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Title: Heat pumps in Europe – a "smart" future?

European energy and climate policy is governed by the overarching goal to reduce the demand for non-renewable energy sources and cut down greenhouse gas emissions (GHG). It also aims to reduce import dependency, provide security of supply, affordability and local employment. It is strongly believed that this goal can be achieved by a rapid uptake of the use of renewable energy sources and a considerable increase in energy efficiency, notably in the heating and cooling sector. If properly executed, it will be nothing less than the third industrial revolution focusing on locally available energy sources, produced decentrally and consumed in an optimal way via smart grids in smart cities.

This shift has already commenced, and a number of key foundation stones are in place. At the European level, the EU's 2020 strategy includes binding targets for the use of renewable energy (20%) and the reduction of greenhouse gas emissions (20% below 1990 levels) as well as an indicative target for an increase in energy efficiency (20%). President Barroso as well as Commissioners Hedegard and Oettinger have recently stressed the need for on-going efforts towards even higher GHG reduction targets, energy efficiency and the use of RES. (IPCC 2011). Several pieces of legislation as well as the EU strategy 2020 address these target areas (see figure 1).

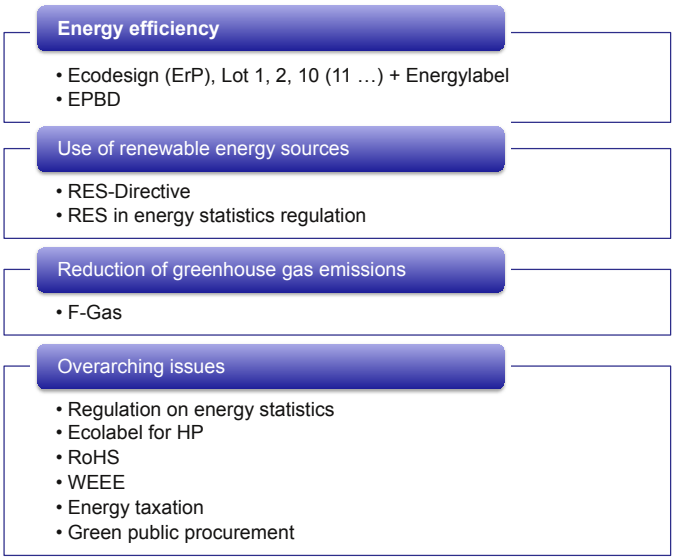

Figure 1: EU legal framework relevant to heat pump technology.

An extended use of **renewable sources** is governed by the Directive on the promotion of the use of renewable energy sources (2009/28/EC | RES-D), which sets national targets, describes support tools and outlines a process of checks and balances to monitor the level of achievement. As a consequence, European Energy Statistics is currently augmented to properly document renewable sources, hence enabling policy makers to set quantifiable targets and the measurement of success of their execution.

Higher **energy efficiency** in all kind of buildings is targeted by the Energy Performance of Buildings Directive (2010/31/EU | EPBD). More energy efficiency on a large set of product groups will be the result of Ecodesign for energy related products (2009/125/EC | ErP). From the demand side, these measures will be supported by an Energy label (2010/30/EC), an Ecolabel (2007/742/EC) and green public procurement criteria, some already available, others under preparation for a multitude of products.

Reduced energy demand will directly result in **less greenhouse gas emissions**, a target supported by the current revision of the regulation on F-gases (842/2006 | F-Gas) which aims at phasing down the use of fluorinated gases with a high GWP potential. Related legislation is addressing (a) the reduction of several products' environmental impact on the reduction of use of certain hazardous substances (2002/95/EC, after revision 2011/xx/EC | RoHS) and, (b) the strengthening of a better recycling of electric and electronic goods (2002/95/EC | WEEE).

All this legislation is currently in the process of implementation, finalisation or revision. Considerable effort is being put into the harmonisation of (efficiency) requirements, with a view to achieving results acceptable to all Member States. The **Commission's long term strategy** up to 2050 (with milestones 2020 and 2030) is currently being updated and it can be expected that the new targets for the use of renewable energy sources will be more ambitious than before. They will possibly be set as high as 80 to 95% with similar targets for the reduction in greenhouse gas emissions (based on 1990 levels) and a much stronger emphasis on energy efficiency including a binding energy efficiency target.

