0.8 are typical for large hospitals and industrial customers where it can be found lots of examples of DG installations, so potential for these range can be considered maximum. Medium/low values of load factors, in the range 0.4 – 0.6, corresponds to medium potential, while load factors are in the range 0.6 – 0.8 can be considered as high potential. Load factor below 0.4 are not common in the commercial sector and are considered as low potential. We can approach analytically this dependence (figure 2.6) by:

$$Adg, lf = 1.5 \cdot LF - 0.5 \cdot LF^2 \quad (12)$$

<u>3.2.7 Day/night use</u> (Adg,peak)

Variable**:** $\mathbf{E_{day}}$, ratio between electricity consumption during on-peak period (8:00 to 21:00) and total electricity consumption:

$$E_{day} = \frac{\int_{8}^{21} P_{Esup}(t)dt}{\int_{0}^{24} P_{Esup}(t)dt} \quad (13)$$

Where $P_{Esup}(t)$, is the annual load curve in hourly values.

Typically, commercial customers have between 60 and 80% of their electricity consumption in the on-peak period, so it can be considered that electricity is expensive, and this is a motivation for DG implementation so high potential is assigned. When the percentage of electricity was more than 80% maximum potential was considered. Percentages in the range 40 to 60% were considered as medium potential. Values lower than 40% are not common in the commercial sector and indicate low potential for DG implementation

The assumed potential dependence on this peak consumption is plotted at figure 2.7. We can approach analytically this dependence by

$$Adg, peak = 1.5 \cdot E_{day} - 0.5 \cdot E_{day}{}^2 \quad (14)$$

3.2.8 Power quality (Adg,q)

This factor indicates the consumer power quality requirements based on its sensitivity to each of the following six power quality events: Voltage Sags, Voltage Swells, Voltage Surges, Harmonic Distortion, Unbalanced Voltage and Voltage Flickers. Higher sensitivity to any of these events can justify totally or partially the installation of a generation unit for high quality backup supply [8].

Variable: $\mathbf{S_{PQ}}$, Sensitivity to power quality events computed as the average percentage of customers in the segment that indicated they had sensitivity to any of the above-mentioned six events. These percentages (q_i) are obtained from surveys performed to the customers of each segment.

$$S_{PQ} = \frac{\sum_{i=1}^{6} q_i}{6} \qquad (15)$$

When more than 30% of the customers of the segment are sensitive to power quality events, high potential is assigned to the segment. For lower percentage the potential decreases linearly down to a lower limit of 0.2 for the less sensitive segments. These considerations result on histogram 8 of figure 2.8. Analytical approach to the potential is given by:

$$Adg,q = 1 - \exp\left(-\frac{S_{PQ}}{50}\right)^2 \qquad (16)$$

3.2.9 Power Reliability (Adg,rel)

This factor indicates the sensitivity of the typical customer in the segment to loss of power. It should quantify the needs for implementation of generation systems for emergency power in the segment. It can be deduced the ratio of installed backup power to average electric power (which provides an estimation of the percentage of load with high reliability needs respect to the total load) [9].

Variable: $\mathbf{P_R}$,, ratio installed backup power (P_{backup}) to average electric power (P_{avg}).

$$P_R = \frac{P_{backup}}{P_{avg}} \qquad (17)$$

The values of potential were assigned looking at ratio (P_R) typical values observed in the commercial sector. Values of $P_R > 0.3$ are typical for hotels, offices and hospitals, where reliability needs are high because interruptions can cause strong loss of comfort, high costs or human losses. So, maximum potential was assigned to values exceeding this ratio. For $P_R<0,1$ it can be considered that, approximately, less than the 10% of electricity consumed should be of high reliability, so emergency power is small and reliability cannot be considered as a main motivation, giving very low potential to segments with ratios below this limit. Between the two limits ($0.1<P_R<0.3$) a lineal dependence is assumed. These considerations result on figure 2.9. The potential can be approximate by:

$$Adg,rel = 1 - \exp\left(-\frac{P_R}{30}\right) \tag{18}$$

3.2.10 Renewable energy (Adg,rw)

This factor deals with the technical, economical and regulatory motivations that can justify the installation of renewable generation technologies in a segment. It takes into account the potential renewable power that can be installed and compares it with the objectives of official policies in the promotion of the participation of renewable energies in the electricity generation.

