# GREENING THE AUDIOVISUAL INDUSTRY

## Assessment of 30 low carbon technologies

Green Screen
Interreg Europe

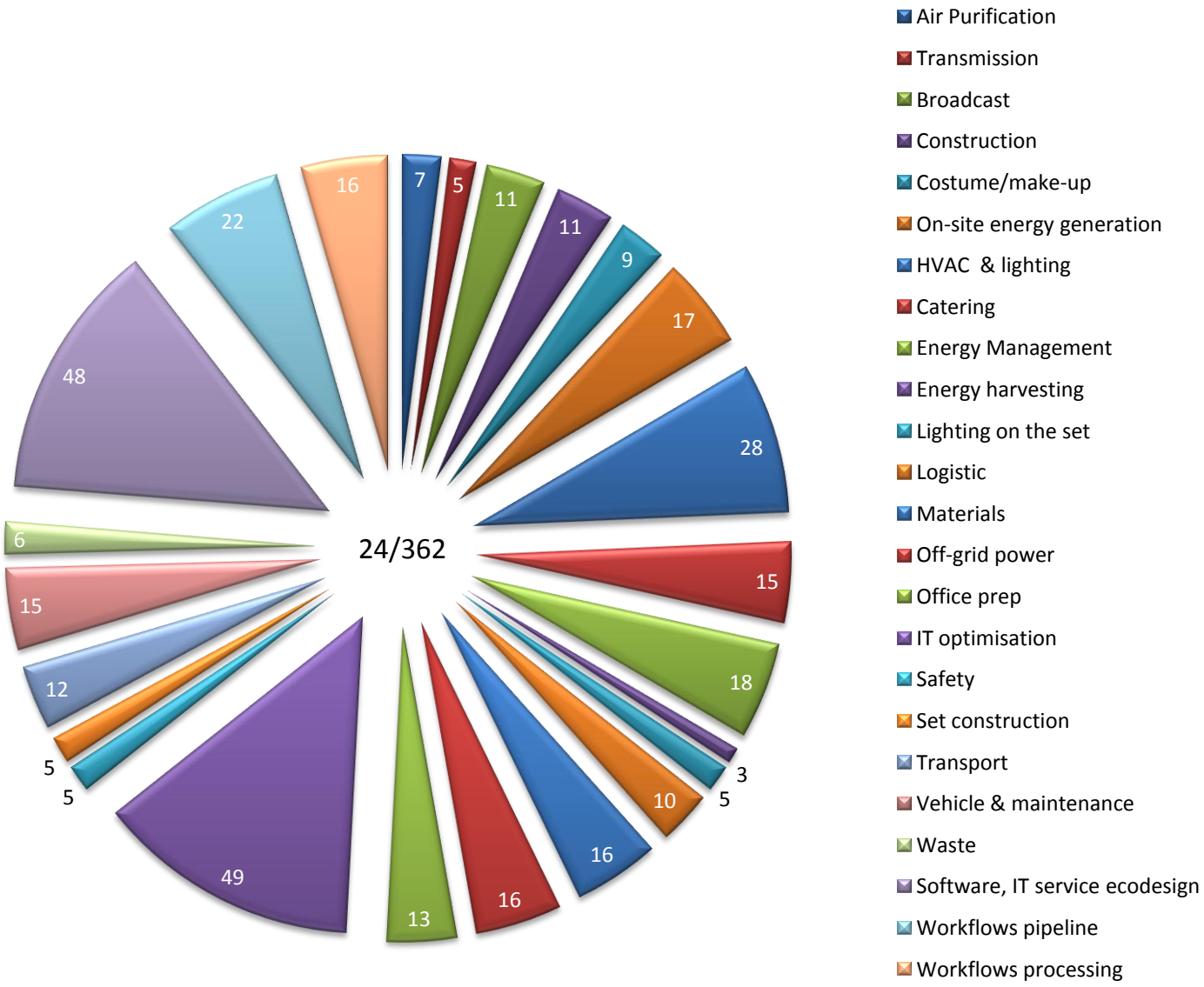
European Union
European Regional
Development Fund

Green Screen
Interreg Europe

# Shorten assessment of 30 low-carbon technologies

Synthesis of the evaluations carried out for Green Screen - Interreg Europe.
The assessed technologies (30) are extracted from a database of 24 AV industry processes and 362 technologies (January 2020).

## Techs by process- low carb & cost data base



Summary by **process**/tech:



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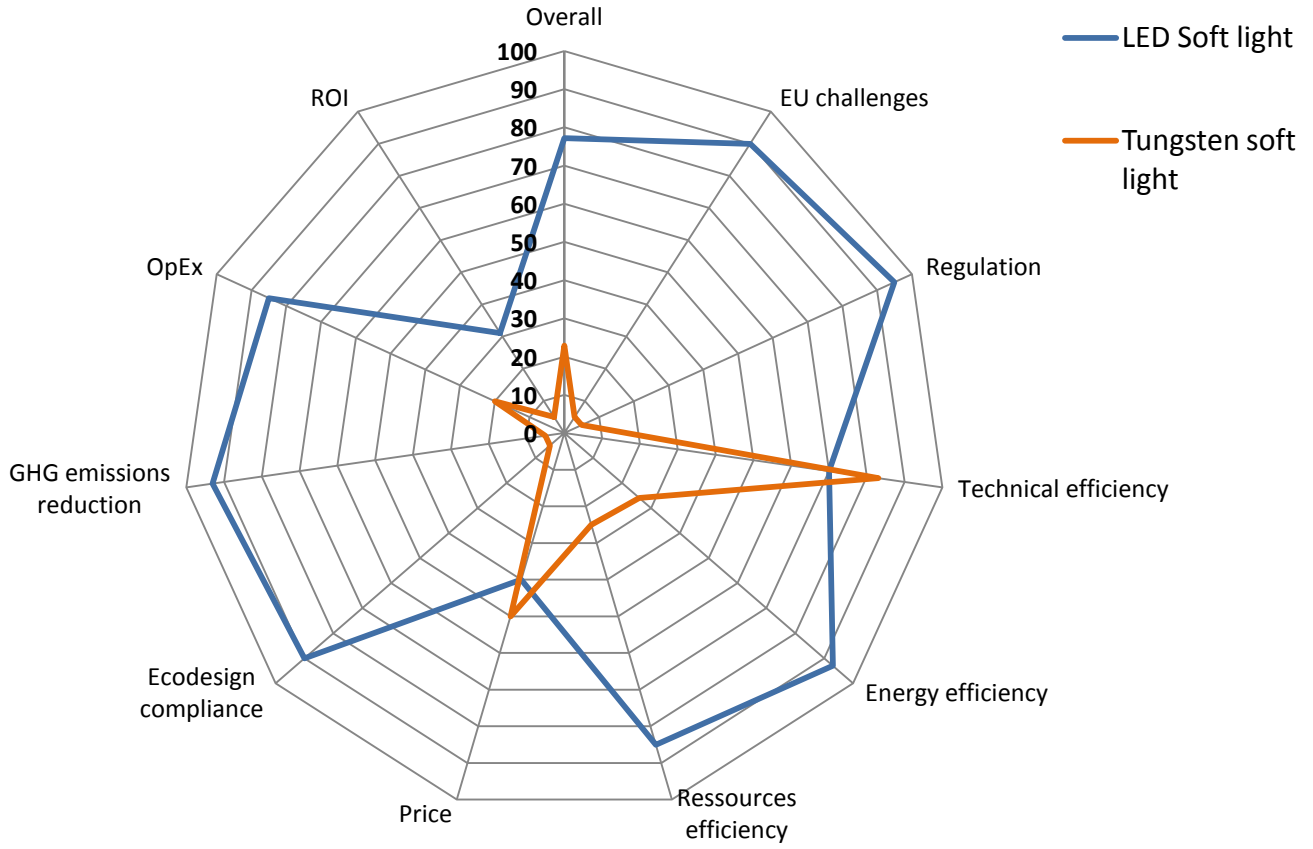
**Structure:** each shortened evaluation has the following parts:

- Context = problem to solve
- Solution
- AV industry application
- Key features
- Impact mitigation
- Profitability

- Graphical comparison to 'conventional technology', e.g. see below




In order to evaluate the **low-carbon technology (Led soft-light),** compared to **conventional one (Tungsten soft-light)**; each technology is represented by a spoke in the web, and the relative benefits are plotted on the graph.

The technology type having the **greatest benefits** (**Led,** in this case) defines the scale, represented by the outer circle at the greatest distance from the center of the web.

The other technology (**Tungsten**) is then normalized to that representation, so the proximity from the center denotes **its inefficiency**.

- Conclusion

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**Caution**: these assessments are shortening, they do not include:

- All the sources
- Regulatory assessment
- Detailed economic and environmental impact calculations
- Other impacts than carbon footprint
- The methodology is a comparative assessment based on **state of the art university research**, however for the environmental part it's not a LCA due to incomplete inventory due( lack of data & resources in time= some environmental assessments limitations) and there isn't a critical review. It aims to give an estimate, a scale compared to conventional technology.

→ *Each non-shorten evaluation per technology averages 30 pages.*

→ *To get more accurate information, please refer to the complete assessment*.