Solid evidence for the potential of achieving more ambitious goals is presented by a number of studies that show pathways towards an affordable, (nearly) complete switch towards renewable sources (Beinhocker/Oppenheim et al. 2008; Edenhofer/Pichs-Madruga/Sokona, et al. 2011; Teske/Zervos/Lins et al. 2010; ECF 2011) or the decarbonisation of the electricity supply (Eurelectric 2007). In all of these studies, the common denominator is the need for decisive and immediate action – 2020 is tomorrow and, changes of framework conditions and investment patters must start today to make the change happen. Unfortunately, an analysis of the existing national renewable energy action plans (NREAP), whose presentation by Member States is part of the RES Directive, shows a different picture (see figure 2).

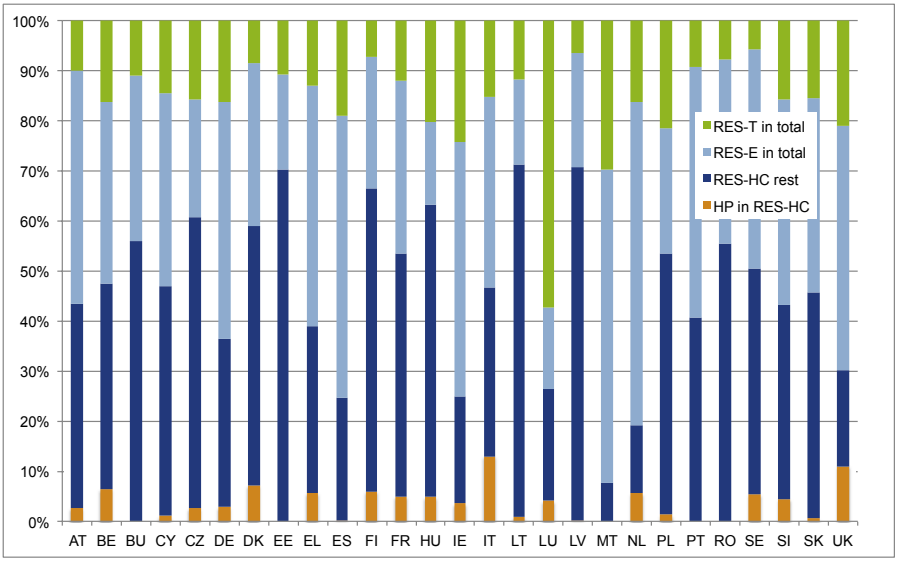

Figure 2: Contribution of electricity, transport, heating/cooling and heat pumps to the 2020 targets (source: own calculation based on NREAPs and EREC 2011).

In the currently available plans

- programs are largely based on a business as usual scenario expecting the existing systems to be robust enough to achieve the respective national targets;
- the Member States plan only slightly to exceed the 20% target in the use of renewable energy sources (+ 20,6%);
- 25 out of 27 Member States are not using the range of flexibility mechanisms available, but believe they can achieve the target on their own;
- most Member States do not recognize the contribution potential of heat pump technology (figure 2 in orange colour), with a few believing they can achieve their renewable targets without it.

The last point especially presents both a risk and an opportunity for heat pumps:

Heat pump technology is existing, reliable and efficient, making use of renewable energy sources and contributing to GHG-reduction. This potential needs to be properly recognized, documented and disseminated in order to guide current and future decisions on institutional and financial support to include and apply to heat pumps. If successful, such recognition will lead to faster marked development, new features and improvements in efficiency.

The heat pump market has largely developed without subsidies in many Member States and will most likely do so in the future. Ignoring its potential, as done in the NREAPs of some Member States, will put an additional burden on other technologies and create cost for their implementation – this is a missed opportunity.

A key-enabling factor towards the improved recognition of heat pumps contribution potential, and the development of the industry at large will be achieved through the availability of statistics and data. Their simple existence may serve as an eye-opener for many governments to understand the true benefit of the technology.

The success of Member States initiatives towards using a larger share of RES is reviewed bi-annually. In case a Member State's planned measures prove inadequate, governments may turn to heat pumps as an efficient technology that can serve as a quick fix, especially when considering its RES use and GHG reduction per Euro invested.

In order to make this challenge an opportunity, industry needs to communicate the heat pump benefits more strongly to eventually find them considered in government strategies and programs.

