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Microgrid implementation Tool

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Pegasus Promoting Effective Generation And Sustainable UseS of electricity

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Introduction

The present document is called “Toolkit” because it is a set of several documents able to steer a correct implementation of the microgrid.

Due to the pilot experimentation, in these documents there are the fundamentals elements to identify the type of location where implement the microgrid, the type of organisational model, the type of governance, the needed resources.

The microgrid will be designed as an organisational model that manage existing and new coming assets (generations, loads, grid, energy management system and eventually batteries).

The documents that compose the toolkit are the following ones:

1) Guidelines coming from the Cost-Benefit Analysis D 3.4.6
2) Conclusion coming from the Report on the conditions required to make the business model financeable D 3.5.3
3) Modelling and report on the reactions of stakeholders and energy regulators (deliverable D 3.4.5)
4) Description of the Term of Reference (ToR) coming from the deliverable (D 3.3.2) and essentially based on the model proposed by the CRES (www.cres.gr).

Specifically in these documents it can be found:

- the "standard terms of reference” (ToR) including general technical specifications to implement a microgrid at territorial level (1,2).
- the financial assessment aiming to determine the viability and the needed for financial support especially in the frame of the existing EU and market resources (as JESSICA, ERDF OP and other EIB instrument) (3 and 4);
- the results of the evaluations, including the operational and management benchmarks on which define the ToR.
- a common template of risks list that has been circulated and discussed in all pilot areas (5).

In the annex are presented all the completed documents.

1. Lesson learnt from the Cost-Benefit Analysis

The cost-benefit analysis performed within the seven developed pilots in the framework of Pegasus project showed that, under appropriate assumptions, the improving of renewable sources to generate electricity locally consumed is not only energy efficient but also economically profitable.

The performed simulation, based on measured profiles of local loads and internal generation systems, have shown that the implementation of microgrids within a more open and flexible electrical system is possible and convenient.

Based on the results of the seven pilot projects in seven rural or peripheral areas and islands in the MED area, the following will summarise:

- the conditions under which microgrid can be fully exploited,
- the key aspects for an effective cost-benefit analysis to be carried out for future microgrid projects,
- the expected benefits from a wide spread of microgrids.

1.1. Conditions for an effective exploitation of the microgrids based on renewables

Microgrids generally make use of distribution generation by renewable source. From one side this is a strong point in favor of the microgrids since the levelized cost of electricity coming from PV and wind systems continue to fall. On the other hand, it is necessary to consider the intermittence of RES that could affect a real development of the microgrid.

There are two possible solutions, both tested within Pegasus project.

The first resides in **electrical system regulation** allowing between the microgrid and the public network the energy exchanges, in and out, that are compensated for each other, not necessarily on an equal basis. In this way the absence of generation by photovoltaic systems during the night or with low insolation conditions is balanced by the surplus generation at sundials with high insolation. The same applies to wind sources. Regulations such as net metering or even more articulated, such as net billing, are of this type: they allow efficient management of sources without burdening either the electrical system or the other end users.

The second one is the use of **storage systems**, today still too expensive but in the short term they can be of considerable interest given the strong investments in the sector all over the world. IEA[1] estimates a cost reduction by 2040 around two-thirds for stationary applications (and even more for EVs). Moreover, the availability of an effective electricity storage systems allows microgrid to operate disconnected to the grid. In presence of a weak network, condition often found in remote locations or islands, a microgrid that can be islanded operated allows to mitigate the effect of grid outages or low quality of supply.

Another significant issue for a well-designed microgrids is the quantity of electricity “generated and consumed on site”. In fact, among the positive effects of the microgrid it has to be accounted the **avoided transmission and distribution costs and the reduction of the technical losses** in transmission and distribution network. The cost of transport is of the order of 16% of the cost of electricity while the technical losses on the network are not less than 3% of the consumed electricity. The improving of the energy self-sufficiency of the microgrids implies increasing amounts of investment that can be remunerated if the benefits of lower costs for the electricity system are fully recognized.

In the current transition towards decarbonization goals of 2050 year, as planned by the European Clean Energy package, it is necessary that the regulations of the member states fully transpose **what defined by the European Directives "Renewable energy community" and "Citizen energy community"** regarding the keeping down of unmotivated energy costs. Among these the avoided costs of transport due to the local use of the locally generated electricity within the microgrids must be duly considered.

Energy Regulators position tends to be little inclined towards microgrids and in general on the collective consumption schemes due to a possible inability of the electrical system to cope with a widespread diffusion of microgrids or possible financial risks of the current system operators.

The opportunity must not be missed for the Member States to transpose the above-mentioned European directives into national law to give the microgrids and local energy communities the role of new players of the electric system.

[1] IEA- Innovation in Batteries and Electricity Storage, September 2020

1.2. The key issues for an effective cost-benefit analysis for microgrid projects

Microgrids must necessarily be equipped with **internal energy sources** and **must be able to integrate those already existing on the local territory**. That said, the **fully energy self-sufficiency is not a goal in itself** as well as the benefits related to the microgrid cannot be limited to those related to the use of RES (such as reduction of fossil fuels, low carbon emission) that can be achieved by any initiative of individual prosumer. The planning of a microgrid has to take into consideration the mix of the energy internally generated, including storage capacity if appropriate, and the one externally purchased in order to achieve a better balance with the load with an investments level such as to assure both the economic and financial viability of the microgrid and measurable benefits achievable by all the involved subjects (consumers, producers, prosumers).