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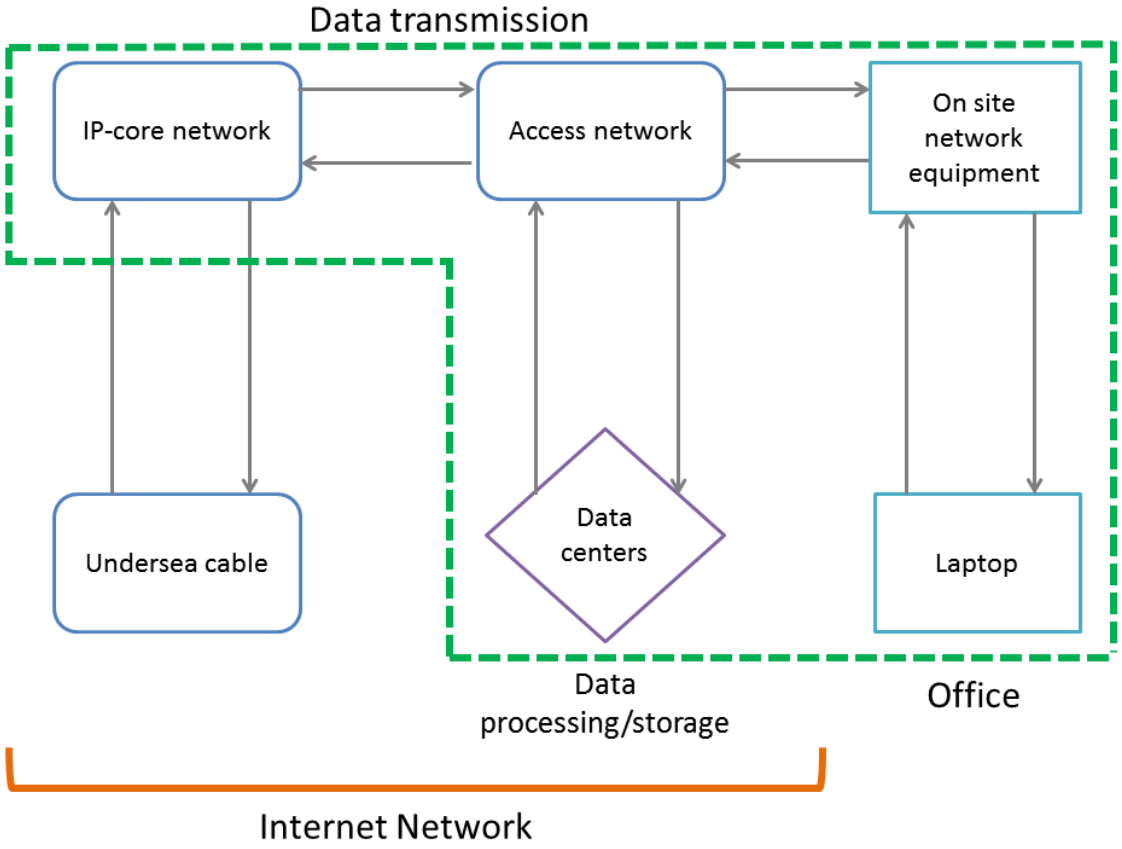
## Estimated carbon footprint of this innovation work: data base + in depths assessments: <u>265, 425 kg $CO_2$</u>

- Stages : entire life cycle for the laptop, run phase for internet ( energy in data centre + data transmission + residential router)

- Boundaries of this assessment (green dot)




- Data base ( man/day): ≈ 45 days
- In depth assessment ( man/day): in average 4 days by assessment = 120 days
- No transport is involved, I am working at home.
- Equipment: laptop (brand Samsung) /internet connection 15Mbps (residential router)

  → **Laptop electricity usage** (kWh/year): 13minimum/56 average/100 max= use of the max consumption : 100 kWh/year **= 0,274 kWh/day** – source: Digital environmental repository – Lean ICT p32 – The shift project

  → If we take into account periods of conservation of 4 years for laptop computers, the energy directly consumed due to utilization represents, proportionally to the energy consumed directly throughout the entire lifecycle of the peripheral device **11% for a laptop computer.**

  - Total energy consumption entire life cycle (extraction +production+ EoL) + run phase =3236,36 kWh (production, 2020 carbon intensity Korea 538 g $CO_2$ eq/kWh – source electricity map) + 400 kWh (use phase, carbon intensity France 58,5 g $CO_2$ /kWh – source Electricity generation – CO2 emission intensity - European Environment Agency)

    = 1, 741 t $CO_{2\,eq}$ (entire life cycle) + 23, 4 kg $CO_2$ **= 1, 764, 56 t $CO_2$** for entire life cycle (2 different carbon intensity Korea/France)

    → *4 years = 1460 days (except bixestile year) =* ***= 1, 764, 56 t $CO_2$/1460 days = 1,208 kg $CO_2$/day***

  → Residential routeur electricity usage (kWh/year): 100 kWh/year **= 0,274 kWh/day** – source: Digital environmental repository – Lean ICT p32 – The shift project

- Internet surfing : assessment thanks to the browser carbon tool : carbonalyser in real time during one day of typical work:
  - 406 minutes of surfing with
  - 993 MB of data
  - 0,32 kWh

  → *123 g $CO_2$ per day*

- Download GBytes of data per in depth assessment ( sources) at 15 Mbitsps = ≈ 15 GB
  To cut bandwidth and its carbon emissions, all the sources are downloaded to avoid consulting them online.
  - Data transmission (network): 27 Wh/GB (run phase)
  - Data center Energy consumption ( hyperscale data centre): 0,16 Wh/GB (run phase)

    Total energy consumption = 27, 16 Wh/GB (run phase)

    → *With French energy mix, carbon intensity 58,5 g $CO_2$ /kWh =* ***1,58 g $CO_2$/GB***