A strong argument supporting the economic feasibility of a greener economy and a much more buildings sector (including heating and cooling) is given by the abatement cost curve approach (Beinhocker/Oppenheim/Irons et al. 2008). It shows that investments in the building envelope and building climatization systems very often have a positive return of investment over the useful life of the product.

Thus we do not need a much-improved technology. Required changes are more of a socio-economic kind.

- Initial investment of RES technologies is higher than their fossil-fuel based competitors. This can be overcome by the provision of financing options and by energy services.
- Externalities of the use of fossil fuel are not included in the price for energy and consequently and a price signal towards renewable systems is missing,
- Short term, investment cost orientated decisions are made towards fossil fuel technologies. Due to the long investment horizon, this leads to a technology lock-in
- For many consumers, RES technologies are new and they are unsure on their reliability and cost efficiency
- There are still too few planners, architects, engineers and installers that can properly plan, execute and maintain renewable energy systems in buildings.

There is increasing agreement on the need for significant political effort to overcome these barriers. The starting point for both institutional and financial support is the policy framework described earlier. Its implementation is now starting to bear fruit and once completed should lead to a **bright outlook for all renewable technologies, but especially for heat pumps**.

The technology is increasingly acknowledged as using renewable energy sources in an efficient manner to provide heating, cooling and sanitary hot water across a wide variety of application fields, and regions. Its contribution to the RES and GHG targets will be accounted for in official statistics, soon. Overall, the technology is understood and requirements are set in line with its potential. The heat pump industry itself is pushing for high quality solutions. Among other activities, it coordinates a European training and certification program for heat pump installers (EUCERT), a training program for drillers (geotrainnet) and a quality label for heat pumps (EHPA Quality label).

Positive recognition of the technology is reflected in the **marketplace.** Whilst the heat pump sector faced a challenging environment in 2009 and 2010, the overall trend since 2005 shows

double digit growth and the first quarter of 2011 has shown a promising outlook. Stakeholders are now reporting a recovery of the market with sales numbers once more on the increase (see figure 3).

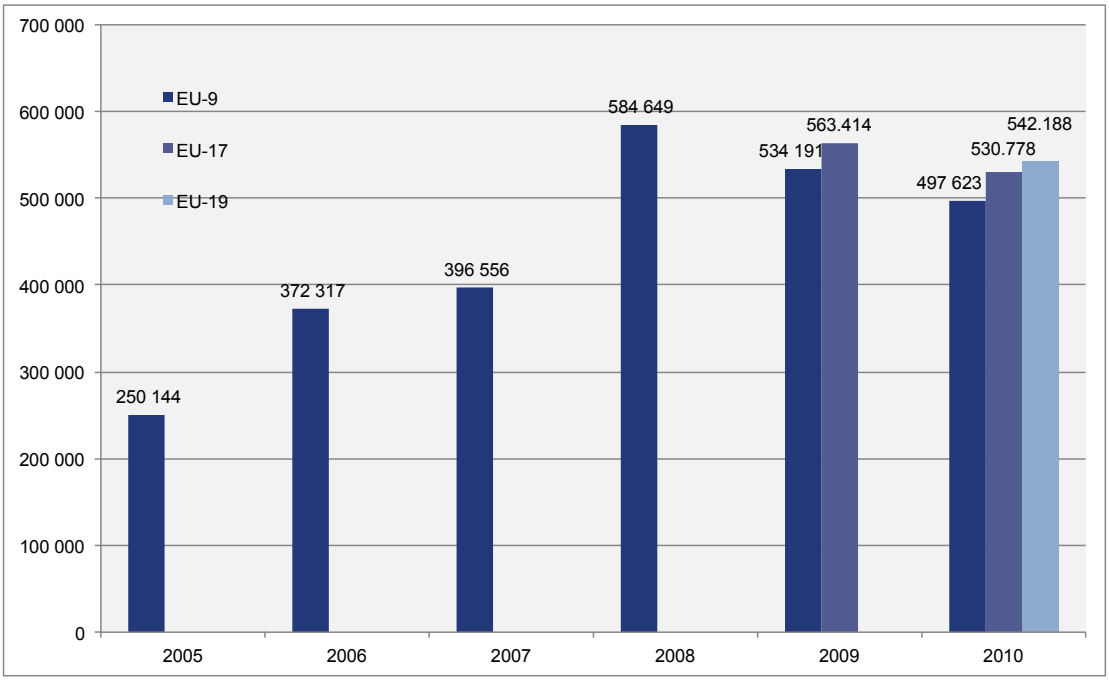

Figure 3: Development of sales figures for 19 European markets
(9 until 2008; 17 in 2009; 19 in 2011; Source: own calculation based on EHPA data)