In addition to ensuring the microgrid energy balance a suitable **Energy Management System** has to allow a more efficient use of electricity, for instance **supporting demand side management** approach or even just shifting the energy consumption at times when the generation by the internal renewables sources is greater. EMS has to be coupled with an **economic dispatching system** able to redistribute the benefits of the microgrid among its participants on the base of **internal "transfer prices".**

In the evaluation of the achievable benefits a careful assessment of the regulatory framework must be made (electricity tariffs, incentives to RES, etc.) and its foreseeable evolution over time.

A reliable assessment of the required investments is crucial for an effective cost-benefit analysis. It must cover not only all the equipment that must be installed but also their real useful life. For instance, the inverters of a PV plant have an average life usually lower than that of photovoltaic panels as well as the useful life of a battery storage system is strongly influenced by the number and characteristics of the expected charging and discharge cycles for their operation within the microgrid. A microgrid able to be operated in island mode must be controlled without the reference input of the main grid and has to detect fault signals from main grid in order to island in time. After islanding the voltage and frequency control, and appropriate power quality levels, must be provided by the microgrid. This implies additional investments and more complexity in operation, especially high when the microgrid is based only on renewable intermittent electricity sources. Those additional investments and operating costs should be carefully weighed against the economic value assigned to a higher power reliability in term of the external costs related to the outages (for instance commercial or industrial activities halt).

No less important is the evaluation of the O&M costs of the microgrid. Among these the most easily overlooked are those related to insurance expenses (to be correlated for example to possible serious damage to PV systems as a result of stormy events) and to the continuous need for updating EMS both to consider both the evolution of the microgrid (new generators or additional loads due to new members) and the reference regulatory framework over the time. Moreover, EMS provides a fair and useful continuous assessment of the efficiency of the different microgrid systems (generation sources, control systems, energy storage system) to be used for an effective maintenance operation.

1.3. The expected benefits from a wide spread of microgrids

In addition to the benefits already considered in the previous paragraphs, the pilots developed within Pegasus project showed that microgrids, by local use of energy locally generated, can **reduce congestions in distribution networks in the event of growing demand for Electricity or an excess of electricity fed into the network by distributed generation**.

In the presence of a weak network the microgrids may allow the deferral of the investments otherwise required to satisfy the loads.

Furthermore, the microgrids, adequately equipped, may be able to provide the **so-called ancillary services related to the control of voltage and frequency** and thus contributing to a better control of the network.

It should also be noted that local residents are generally interested in acting as members of a local energy community, being able to directly influence local energy strategies and able to directly verify the results of the choices made with the related benefits, whether they are of a better quality of service or a greater use of RES or a reduction in invoicing. This **greater democratization** in the matter of energy choices as well as the development of a stronger link of people with the territory is a further advantage achievable through the microgrid.

2. Conditions required to make financeable the business model

2.1. Funding opportunities for the microgrids

An extended use of microgrid systems can generate a quite large range of benefits both on the side of energy savings and in economic terms for the consumers.

So European funds may support part of the required investments as microgrids are able to effectively contribute to achieving the EU and national objectives in terms of renewables and energy efficiency. After the assessment of the existing financial gap it is convenient to implement suitable tools for overcoming the barriers for the establishment and successful operation of the planned microgrids.

It must be said, that it's not easy to investigate the financing support to achieve a reliable cash flow and thus viable solutions of microgrids. In many cases there are limited options for cost recovery because of local regulations. Finally, there is no "one-size-fits-all" business model for microgrids in the European territories.

In fact, there is limited experience of investments in intelligent distribution systems and microgrids through financial instruments given the limited experience and in light of the fact that they are still in progress.

With a view of proposing criteria to strengthen financial possibilities for microgrids, a first option could be the process through grants for projects supposed to present a higher level of risk, or, on the other side using Financing Instruments for interventions with a lower risk margin. Grants seem more appropriate in cases where the return on investments is not compatible with the project risks or the return period of the investment exceeds the expected time of the amortization plan. A second criterion is the financial sustainability of projects which suggests to target support through grants projects which costs are overcoming incomes.

The public sources may come from financial institutions at EU level as well as from the Financing Instruments operated by the State Members for supporting projects not ready for financial market but expected to repay the investment.

Economic public support for the development of microgrids not financeable by private market condition might concern the issue of state aid. State aid means any transfer of public resources that can grant a selective economic advantage, distort or threaten to distort competition.

As a general rule, state aid is prohibited by European legislation and the Treaty on the Functioning of the European Union which regulates the matter in Articles 107 and 108, as they are detrimental to the principle of free competition in the internal market. It is state aid every time that an intervention by the State or through State resources (e.g. grants, interest and tax reliefs, guarantees, etc):

- gives the recipient an advantage on a selective basis (for example in the case of inside consumers in relation to all other consumers);
- competition has been or may be distorted (for instance the power sources of microgrid are advantaged in comparison to other power suppliers)
- the intervention is likely to affect trade between Member States.

Therefore, funding for the construction of an energy network could potentially constitute state aid and fall back into European constraints. It has to be outlined that the state aid may be allowed when it make possible the achievements of common interest objectives, such as services of general economic interest, social and regional cohesion, employment, research and development, sustainable development (see Article 107/2 of the Treaty on the Functioning of the European Union). Therefore, according to the rules of the European Union, where there is an overarching common interest it is possible to proceed with the granting of aid.