  Sources:
  - Shehabi, A., S. Smith, D. Sartor, R. Brown, M. Herrlin, J. Koomey, E. Masanet, N.Horner, I. Azevedo, and W. Lintner. 2016. "United States Data Center Energy Usage Report." Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-1005775, 56pp.
  - Coroama, V. C., D. Schien, C. Preist, and L. M. Hilty. 2015. The energy intensity of the Internet: Home and access networks. In ICT innovations for sustainability. Advances in intelligent systems and computing, Vol. 310, edited by L. M. Hilty and B. Aebischer,137–155. Cham, Switzerland: Springer
  - A meta-analysis of the energy use associated with data transfer across the Internet—from the point at which the data leaves the data center to where it reaches the User—estimated this energy use at 0.027 kWh /GB - Aslan, J., K. Mayers, J.G. Koomey, and C. France. 2017. "Electricity Intensity of Internet Data Transmission: Untangling the Estimates." *Journal of Industrial Ecology.*

- French energy mix, carbon intensity 2016 : 58,5 g $CO_2$ /kWh

  - Source: Electricity generation – CO2 emission intensity - European Environment Agency

- Limitations:
  - I am not sure about the country where my laptop has been assembled (Vietnam, Korea or China? Or a mix);
  - Phone call, e-mails are not taken in account;
  - Only the data transmission, data centers, residential router run phase is taken in account
  - Imprecise estimate in GB;
  - French energy mix, carbon intensity is a yearly average from 2016;

- Carbon footprint of the Green Screen "innovation work"

| $CO_2$ emissions: Data base + assessments | | |
|---|---|---|
| | Unit | Emission- kg $CO_2$ |
| Laptop | 165 Days | 199, 419 |
| Residential router | 165 Days | 45,21 |
| Download | 450 GB | 0,711 |
| Internet surfing | 165 Days | 20,295 |
| Total | | **265, 425**<br><br>= **1 769,5 km** by car with 150 g CO2/km |

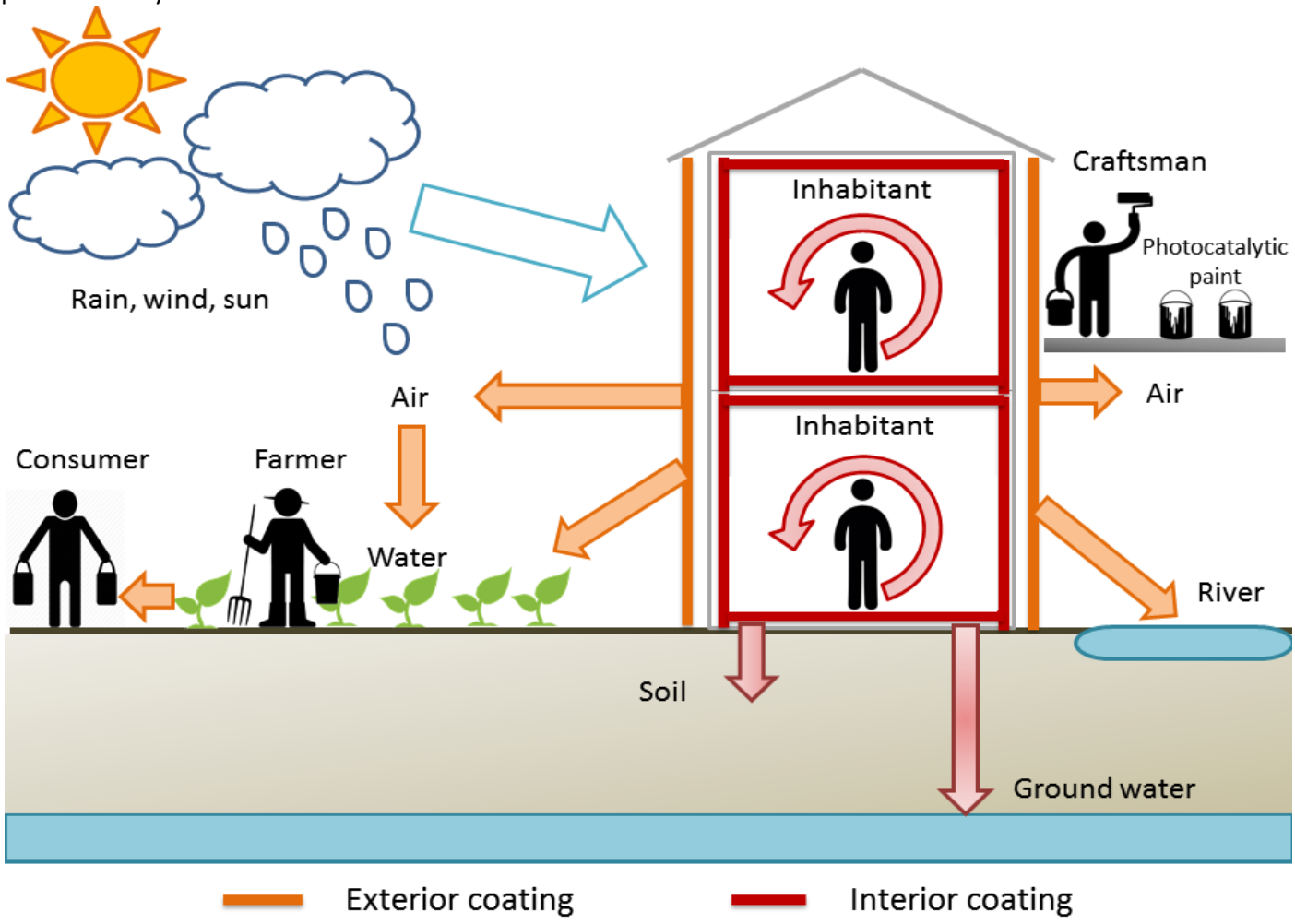
# 1. Air purification - Photocatalytic paint