During 2010 heat pump markets across Europe were negatively affected by a combination of factors: the uncertain economic conditions, the resulting lack of available funds from end consumer and government budgets, and a general reluctance to take on new investments, in particular in the building sector. In addition, low fossil fuel prices negatively affected the total cost of ownership of heat pumps vs. fossil fuel-based systems. A preliminary analysis of EHPA data for 9 key markets (AT, CH, DE, FI, FR, IT, NO, SE, UK) for which longitudinal data is available, shows a decline in 2010 sales by roughly 7% to 497 623 units (2009: 534 191) (Nowak/Murphy/Forsen 2011). Markets most heavily affected were France (-33%), followed by Germany (-13%), and the Netherlands (-13%). Positive signals could be seen in smaller markets like Belgium, Slovakia, Finland, Hungary and the UK. However their growth was not sufficient to overcompensate losses in the large markets. The rest of the European markets demonstrated a rather stable development (plus/minus 5%). The 19 markets covered in 2010 showed a total sales of 524 188 units (**Note:** these numbers are still preliminary due to a current update of statistics methodology to better accommodate for the contribution of air source units). The positive side-effect of the market slowdown was seen in the overall market consolidation: manufacturers and installer companies restructured and the number of players was reduced through mergers and the natural attrition of less reliable players (free riders, “cowboys”). With regard to quality, the time was used constructively for product development, personnel training and certification. As a result, the industry is better positioned for the expected next growth phase.

And in the future?

The various national markets are maturing, albeit at differing speeds. It is noteworthy that in many national markets, heat pumps are achieving stable double digit shares in the segment for new buildings, often being number two in the list of heat generators installed – after gas condensing units. A number of yet unrecognized markets have seen the establishment of national heat pump associations, which are lobbying for the acceptance and promotion of heat pumps in line with implementation of EU legislation by their national government. Most of these new associations are also commencing the task of compiling detailed statistics. In some cases, the larger, more mature markets are now seeing a saturation of heat pumps in

the new building segment and a hence an associated shift of attention towards the renovation market is becoming apparent. As this segment covers 80-90% of the building stock, the successful positioning of heat pumps in this segment positions the technology to potentially dominate a tremendous growth field. The number of market segments successfully addressed by heat pumps is increasing and the technology is now also realising its potential in large, industrial and commercial projects. In the latter segment, heat pumps are already a viably option, comparing favourably on cost with other alternatives (see table 1). A typical development starts in the new buildings segment for new houses and spreads from there to other new building types and the renovation segments. The commercial and non-residential sector is typically addressed with individual projects at first and reaches a mass market state much later.

	New Building	**Renovation**
Residential building, individual house	Mass market in many countries, growth phase	Increasingly recognized market (AT, CH, DE, FI, FR, NO, SE, UK)
Residential building, multi-family house	Small segment, market development picking up speed	Increasingly recognized segment
Non-residential building and commercial applications	Small share in heat pump sales. Increasingly interesting with demonstration projects available, heat pumps are chosen, when heating and cooling is required simultaneously. Potential not yet exploited.	Increasing importance

Table 1: market segments.

Renewables produced and greenhouse gas emissions saved

The analysis of heat pump contribution to the targets in the use of renewable sources and the reduction of primary, non-renewable energy and of greenhouse gas emissions provides a positive picture. Based on EHPA market statistics a total of 2 637 129 heat pump units has been sold from 2005 to 2010. Using a method developed by EUROSTAT (EUROSTAT 2011) and deemed in line with the RES Directive these heat pumps will provide 27,37 TWh of renewable energy to the overall energy balance. Their use saves approx. 6,83 Mt of greenhouse gas emissions every year.