2.2. The European microgrid incentive system

In order to meet the objectives of the European directives on RES, Member States have implemented strategies based on economic incentives. Making reference to the Renewable Sources used in the microgrids, these main economic incentives can be classified as follows:

Net metering allowing consumers who generate some or all of their own electricity to use that electricity anytime, instead of when it is generated. This is particularly important with renewable energy sources like wind and solar, which are non-dispatchable. Monthly net metering allows consumers to use solar power generated during the day at night, or wind from a windy day later in the month.

Feed in tariffs: incentives supporting investment in renewable energy including priority access to grid, long term energy exchange contracts and trading at market prices for owners. Then, this incentive purchases the investment risk and the price risk related to competition in the market. In the EU, a well-adapted FIT regime is considered as the most efficient and effective scheme to promote renewable energy sources.

Market Premium: provides extra revenues to RES producers above energy prices defined by the market. In this way a certain compensation for the investment made is ensured for RE generators. Differently from Feed in tariffs the market premium eliminates price risk but not purchase risk.

Green Certificates: in connection with annual renewable energy targets defined by each Member State additional revenues above those from power sales are established for renewable producers to comply with these goals. Green certificates can be traded so that companies comply with regulatory energy obligations.

Most Member States have developed their own plans and targets to stimulate the penetration of renewable energy into the energy mix and to overcome key financial and economic barriers as shown in Table 2. However new challenges and barriers arise, such as the differences in national policies and regulation of each Member state, which highlights that the EC directives cannot be transposed and implemented uniformly.

Table 1. Renewable Energy Electricity Support Instruments in EU 28 Member States

Country		Incentives																							
		FIT			Quota System									Premium						Net Metering			Tax Exemptions		
		PV	Wind	Hydro	% of Quota			No. of Certificates According to Tech.			Minimum Price per Green Certificate			Amount			Cap			PV	Wind	Hydro	PV	Wind	Hydro
					PV	Wind	Hydro	PV	Wind	Hydro	PV	Wind	Hydro	PV	Wind	Hydro	PV	Wind	Hydro						
Austria	AT	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Belgium	BE	x	x	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	x	x	x	x	✓	✓	✓	x	x	x
Bulgaria	BG	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Croatia	HR	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cyprus	CY		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	x	x	x
Czech Republic	CZ	✓	✓	✓	x	x	x	x	x	x	x	x	x	✓	✓	✓	✓	✓	✓	x	x	x	x	x	x
Denmark	DK	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	x	x	x	✓	✓	✓	x	x	x
Estonia	EE	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	✓	✓	✓	x	x	x	x	x	x
Finland	FI	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	✓	x	x	x	x	x	x	x
France	FR	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓
Germany	DE	✓	✓	✓	x	x	x	x	x	x	x	x	x	✓	✓	✓	x	x	x	x	x	x	x	x	x
Greece	GR	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	x	✓	✓	✓
Hungary	HU	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	x	x	x
Ireland	IE	x	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓
Italy	IT	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	✓
Latvia	LV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	x	x	x
Lithuania	LT	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓
Luxembourg	LU	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	x	x
Malta	MT	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Netherlands	NL	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Poland	PL	x	x	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	x	x	x	x	x	x	x	✓	✓	✓
Portugal	PT	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Romania	RO	x	x	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x
Slovakia	SK	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓
Slovenia	SI	✓	✓	✓	x	x	x	x	x	x	x	x	x	✓	✓	✓	✓	✓	✓	x	x	x	x	x	x
Spain	ES	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	x	x	✓	✓	x	x	x	x	x	x
Sweden	SE	x	x	x	✓	✓	✓	✓	✓	✓	x	x	x	x	x	✓	✓	x	x	x	x	x	x	✓	x
UK	GB	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	✓	x	✓

Source: "*Overview of Current Microgrid Policies, Incentives and Barriers in the European Union*". Amjad Ali, Wuhua Li, Rashid Hussain, Xiangning He, Barry W. Williams and Abdul Hameed Memon.

2.3. Analysis of the financial incentives

Which incentives related to the use of RES within the microgrid are allowed by the existing regulations in the territory and which additional incentives are deemed to enhance the economic-financial frame of the microgrid.

The conditions represented on the territories, through the analyzes conducted through the pilots, do not appear uniform, with rather diversified regulatory situations and stages of development in the sector.

In some territories the legislation provides that the possibility of activating net billing or net metering policies capable of supporting the development of smart grids. However, this possibility is not uniform, with markets such as the Maltese one where it is not applicable. In general, although it depends on the type of consumption, between the two policies the experience conducted by the partners leads to consider that net metering policy is preferable.

However, as these policies are not common heritage between all territories, in some cases they are not contemplated and therefore do not allow in some contexts an extraordinary incentive action for the development of micro grids.

Furthermore, in two cases the interventions the energy exchange policies with the grid, even if envisaged, find a territorial limit, correlated to the choice of the national programmer to facilitate only certain delimited areas of the single country.

In addition to the above, a positive consideration is given by the territorial analyzes, assigned to the possibility of receiving investment support for the construction of the plants, which is practiced in some areas, although this requirement does not appear to be a primary requirement.