Variable: $\mathbf{P_{RW}}$, the power from renewable sources under operation or potentially installable, normalised to the average power needs of the segment.

$$P_{RW} = \frac{P_{Generation,RW}}{P_{avg}} \tag{19}$$

Where $P_{Generation,RW}$ is the renewable power assigned to the segment based on present innovative applications, regulations, technical issues and estimations from sectorial studies.

The potential values are deduced using the EU goal of the fraction of renewable energies, aprox. 20%, in the total electricity production by 2010 [10].

We can approach analytically the potential dependence (figure 2.10) by:

$$Adg,rw = P_{RW} \tag{20}$$

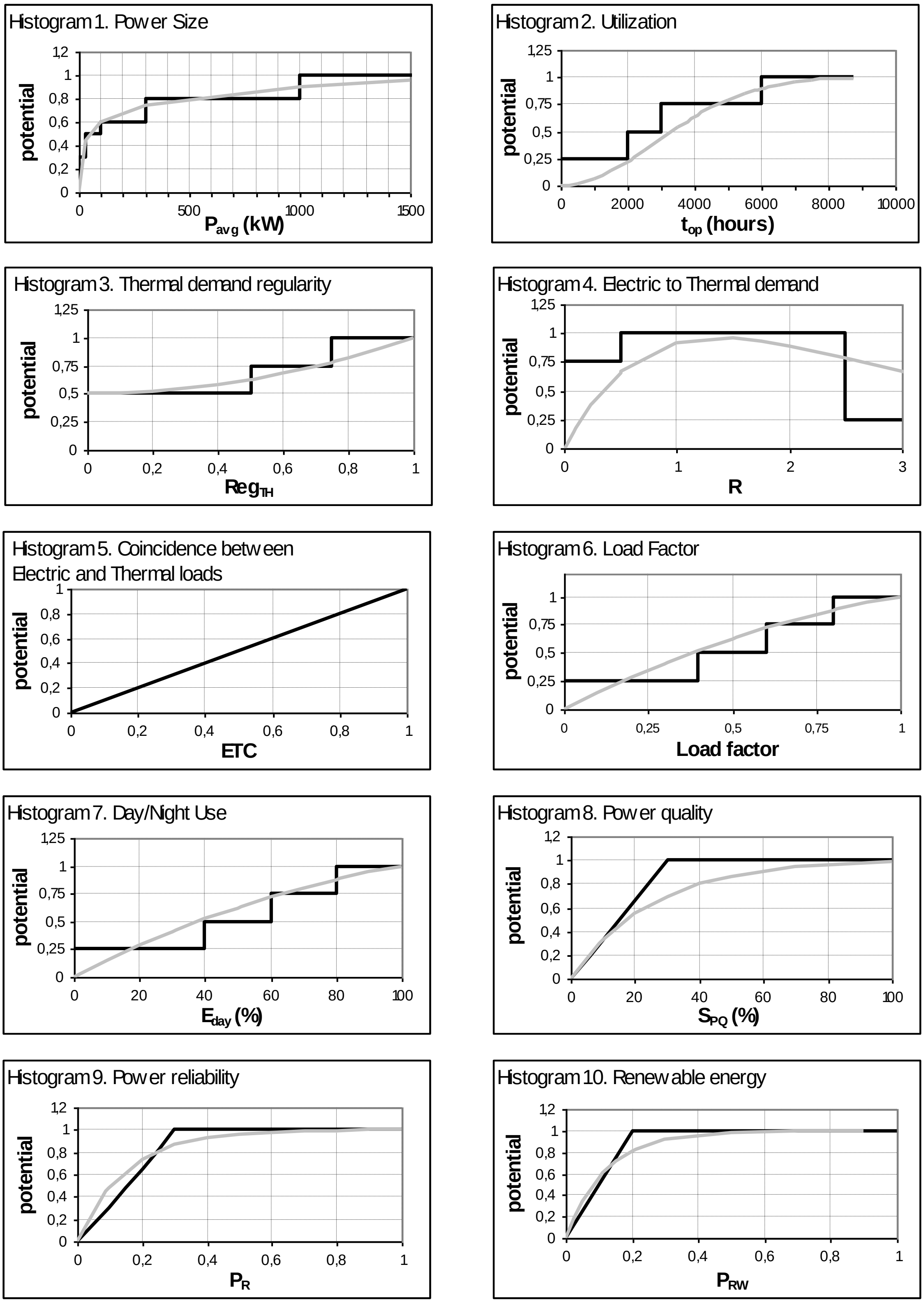

Figure 2: Potential dependence for factors in DG implementation analysis.

(The histogram is presented in black and, in grey, it has been included the analytical fitting)

3.3 Weights

Factor weights are defined by the specific scenario assumed for the ranking application. A possible scenario to consider is that one where higher efficiency by mean of cogeneration is the main motivation for the DG implementation. In this case, a weight distribution as the presented in Table 2 is the adequate. The factor related to the size of the installable system has the highest weight given higher size of equipment, always below the limits of DER systems in the order of several MWs, implies lower specific cost and, usually, higher efficiency). Factors related to thermal demand, (coincidence with and ratio to the electric demand) of the segment are also important in this scenario and they are assigned high potentials. Utilization and regularity factors are also important due to the need to optimise economically the use of the installed unit. All the remaining factors have less influence in the determination of the suitability of the segment for DG implementation in this scenario, so medium or low weights are assigned to them..

Table 2 Weights for the factors considered in the DG ranking

Factor	*Importance*	*Weight*
Power size	Very High	1
Utilization	High	0.5
Electric to thermal demand	High	0.5
Thermal demand coincidence	High	0.5
Load factor	Low	0.1
Day/night use	Medium	0.25
Power reliability	High	0.5
Power quality	Medium	0.25
Thermal demand regularity	High	0.5
Renewable Energy	Medium	0.25

3.4 Results