Accumulated values	**2005-2009**	**2010**	**2011-2020**	**Total**	**Target**	**Share of target**
RES use (TWh)	21,65	5,72	105,93	**133,31**	2.843	4,69%
GHG emission savings (Mt)	5,05	1,33	24,766	**31,14**	1124,2	2,77%
Number of units sold	2 094 941	542 188	7 625 156	**10 262 285**		

Table 2: Contribution of heat pumps to the use of RES and the reduction of GHG emissions (Source: own calculation based on EHPA statistical data).

Simply using a 15% annual growth rate to project these figures into the future 10,262 million heat pumps will be installed in the currently covered 19 European markets by 2020. They will contribute a total of 133,31 TWh of renewable energy and reduce emissions by 31,14 Mt. Comparing this number to the 2020 targets, heat pump contribution can be as high as 4,96% for RES and 2,77% for GHG reduction. The target set for heat pumps in the NREAPS amounts to 141 TWh (4,97% of the target). This number is even a bit higher than the EHPA

projection also outlining, that governments need to provide insituational and financial support for heat pump market development.

As the EHPA calculation does not yet include a) additional markets covered, b) improvements in the technologies efficiency, and c) developments towards a greener electricity mix the result must thus be considered very conservative and real contribution can be expected to be larger. In consequence it will be even more worthwhile to explain heat pump contribution better in order to sensitize decision-makers regarding the availability of a readily available, efficient and reliable solution.

2011 trends

Apart from the mentioned policy framework directly affecting heat pumps, their market is also influenced by the trend towards more energy efficient buildings - often linked to a limitation of acceptable (primary) energy demand. The latter applies both to new buildings and to renovating old ones. In all instances heat pumps are welcome participant in the technology mix employed. The benefit is particularly noticeable in the case of hybrid heat pump based heating solutions that can be used in new buildings, but maybe even more efficiently in renovation projects, as they allow for the use of several technologies. Another trend is the revival of the stand-alone sanitary hot water unit, a technology that has been available in scale in the 1980s. The acceptance of cooling as a comfort aspect in buildings increasingly taken for granted presents an economic advantage for a heat pumps that can provide both heating and cooling from a renewable energy source at no additional cost. All heat pumps are getting smarter and are increasingly integrated into building communication and control infrastructure. Once connected to information grids, information provision to the user and unit control is also possible remotely. This concept is elaborated more below.

Smart heat pumps: Let them talk – and listen carefully

Heat pumps are getting “smarter”: the units are increasingly equipped with sensors and better controls. They can ‘observe’ user behaviour, ‘understand’ its comfort requirements and adapt their function accordingly. Interfaces to the outside world enable an information exchange with the building’s heating/cooling system, and allow for data exchange with electricity meters. They also enable the use of data sources on the internet. These interfaces are not simply one -way streets from the user to the utility. They allow for data input and enable the heat pump system to react to changes in the electricity price, to recognise weather changes and to ‘understand’ the consequences this has for a buildings heating or cooling demand. An integrated energy supply and demand system allows the utilities to adapt their energy production to changing usage patterns and to set demand side incentives via price signals. From the manufacturer perspective, access to performance data allows for a better service: configuration settings can be checked remotely, performance data can be evaluated and possibly service warranties can be issued. The use of this increased knowledge of system status and performance enables more efficient and reliable operation and should reduce maintenance cost.

Online measurements of seasonal performance and energy produced help determine much more precisely the renewable energy share and the emissions saved by heat pumps. Information provision via web interfaces and smart phone applications catapult the heat pump from the dark side of the basement to the bright side of the user’s hand.

Smart heat pumps in smart cities: heat pumps as integrators

On a more aggregated level, the existing benefits of heat pump technology can be made much more useful in cities. It is expected that population density in cities will continue to increase. As a result of urbanisation, the share of the world population living in urban areas is expected to reach approximately 75% by 2050. This trend is connected to an increased energy demand which needs to be counterbalanced by a much more efficient use of available energy. Heat pumps can make a major contribution to this endeavour by:

- the provision of heating, cooling and sanitary hot water to the majority of applications – both residential and commercial
- the balancing of temporary and spatial differences in supply and demand of thermal and electric energy
- the more efficient use of waste energy for a “reversal” of energy flows
- the use of all available sources at the different available temperature levels (see figure 4)