It is probably considered more interesting to use the tax lever (in particular acting on VAT), used in some cases and indicated by the partners as an operational proposal in others, an instrument which, in integration with net metering policies, appears to be in able to facilitate the profitability of the investment and therefore the diffusion of the use of smart grid systems powered by renewable sources.

2.3. Analysis of the financial sustainability

Which financial instruments among those described in the previous chapters (grants, lower interest rates on loan, etc.) are activated in the territory and can be applied to the investigated micro grid. And what are the conditions that would make the financial instrument applicable and sustainable

With reference to financial instruments available at territorial level, the panorama outlined by partners in their contributions highlights a quite limited range of instruments, especially those financed by ESI Funds. On the other side, however, partners stressed the need for a comprehensive and holistic set of measures, not all of repayable nature, to speed up or enhance the development of investments in the area explored through pilot cases.

An in depth analysis of answers, cross checked with a survey on EC platforms containing data about Financial instruments al EU level can be summarized as follows.

There is not a prevalent source of public support to investments in micro grids now in different UE areas in which Pegasus project has been implemented.

In a couple of cases, grant schemes are available on annual basis, but only in one case the grant is relevant for micro grids even if beneficiaries are persons and not economic organization. The other one is a co-investment measure, which covers only 25% of the investment at household level.

In another case, a national development law sets out a comprehensive set of financial measures, including grants (also to cover job creation), leasing costs coverage, tax exemption and tax system, risk sharing.

On the side of financial products, currently it seems there are no Funds available from Operational programmes even if Financial Intruments are foreseen or have been activated in previous and present programming period but not covering this area of energy policy.

On private side, Commercial banks offer capped small loans with a quite high interest rate to buy eco friendly products, while a National Promotion bank, seems to be developing very interesting financial schemes in the field of Energy efficiency both on the side of direct loans and on the level of guarantees, especially to finance infrastructural investments. These products are somehow linked with another financial operation implemented with a commercial local bank to provide loans up to 750k with low interest rate, benefitting from a guarantee by the national bank. Also products tailor made for SMEs may support innovative business or technologies not currently the usual coverage of commercial banks.

2.4. Analysis of the financial benefits

Quantitative analysis of the benefits to be gained from the considered incentives at point A and from the financial instruments referred to in point B in order to overcome the existing economic and financial critical points of the microgrid.

In the cases analysed, the quantifications of possible benefits are mainly related to the savings in user bills.

From the cases analysed, the impact of these benefits depends on the intensity of the subsidy and the cost of making the microgrid.

In fact, it is the intensity of the subsidy that determines the impact on the economic balance of the microgrid.

If it were to invest only in the self-consumption plan, much more subsidies would be needed for the projects to be viable (more than 50% of the investment).

For example, in the case of partner French, a 15% investment subsidy would allow the producer to market local electricity about 30% less. Which makes a very big difference.

However, these results are only valuable if the manufacturer invests in both the photovoltaic system for the microgrid and other power tariff (scale effect) systems.

In short, the financial benefits depend on the value of the subsidy and the cost of the investment. It should be noted that the level of subsidy affects the market of the microgrid. A high subsidy tends to keep investment costs high. Right balance is determined by the pay-back of the investment.

3. Modelling on the reactions of stakeholders and energy regulators

3.1. The microgrid risk model

Risk management is an important function in organizations today. As microgrids are increasingly complex and ambitious projects, and they must be installed and operate successfully, in an uncertain and often risky environment. It is necessary to be aware of these risks. But to try to address each and every risk that a project might face can be much too expensive, both in time and resources. Instead, there is a need to prioritize risks. If this can be done effectively, we can focus the majority of the time and effort on the most important risks.

A useful framework that helps to decide which risks need attention is provided by the Risk Impact / Probability Chart. This is based on the principle that a risk has two primary dimensions:

- ***Probability*** *– A risk is an event that "may" occur. The probability of it occurring can range anywhere from just above 0 percent to just below 100 percent. (It can't be exactly 100 percent, because then it would be a certainty, not a risk. And it can't be exactly 0 percent, or it wouldn't be a risk.)*
- ***Impact*** *– A risk, by its very nature, always has a negative impact. However, the size of the impact varies in terms of cost and impact on health, human life, or some other critical factor.*

The chart allows to rate potential risks on these two dimensions. The probability that a risk will occur is represented on one axis of the chart, and the impact of the risk, if it occurs, on the other.

In order to prepare the Risk Impact / Probability Chart the steps that were followed are:

CRES gathered all the lists from the partners of the likely risks that their microgrid projects seem to face. CRES experts then combined them and assessed the probability of each risk occurring, and assigned it a rating (see Table 1: List of risks for the microgrids).

A scale of 1 to 4 was used. Assigning a score of 1 when a risk is extremely unlikely to occur, and use a score of 4 when the risk is extremely likely to occur and assigned a 1 for low impact and a 4 for a critical / catastrophic impact. With all these data the ratings on the Risk Impact/Probability Chart were drew (see Table 2: Risk Impact/Probability Chart for a microgrid).