## Context

The financial cost of air pollution (indoor and outdoor) in Europe stands at more than $1.6tn (£1.5tn) a year in illness and lost productivity, equating to about a tenth of the GDP of the continent. The costs come in the form of 600,000 premature deaths each year, and the sickness caused to hundreds of thousands of other people from preventable causes.
Source: Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth -2015 – World Health Organisation (WHO**)**

## Solution

A mean to reduce this concern can lies in **photocatalytic paint**, which is an air purification technology based on the photocatalytic oxidation effect of Titanium dioxide (TiO2), that purify air from pollutants to protect health and preserve ecosystems.




→ Photocatalytic/ conventional paints for interior and exterior coating have an impact on the entire ecosystem
Source: European project NANOHOUSE (Life Cycle of Nanoparticle-based Products used in House Coating) Ensuring the safety of nano-based paint–FP7

## AV industry application

- Indoor & outdoor air puirification e.g. for set construction workshop, restoration laboratory...

## Key features

- Functional paint that can be apply like conventional paint
- Many air purification effects: mould, bacteria, odour, and VOC emission free…

- Decompose the other pollutants in the air such as VOCs and decrease PM2.5
- Protect employees health

## Impact mitigation

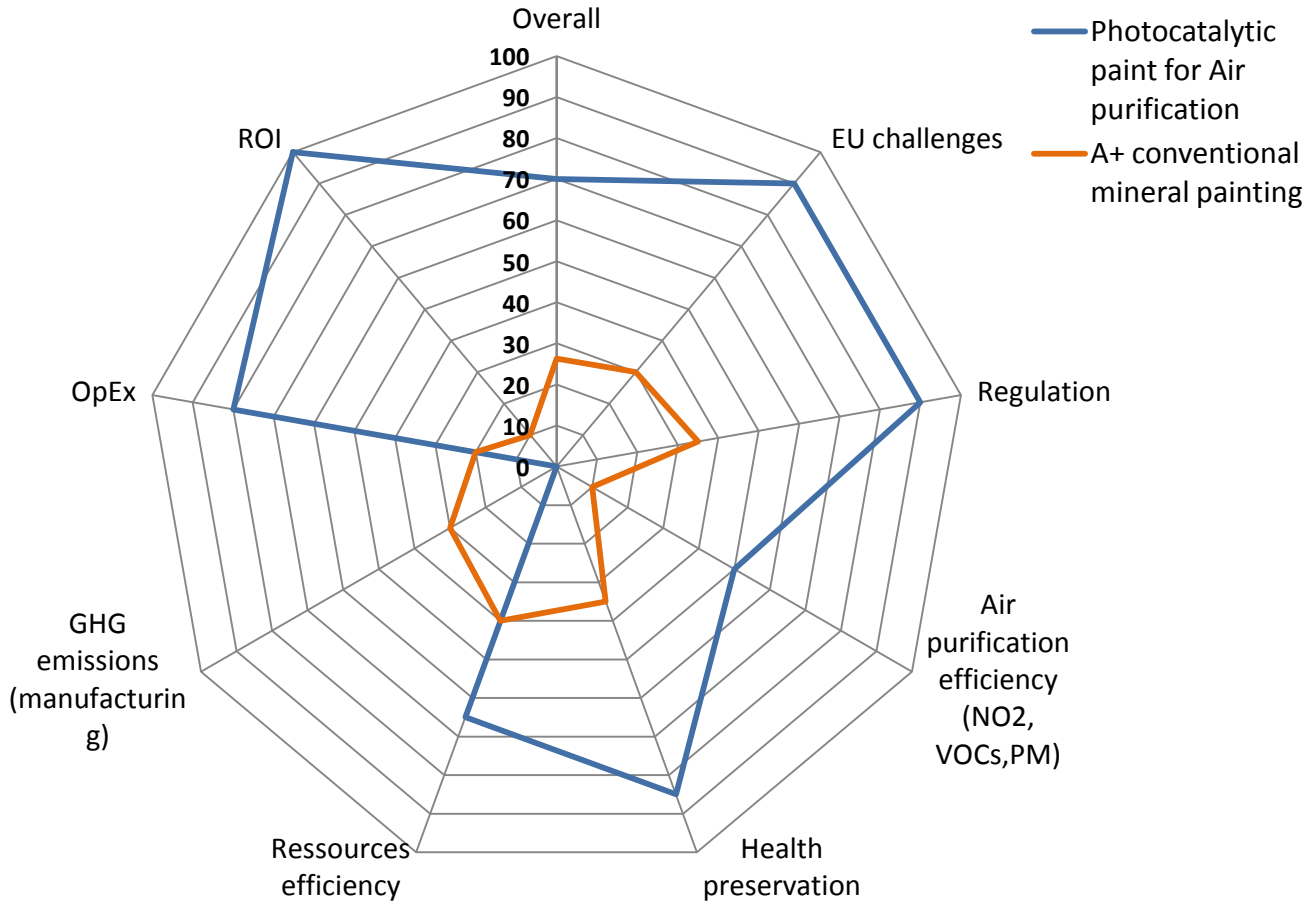
- Cut NO2 (NOx+SOx) pollution to meet Directive 2008/50/EC that requires a maximum exposure limit of 40 µg.m3:
  - - 31,5 NO2µg/m3 = - 50%