As an example of the application of this methodology, a set of different segments covering very different types in the commercial sector has been considered, and the developed methodology was applied to all of them trying to rank them in accordance with its degree of suitability for DG implementation in the above mentioned scenario. This set of segments includes:

a. Large Hospitals in Northern Europe

b. Standard Hotels in Northern Europe

c. Big Offices in Northern Europe

d. Small Offices in Southern Europe

Table 3: Values of variables and potential for each factor considered in the DG ranking

	Large Hospitals Northern Europe		**Standard Hotels Northern Europe**		**Big Offices Northern Europe**		**Small Offices Southern Europe**	
Factor	**Variable**	**Potential**	**Variable**	**Potential**	**Variable**	**Potential**	**Variable**	**Potential**
Thermal demand coincidence	0,87	0,87	0,95	0,95	0,84	0,84	0,58	0,58
Day/night use (%)	64	0,75	58	0,50	67	0,75	77	0,75
Electric to Thermal Demand	0,88	1,00	0,24	0,65	0,03	0,65	0,40	0,65
Load Factor	0,74	0,75	0,79	0,75	0,75	0,75	0,55	0,50
Power Quality	0,00	0,50	0,00	0,50	0,50	1,00	0,50	1,00
Power Reliability	2,5	1,00	3,7	1,00	1,2	1,00	0,00	0,50
Power Size	1250	1,00	82	0,50	63	0,50	9,9	0,30
Renewable energy	0,90	0,90	0,70	0,70	0,50	0,50	0,60	0,60
Thermal Demand Regularity	0,43	0,50	0,41	0,50	0,22	0,50	0,09	0,50
Utilization	6600	1,00	8100	1,00	4700	0,75	3650	0,75

Using the standard values for the characteristics of the typical customer in each of these segments [3], we deduce the values of variables and factor potentials summarised at Table 3. Considering the weights defined at Table 2, the final ranking parameter is deduced for each segment, resulting the ranking presented in Table 4

These results show that hospitals and hotels obtain the highest DG potential. Analysis of the current situation confirms this result because nowadays DER applications in the commercial sector are focused on these two segments. Characteristics of energy use in hospitals in the aspects of electric to thermal demand ratio, high coincidence between electric and thermal loads, high utilization, high reliability needs and large power size provides a high suitability for this DG implementation. Standard hotels present also high potential for DG applications, but their requirements on smaller power size and higher electric to thermal demand ratio does not exactly fit with common cogeneration technologies, making its suitability lower than the hospital segment for the assumed scenario.