The corners of the chart have the following characteristics:

- *Low impact/low probability – Risks in the bottom left corner are low level, and they can often be ignored.*

- *Low impact/high probability – Risks in the top left corner are of moderate importance – if these things happen, they can be coped. However, it should be tried to reduce the likelihood that they'll occur.*
- *High impact/low probability – Risks in the bottom right corner are of high importance if they do occur, but they're very unlikely to happen. For these, however, you should do what you can to reduce the impact they'll have if they do occur, and you should have contingency plans in place just in case they do.*
- *High impact/high probability – Risks towards the top right corner are of critical importance. These are the top priorities, and are risks that are necessary to pay close attention to.*

For a successfully implementation of a microgrid project, there must be a focus attention on the middle and high-priority risks – otherwise there is the risk of spreading efforts too thinly, that will lead to waste resources on unnecessary risk management.

Table 2. List of the risks for the microgrids

No	Risk Description	Impact of Risk • Low • Moderate • Serious • Critical	Probability of Occurrence • Very low <10% • Low 10%-40% • Medium 41%-70% • High>70%
1	**Low adoption of micro-grid from household customer** This risk corresponds to the potential overestimation of the number of customers that will be connected compared to actual results, as it is difficult to estimate the potential adoption of a new service such as electricity. The associated revenues are therefore reduced.	**Serious**	**Low**
2	**Low demand from household customers** it is commonly seen that “customers tend to overestimate how much electricity they need” resulting in an actual consumption that is lower than expected. The fact that households will “climb the energy ladder” progressively should be expected, with limited consumption in the first months/years (light, mobile charging).	**Serious**	**Medium**
3	**Low adoption from productive users** for productive users, the adoption of electrical appliances can be uncertain due to limited equipment information (price, benefits) and limited investment capacity.	**Critical**	**High**
4	**Customer payment delay and default** revenue collection has been often highlighted as one of the main issues in microgrid operations as it can require a significant workforce and potentially lead to customer default	**Low**	**Low**

5	**Electricity theft** electricity theft can occur in a rural micro- grid through a direct link to distribution lines. In addition to unpaid electricity, risks include safety issues related to uncontrolled wiring, damages to the distribution lines, uncontrolled consumption leading to battery damage, etc.	**Moderate**	**Very low**
6	**Cyber security** Micrograms share a growing operational risk exposure to cyber-attacks. The integration of legacy and new technology systems that are commonly joined as microgrids makes this risk exposure a growing concern that needs to be addressed in the overall microgrid performance risk modelling.	**Moderate**	**Very low**
7	**Default payment of customers**	**Moderate**	**Medium**
8	**Increased capital expenditure (i.e., delays in construction, legal costs, etc.)** Cost overruns during the construction phase may seriously over-extend an investor financially, to the point where the project may not be finished to the expected standards, or may even have to be abandoned.	**Critical**	**Low**
9	**Lack of economic balance**	**Critical**	**Medium**
10	**Lack of funding**	**Critical**	**Low**
11	**Lack of PV production to feed the consumers**	**Low**	**Low**
12	**Low adoption of a small-scale or large-scale micro-grid from potential customers (i.e. public buildings, company offices)** This risk corresponds to the potential overestimation of the number of customers that will be connected compared to actual results, as it is difficult to estimate the potential adoption of a new service such as electricity. The associated revenues are therefore reduced.	**Serious**	**Low**
13	**Non-efficient operation of electricity market**	**Serious**	**Medium**
14	**Regulatory roadblocks for the implementation of a microgrid** In some countries legislature and energy regulatory agency should recognize the benefits of the microgrids and prioritize microgrid expansion by adopting relevant legislation. Moreover, the state could award grants to local public authorities, municipalities or industries for developing and implementing microgrids	**Critical**	**Medium**

Table 3. Risk/Impact/Probability Chart for a minigrid

impact	1 Very low <10%	2 Low 10%-40%	3 Medium 41%-70%	4 High >70%
Critical 4		8, 10	9, 14	3
Serious 3		1, 12	2, 13	
Moderate 2	5, 6		7	
Low 1	4	11		

Approximate probability

3.2. Main considerations

Even though microgrids are composed of equipment whose operational and risk exposure characteristics are well understood, the same cannot be assumed for a microgrid system overall. They can cover large areas and require reliable power generation and distribution capabilities under adverse conditions. This geographic diversity can provide unique weather- and system-related risk exposures – and not just for microgrid activation due to utility power failures, but for sustained island mode operation.

For a specific microgrid in a specific location, performance risk can be quantified with reasonable accuracy. However, in a general analysis we are interested in identifying and estimated the overall importance of different risk drivers.

From the above Risk Impact/Probability Chart we can have a number of key conclusions.
The following 3 risks

- Low adoption from productive users
- Lack of economic balance
- Regulatory roadblocks for the implementation of a microgrid

are the most important risk for a microgrid. These risks towards the top right corner are of critical importance. These are the top priorities, and are risks that are necessary to pay close attention to.

The following 4 risks

- The Customer payment delay and default,
- Electricity theft,
- Cyber security,
- Lack of PV production to feed the consumers

are the 4 less important risk Risks and they can often be ignored.

4. Terms of references (general guidelines for a ToR for a microgrid)

The scope of this document is provision guidelines for the invitation to tender for supply, installation, testing and maintenance of a microgrid for a standard Community, based on the Greek pilot[2]. The document includes examples of some administrative and technical criteria to be included in tender document.

The terms of reference act as a set of guidelines that allow Community to prepare the request for offers and includes the following main ones aspects:

- Frame (details of the contracting authority, general details of the contract and administrative data)
- Reference terms (project description, technical details, evaluation criteria)
- General terms.

Not all the part of the ToR have been completed as some are related to the specific legal and regulatory framework of each own countries and also some other are enough standard for which no really added value would have been provided here.