## Profitability

- Cost = 14,5 € / m2 to paint
- For an AVP industry SME with 10 employees in an urban area , close to a major axis of road traffic:
  - Interior wall surface to paint = 50 m2
  - Liters of Airlite Purelight painting needed = 50
  - Price = 638 € without taxes
  - **Cost of absenteeism** = on average, 10.1 days of absence per employee and per year in the private sector if **10% are related to indoor air pollution** ( disease)= 1 day of absence per employee/year .
  - Source: [the hidden cost of absenteeism study] in France - Institute sapiens - November 2018

→ Very cost-efficient ROI = 626%
  - Low cost solution
  - By protecting the employee health this solution drastically reduces the cost of absenteeism

## Comparison to A+ indoor air emissions certified conventional painting




## Conclusion

→ *Photocatalytic paint is a much cost efficient investment as it preserves employee's health and therefore their productivity.*

# 2. Transmission - Millimeter Wave (MMW) E-band for wireless signal transmission

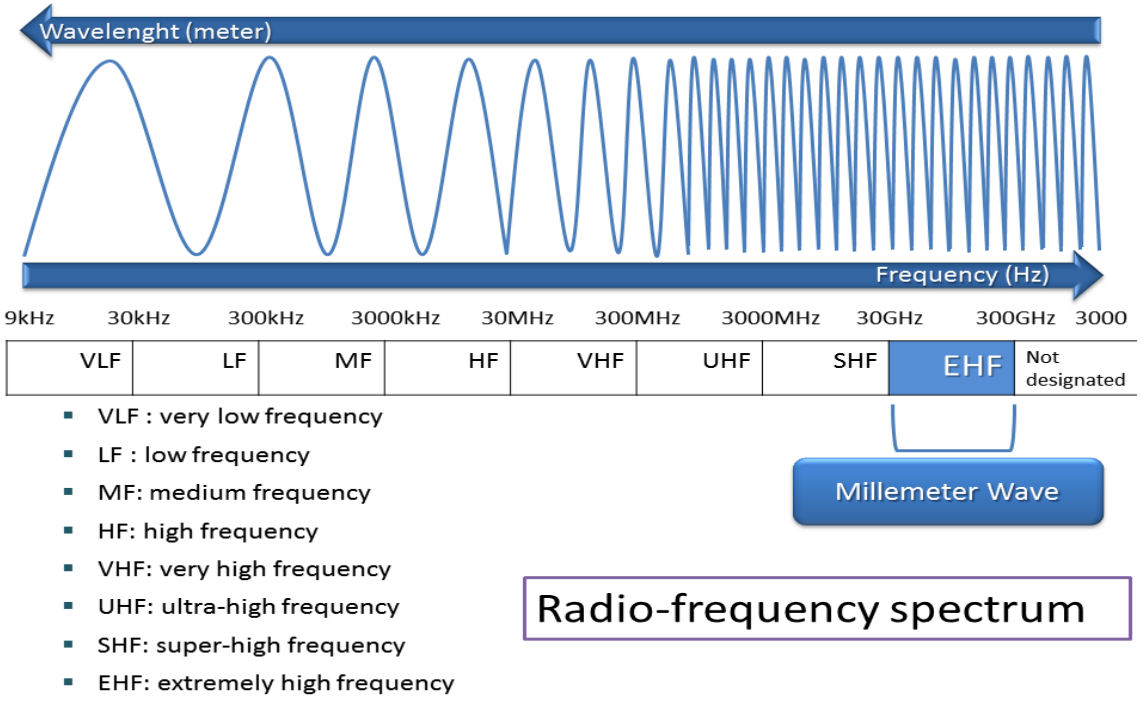
## Context

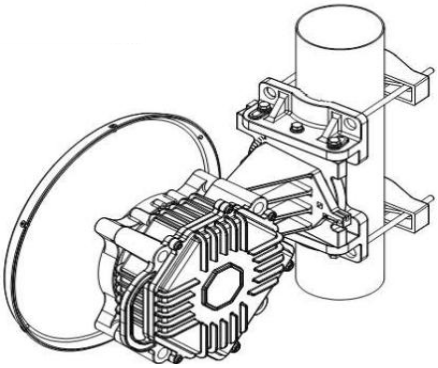
Today HD resolution is a de facto standard used in TV broadcasting and computer displays. The so-called Ultra HD 4K pixel resolution has just started to spread in the industry, and NHK Japan's national public broadcasting organization announced to use 8K video standard during 2020 Winter Olympic Games.
The most obvious solution for high speed transmission of data-intensive content would be to establish a physical connection via fiber optic cabling. However, digital 3D/HD fiber optic cable has significant latency issues that can affect the synchronization of the two digital streams of data.
Therefore the limitations of data transmission often lead to stepping down the resolution and sacrificing quality.