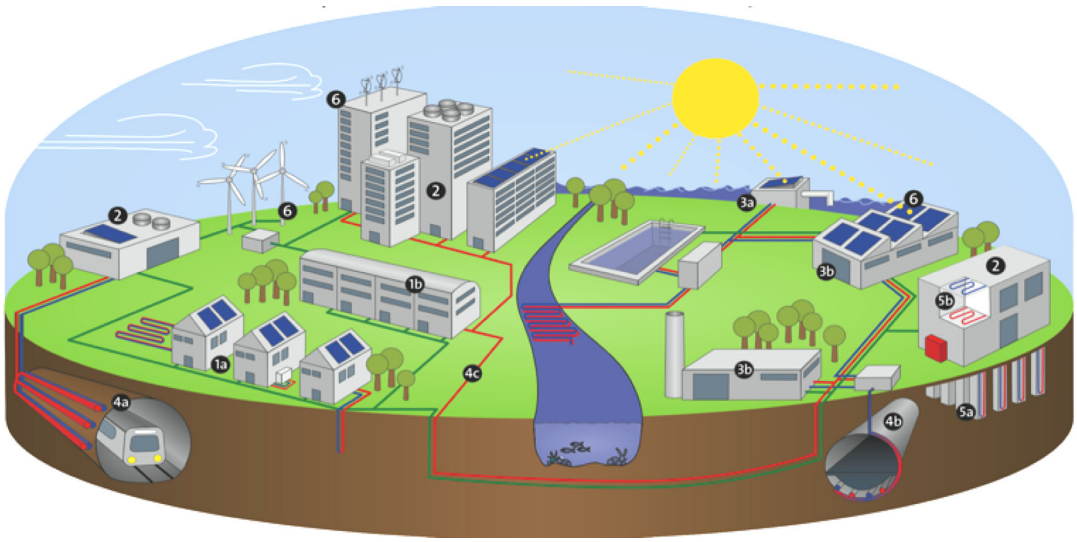

Figure 4: Future cities = smart cities = heat pump cities

Smart cities will not only require the creation of **smart (electric) grids**, they will themselves become much more energy efficient by supporting the **smart energy grid**. Combining information on electric and thermal energy supply and demand will result in a flexible, decentralised system, also serving as **storage medium for intermittent electricity, mainly from wind and photovoltaic**, and **balancing the temporary and spatial distribution in supply and demand of energy while catering to the users comfort requirements.**
Heat pumps can contribute to smart cities as an ‘integrator technology’ transforming excess electricity into heat and reversing the usual downward cascade of thermal energy flow – bringing available energy efficiently back to a useful level.

Heat pump cities?
The idea of a heat pump city goes beyond the focus on an individual application. It shows usage examples in residential buildings (1), both in single (1a) and multi-family (1b) houses. It illustrates commercial (2) and industrial (3) applications as well as the combination with other renewable energy sources such as wind and PV. Here renewable electricity is used directly or ”stored” as thermal energy in hot water tanks and in the building mass (**6**). Heat pumps utilise all heat sources: outside air, water or ground, but similarly exhaust air, cooling water or underground parking garages, (metro) tunnels and concrete foundations. (**point 5**).
Heat pump technology is poised to provide an i**mportant contribution towards smart future cities, whose energy supply is based largely on the efficient use of existing and renewable energy sources.**
The concept of smart cities is now gaining momentum at the EU level driven primarily by the recently launched Smart Cities and Communities Initiative, an approach within the SET-Plan aimed at shifting energy supply and demand structure in large agglomerations towards efficient and sustainable provision and use patterns.

Summary and outlook

The future outlook for heat pumps is brilliant. A mature industry has developed to deliver efficient, reliable solutions for a wide variety of application fields. Product and installation quality is increasing and the political framework conditions are supportive. Their implementation should lead to even faster market penetration across all segments. The

integration of heat pumps in distributed smart energy supply and demand environments will have an additional positive influence.
It will require concerted action by industry stakeholders to maintain the momentum of these initiatives and developments. This needs to be underpinned by continuous communication of the technology's compelling benefits coupled with a relentless drive towards high quality, and efficiency in real life installations in both new and refurbished buildings.

We have the map, the vehicle and the skills – what remains ahead is the drive, on the journey towards a future energy system that fully incorporates heat pumps. This journey should be an exciting but nonetheless a pleasant one!

Resources

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