4.1 Contracting authority and object of the contract

Details of the Contracting Authority

In this section it will be necessary to include the data of the Authority that will assign the contract.

Process details - Funding

In this section it will be necessary to include: Type of procedure; related competition regulation; financing of the contract.

Brief description of the contract's physical and economic object

The scope of the contract is the supply and installation of photovoltaic systems, energy management software and other support hardware for construction and operation of a pilot microgrid. The equipment will be installed in the area (Community) of XXXX of the municipality of XXXX.

The items to be procured are classified in the following Common Vocabulary codes Public Procurement (CPV): 71314000-2 and 31682210-5. This contract is subdivided into the following sections:

[2] It was essential to consider one to of the seven pilot to give concreteness to the case. The case considered is the one of Megalo Evydrio. The ToR was prepared based on the results of deliverable 3.3.1 - " 1 the cost-benefit analysis report and market share report ", which took into account the technical and financial aspects of the new photovoltaic system installations and power storage for the proposed microgrid.

SECTION 1:
Supply and installation of 76 photovoltaic systems[3] (75 x 2.25 + 1 x 9 = 177.75 kWp) with the corresponding inverters and batteries (200 kWh) with a total estimated value 240,000.00 Euros, plus VAT.

SECTION 2:
Supply of an Energy Management System (EMS) with a total estimated value 50,000.00 Euros, plus VAT.

SECTION 3:
Supply of a Common Coupling Point (PCC) Switch to the mains with total estimated value 10,000.00 Euros, plus VAT.

Tenders can be submitted for one, two or all three parts of the contract. The total estimated value of the contract is 372.000,00 € including VAT 24% (budget without VAT: € 300.000,00, VAT: 72,000.00).
The duration of the contract is set at 12 months.

A detailed description of the physical and financial object of the contract is given in Annex xx.
The contract will be awarded on the basis of the most economically advantageous offer, based solely on the price for each section separately.

Institutional framework

The assignment and execution of the contract is governed by the current legislation and the regulatory acts issued under its authority, as in force and in particular:
1. of Law XXXX/XXXX (Government Gazette-XXX) “Public Procurement of Works, Procurement and Services (adaptation to Directives 2014/24 / EU and 2014/25 / EU) ", and in particular Articles 116 and 117,
2. of Law XXX (Government Gazette-YYY) "Principles of financial management and Monitoring (incorporation of Directive 2011/85 / EU) - public accounting and others provisions",
3. Any related Law and regulations…
4. Any related Guidelines and Questions - Answers (FAQ) of Contract Authority that have been issued up to the date of publication of the tender notice and are posted on the official website of the Authority,
5. Any Decisions of involved and related Ministries

Deadline for receipt of tenders and tender

The closing date for receipt of tenders is dd / mm / yyyy, day xxxx and time xx: xx.
The process will be performed using the platform of the National and Regional System Electronic Public Procurement

[3] The figures refers to the case of Megalo Evydrio based for this case.

Publicity
A. Publication in the Official Journal of the European Union
(*Indicate whether or not the publication of the notice in the Official Journal of the European Union is required*)
B. Publication at national level
C. Publication costs
(all according to the national and EU rules).

Principles applicable to the conclusion procedure
According to the national and EU rules

4.2. General and special conditions of participation

General information
According to the national and EU rules

Eligibility - Quality selection criteria
- Participation right
The right to participate is set up according to the national and EU rules.

- Economic and financial adequacy
Regarding the economic and financial adequacy for the present procedure economic operators state that they have / provide a general instrument annual turnover for the last 3 years at least 250,000.00 Euros

- Technical and professional ability
Regarding the technical and professional capacity for the present concluding process
contract, economic operators are required

SECTION 1:
During the last 3 years, have performed at least 3 contracts supplies of photovoltaic systems, amounting to 300,000 Euros in total.

SECTION 2:
During the last 3 years, have performed at least 3 contracts Supply Power Management Software for electrical applications, amounting to 60,000 Euros in total but in order to achieve a satisfactory level
projects delivered or executed before will also be taken into account in the last three years. All projects are equivalent, regardless of when they were delivered or executed (within the last three years or before)

SECTION 3:

During the last 3 years, have performed at least 3 contracts supplies of electrical equipment for electrical applications, amounting to 40,000 Euros in total. However, in order to achieve a satisfactory level of competition, it will projects delivered or executed before the last three years should also be taken into account.
All projects are equivalent, regardless of when they were delivered or executed (within the last three years or before)

Award criteria
Contract award criterion is the most economically advantageous bid exclusively on the basis of price for each section separately, as defined in the article XX of Law XXXX.

Content of offers
According to the national and EU rules

4.3. Delivery time of materials

The contractor is obliged to deliver the materials according to the following schedule

SECTION 1:
It must be delivered installed and with all the individual components and systems in full operation in 75 houses and in a public building in the area of XXXXX of the municipality of XXX (Region of XXXX) in XXXXXX. In Annex I is given topographic sketch of the area with indicative installation locations of the systems. Final installation locations may show small deviations (10-20m) from indicative for reasons of optimal growth of the microgrid. The delivery of the department 1 must be executed within 8 months of signing the contract.

SECTION 2:
It must be delivered installed and with all the individual components and systems in the area of XXX of the municipality of XXXX (Region of XXXX) in XXXX. Delivery of Section 2 must be completed within 12 months of signing of the contract.