→ High bandwidth wireless, naturally, would be the ideal solution and eliminate the need for any kind of physical connection. But traditional wireless options are unable to keep up with the bandwidth requirements as well.

## Solution

A little used portion of the wireless spectrum known as the millimeter wave spectrum band has all the bandwidth capability, and more, to ensure the highest fidelity and resolution of signal from source to receiver.



→ MMW E-Band is a critical technology within European Spectrum Strategy and 5G implementation

## AV industry application

- MMW E-Band is a useful technology for many AVP industry wireless applications = can supporting high data rate connectivity

- Portable and temporary links for high-definition video or HDTV transport = suited for live sports and events.

## Key features

- This solution offers up to 10Gbps and 40Gbps throughput in 70-80GHz E-band spectrum and 2.5Gbps in 60GHz V-band = depending on the Quadrature amplitude modulation (QAM) formats.
- High QAM format are less resilient to noise and interference and rain can affect signal transmission.
- Operating distances vary **from 1.6 to 20 km** for varying weather conditions depending of the link frequency and rain intensity.

## Impact mitigation

- Compared to optical fiber /coaxial wire MMW E-Band is a low carb technology for portable / temporary links = -123, 5 kg $CO_2$ eq for outside links installation = - 94, 42%.

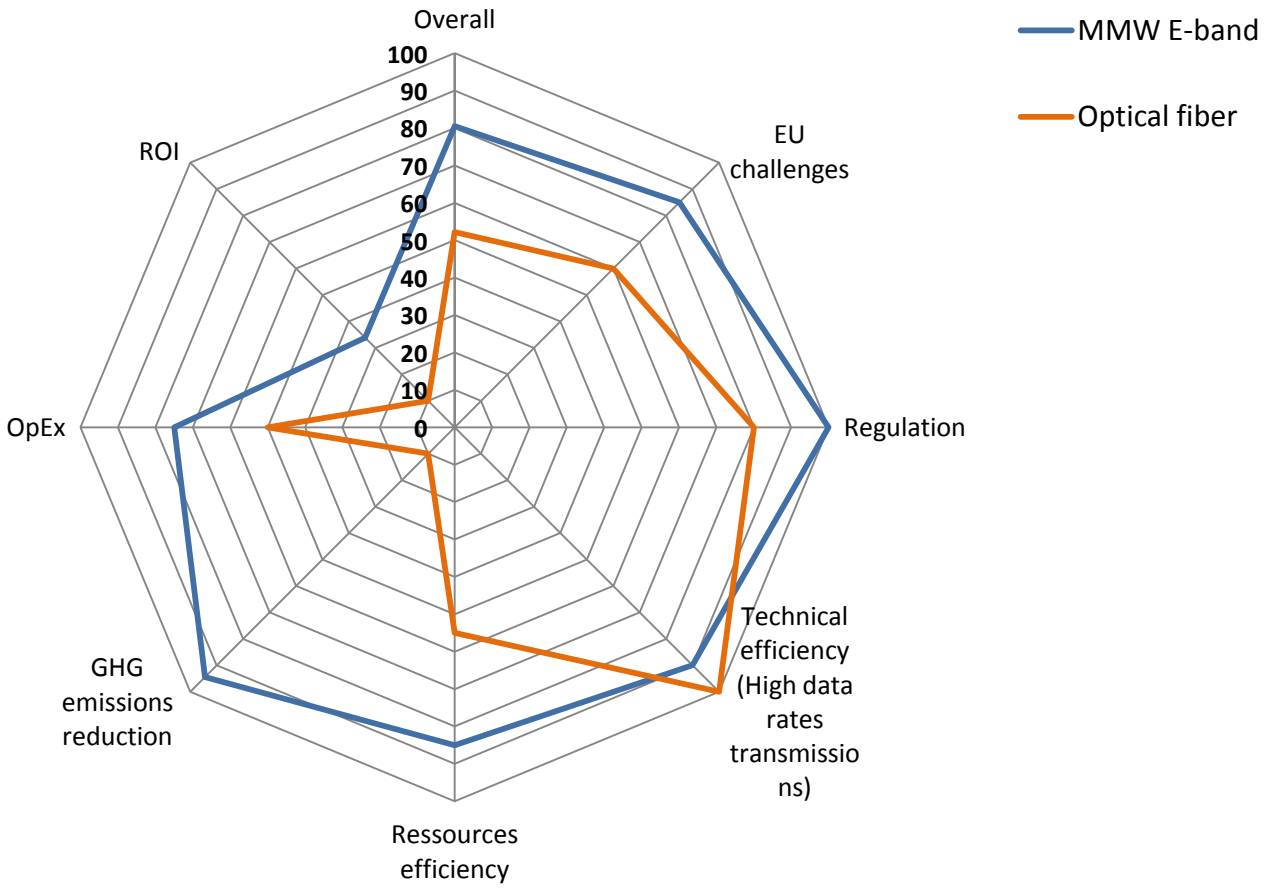
  Source: data from PEP ecopassport® Program – specific rules for Wires, Cables and Accessories