Low suitability is obtained for small offices buildings. This result can be explained, in the case of those located in hot climates, because of their low values for utilization times, load factors, coincidence between electric and thermal loads, in addition to the small electric size and lower needs of power reliability. It is observed that suitability increases when these offices buildings are located in colder climates, due to their larger energy consumption.

Table 4: Ranking for the studied commercial segments

Ranking position	*Segment*	*DG Suitability*
1	Large Hospitals Northern Europe	0.88
2	Standard Hotels Northern Europe	0.72
3	Big Offices Buildings Northern Europe	0.69
4	Small Offices Buildings Southern Europe	0.53

Sensitivity of the ranking factors to dispersion in the data of each typical customer has been addressed by using the analytical expressions deduced for the factor potentials. These formula, detailed at Table 1, enable to deduce the ranking potential error by propagation of the data uncertainties to this final ranking potential. Previously to apply then to a specific ranking, we have compared the errors deduced analytically with the corresponding ones deduced by MonteCarlo using the histograms as the relationships between variables and potential. Results prove the analytical approach is more pessimistic in about a 60% about the final errors, as can be seen at figure 3

Assuming a 30% relative uncertainty in the customer data, the analytical approach gives a 12% error for the ranking parameter. This result proves the difference between the segments considered in our application is significant enough because they exceed the error value.

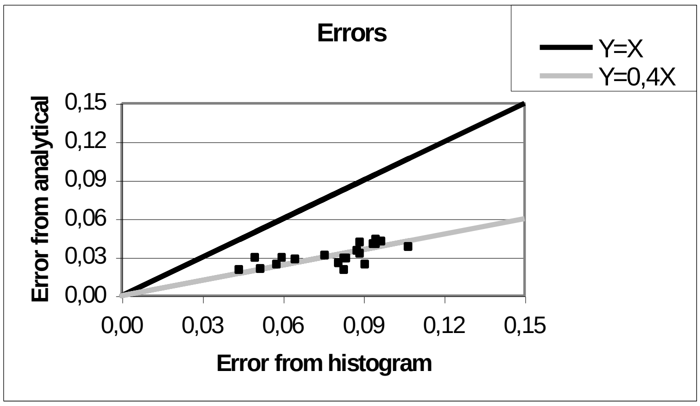

Figure 3: Errors

The methodology can be applied in identical form to the other two main elements in DER: DS and LTS, by defining the set of factors to be taken into account to analyse the segment suitability for these two types of applications and the scenario for the specific application under consideration. In table 5 it is presented a list of factors that can be employed to analyse DS and LTS suitability

Table 5: Factor taken into account to analyze DS and LTS suitability

Distributed Storage	Local Trading Strategies
- Space heating and cooling thermal loads	- Load patterns
- Load factor	- Demand flexibility and reliability/quality needs
- Day/night use	- Attitude and investment capabilities
- Power reliability	- End uses ratios and general size
- Power quality	- Supply and storage options
	- Geographic concentration

4. Conclusions

Benefits associated to DER in the economical, technical and environmental aspects justify its implementation in the highest possible degree and makes necessary the identification of new demand segments where they can be implemented. A methodology, based on a multicriteria approach to quantify the suitability for DER implementation in demand segments according to their requirements and motivations for DER applications in a specific scenario, has been developed to facilitate such identification.

The methodology is based on a set of factors evaluated according to data about energy supply, energy end use and general description of demand segments. It has been tested for DG in the commercial sector with demand segments as hotels, hospitals or offices were general DG suitability is known. Methodology application showed very high potential, for hotels and hospitals in northern Europe and lower, but still significant, potential for offices of southern Europe countries.

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