SECTION 3:
It must be delivered installed in the area of XXXXX of the municipality XXXX (Region of XXXX) in XXXX. Topographic sketch of the area with indicative installation location of the device is given in Annex xxx. The final position of the installation may deviate (50-200m) from the indicative for reasons related to the optimal microgrid development. The delivery of the whole Section 3 must be completed within 4 months from signing the contract.

4.4. Other Sections

The following sections will be developed according to the national and EU rules:
- Carrying out a procedure - evaluation of bids

- Terms of performance of the contract
- Special conditions for the performance of the contract (method of payment, sanctions, guaranteed supplied operation, Receipt of materials - Time and manner of receipt of materials, etc…).

4.5 Annex 1. Technical description and features of the selected items

Technical description

In the framework of the PEGASUS project of the MED program, 7 pilots were studied microgrids in the Mediterranean region. His case was studied in Greece pilot micro-network of the XXXX.

The numbers and types of consumers, consumers and producers in area of XXXXX are the following:

Consumers

- 295 houses (of which 165 are permanently inhabited)
- 16 stores
- 4 public buildings
- Street lighting (471 lamps with a total power of 150kW)
- 2 public water pumps (25kW and 40kW)
- Private pumps for irrigation (Total number of wells 147).

Prosumers

- 5 houses that are permanently inhabited with PV installations on the roofs with a total installed power 45 kWp
- 75 houses with new PV installations on the roofs (to be installed) with total installed power 168.75 kWp
- 1 public building with a total installed capacity of 9 kWp PV.

Producers

- 5 PV parks with a total installed capacity of 500 kWp (5 * 100).

The pilot microgrid is going to be connected to the public grid, but it will be able to operate in "islanding" mode (will have storage capacity electricity with batteries). The microgrid will manage an Energy Community (consumer and seller cooperative), with a common connection point (PCC) with the distribution network.

This supply is intended for the use of photovoltaic systems for electricity generation and the creation of an electrical microgrid The installation of the new PV systems will take place on the roofs of the houses which will be selected based on their orientation in order to achieve maximum performance of photovoltaic generators. The systems include the generators, the frames batteries, inverter and electrical equipment interconnection and safety devices. Specifically, the installation is planned 2.25kWp power systems in seventy five (75) homes. The 2.25kWp systems are identical in their equipment and its interconnection. It will interconnected in the existing electrical installations of the buildings that will settle. The installation as well as their interconnection with the electrical one Installation of housing is included in the cost of supply. The wiring and the characteristics of the equipment are shown in the attached monogram diagram of their electrical installation.

In addition, in addition to private residences, it will be installed independently 9kWp photovoltaic system in the municipal store of XXXX.

Finally, the necessary software will be procured that will manage the electricity energy generated by new and existing photovoltaic systems and will be distributed on the microgrid which will be connected to the upstream network at a common point connection.

The following is a detailed description of the items supplied.

Features of items offered

A. Photovoltaic systems

1. Photovoltaic Generators
Nine (9) pieces per system will be offered for 2.25kWp systems (total 630 pcs.) of the houses and thirty six (36) for the 9kWp system of the municipal store with dimensions less than or equal to 1650mm x 1000m x 50mm. Their technology will be polycrystalline or monocrystalline silicon with a nominal strength of at least 250 Wp / generator. Its efficiency should be at least 15% in conditions STC (STC conditions are determined by EN 60904-1 and EN 60904-3). The open circuit voltage should be less than 38V and current short-circuit less than 9.5 A. The maximum system voltage must not exceeds 1000 V. The temperature power factor should be ≥ -0.45%/^{o}C. Photovoltaic generators should be on compliance with IEC 61215 and IEC 61730 and be CE marked, which will be proved by the corresponding certificates.

2. Charging Regulator
One (1) charge regulator per system will be offered for 2.25kWp systems (total 70 pcs.) of the houses and four (4) for the 9kWp system of the municipal building. The rated input power should be at least 2400 W and a maximum input voltage of 140 V DC. It is possible to connect the number of panels on the charge controller and describe how to connect (eg 9 panels in a row or 3 rows in parallel of 3 panels) They must be equipped with electronic maximum power point detection device (MPP Tracker). The rate yield should be equal to at least 98%. Its nominal trend battery is equal to 48 V and can provide maximum charging current equal to at least 50 A. Charging regulators shall comply with protection class IP 65 according to IEC60529 and be marked with the corresponding ones certificates.

3. Inverter
One (1) inverter per system should be offered for the 2.25kWp systems (total 70 pcs.) of the houses and four (4) for the 9kWp system of the municipal building. The rated output power should be greater than or equal to 4.6 kW and with a maximum AC output current of at least 20 A. There should be an input for a backup AC source for a generator or network and be able to automatically switch to the backup source of alternating current when the battery charge is insufficient. The degree of efficiency should is greater than or equal to 95%. Inverters should agree at least with protection class IP 54 according to IEC60529 and be marked with the corresponding ones certificates.

4. Strainer Material
The cut-out material must be in full compliance with IEC EN standard 60947-2, while the quantities and items should be in accordance with the attachment monogrammed diagram.

5. Wiring
DC wiring should be indicative of HO7RNF type. The AC wiring should be indicative of type J1VVR / NYA. The off-board wiring will be located inside a grate, plastic duct or plastic tube.

6. Support bases
The support system should be made of aluminum profiles. I will there must be full compliance and static control of the support system in accordance with Eurocodes 1 and 9 and submission of a relevant certificate by manufacturer.

7. Batteries
Eight (8) batteries per system will be offered for 2.25kWp systems (total 560 pcs.) Of the houses and thirty two (32) for the 9 kWp system of the municipal building. It should be of the deep discharge type, with a rated voltage of 6 V and a capacity of at least 225Ah at a C20 charging rate. Life time should be is at least 1250 discharge cycles at 50% discharge level.

B. Energy Management System (EMS)
The energy management system should have the following features

1. Micro-network connection
The system provides information about the status of its coupling switch network. It synchronizes the microgrid with the main grid and can control the power flow throughout the connection, controlling the power consumption / output of electrical devices on the microgrid. It is connected with two special power meters on each side link.

2. Energy storage system
The system provides information on the status of storage devices power system, - battery system, and is able to control the unit either by activating and switching off or modifying the amount of power it produces or absorbs.

3. Data recorder
The data logger is based on industrial PC. It is a storage solution to record all the data of the connected monitoring points auditors. It must be equipped with a standard 2.5” hard drive with a capacity of at least 1.5 TB. The data logger also hosts the interface SCADA website allowing those who operate it to monitor and to control the distributed control system

4. Data acquisition and management
Each monitoring point in the system has a corresponding data pool that conveys the information needed to control the devices. As in one PLC environment can be set, downloaded, forced or unforced. The data tank protocol is a protocol to exchange power plant information in a fast and efficient readable format.

5. Connection of the microgrid to the electricity network
The network monitoring and control system provides information about condition of the main grid / microgrid switch. Allows to microgrid to synchronize with the main network and can control power flow throughout the connection controlling the consumption / production of electrical appliances in microgrid. It is usually connected with two special power meters on each side of the link.

6. Remote access
Since the microgrid controller is based on standard Ethernet components, the Remote access to a location can be done through standard routers and gates. It is possible to use 3G, ADSL, satellite or even telephone modems. Remote access is used for:
- Remote service and support of the station
- Remote software updates
- Connection for long-term storage of data in a remote location.

<u>C. Power Interface at the Common Coupling Point (PCC)</u>
- The interface should allow the features of the distribution architecture on both sides of the Common Coupling Point (PCC) to be completely different
- The flow of both active and reactive power can be controlled
- A circuit breaker is required to secure one way to disconnect the microgrid from the network
- The presence of the electronic power circuit leads to energy loss which should be less than 1%
- Must comply with the basic provisions of IEEE 1547.

Equipment Warranty

When submitting bids, the bidder should responsibly state that for him offered equipment is guaranteed to function at least in accordance with the following table.

Table 4. Warranty requirements

Item	Brief description	Warranty good operation [years]
1.1.1	photovoltaic generators	10
1.1.2	Generation production at least 80%	25
1.2	Charge Controllers	5
1.3	Inverters	5
1.4	Mounts	20
1.5	Batteries	2
2	Energy Management System (EMS)	20
3	Interface at the Common Coupling Point (PCC)	20

Reference Documents

1) Pegasus Project - Pilot of the Megalo Evydrio "Technical and economic evaluation "
2) Instructions for the installation of PV Systems in buildings facilities http://www.XXXX.xxx

Reference templates

1) IEEE 1679.1-2017. IEEE Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications
2) IEC / EN 61968-1 to 9 Application integration at electrical utilities – System interfaces for distribution management
3) IEC / TS 62257-5 Recommendations for small renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards
4) IEEE 2030.7-2017. IEEE Standard for the Specification of Microgrid Controllers
5) IEEE 1187-2002. IEEE Standard for the Testing of Microgrid Controllers
6) IEC / TS 62257 Recommendations for small renewable energy and hybrid systems for rural electrification
7) IEEE 1547. IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
8) IEEE 519 PCC IEEE Standard for Harmonic Control in Electric Power Systems

Annex I. Final report on Cost-Benefit Analysis

Annex II. Annex II. Report on the conditions required to make the business model financeable

Annex III. Modelling and report on the reactions of stakeholders and energy regulators

Annex IV. Terms of Reference for the Supply, Installation, Testing and Maintenance of a Microgrid

All the following documents are the ToR elaborated for each pilot

I	Cogeneration system to be installed in the Montereale Swimming pool of Potenza	PDF Adobe Acrobat Document
II	Battery Energy Storage System in a university microgrid planned in University of Cyprus	PDF Adobe Acrobat Document
III	Dokumentacija o nabavi u otvorenom postupku javne nabave za nabavu, ugradnju i implementaciju fotonaponske elektrane za potrebe mikromreže - PREKO	PDF Adobe Acrobat Document
IV	Lignes directrices pour la réalisation d'un projet d'autoconsommation collective - AURA-E	PDF Adobe Acrobat Document
V	Photovoltaic power plant to be installed to the roof of Gymnasium, Secondary Scholl of Ruše and the roof of the Ruše Sports Hall in the Municipality of Ruše - ENERGAP.	PDF Adobe Acrobat Document
VI	Microgrid for the Community of Megalo Evidrio - CRES	PDF Adobe Acrobat Document
VII	108 kWp PV system for the Energy Community of San Lawrenz - MIEMA	PDF Adobe Acrobat Document