## Profitability

- MMW links installation 1 600 m.
- Assumption: 5 outside links per year in remote location.
- Compared to optical fiber ROI for a life cycle use of 1 year = 33, 87 %

→ MMW E-Band wireless network is cost-efficient

## Comparison to Optical fiber installation




## Conclusion

→ *MMW E-band can meet fiber performance +overall better performance than other wireless technologies> mmW, FSO, V-band; while being cost efficient and less harmful for the climate.*

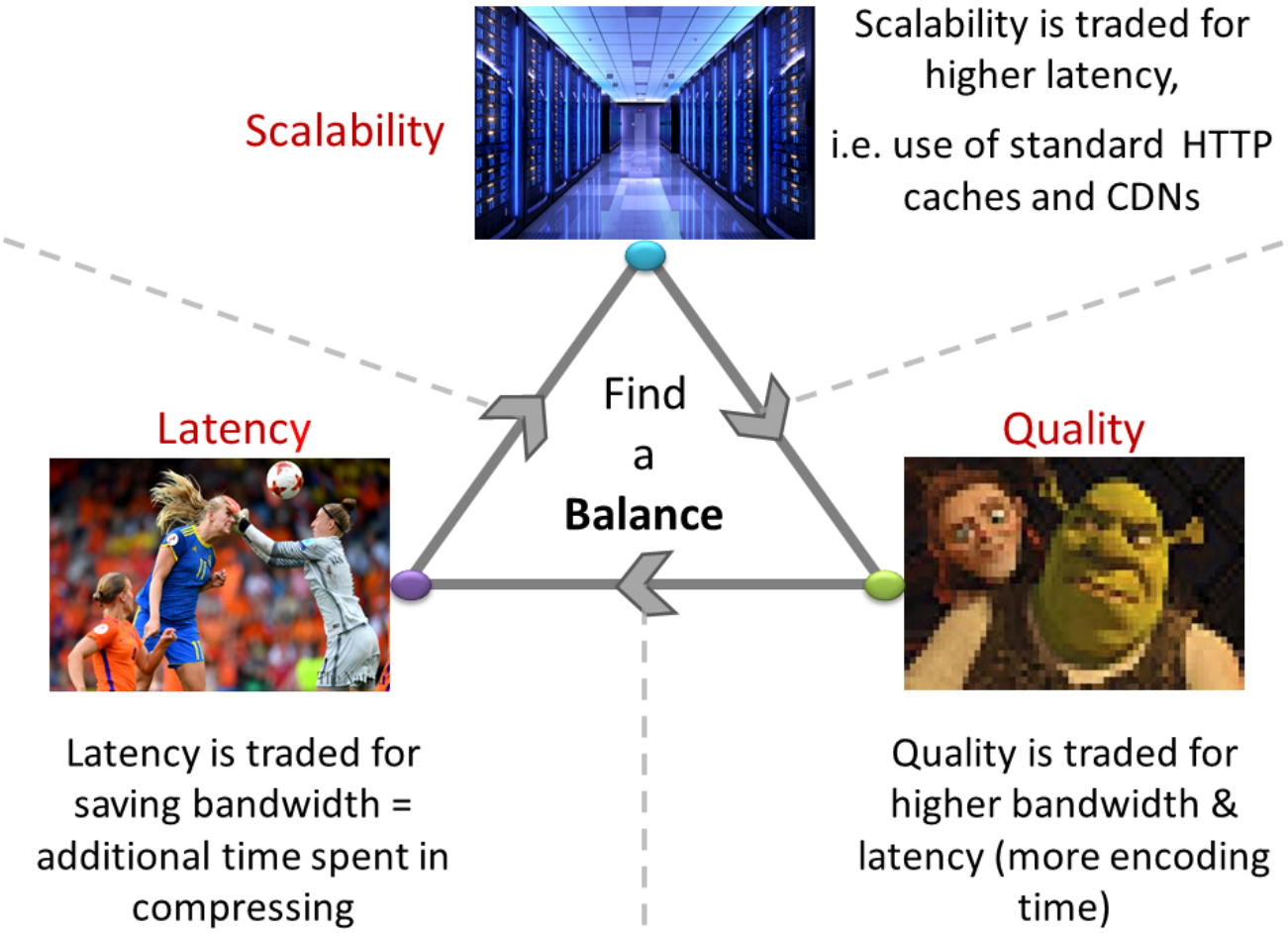
## 3. Broadcast IPTV/OTT – High efficiency streaming protocol (HESP)

### Context

Video streaming is accounting **for 79% of global Internet traffic in 2019 (82% in 2022).**

Video streaming consists in the encoding, transcoding, delivering, decoding & displaying of videos on smartphones, tablets, PCs, smart TVs & consoles. Videos distributed "over-the-top" (OTT) are streamed rather than distributed through traditional networks (broadcast, pay TV) and distributors (cable, satellite). Streaming protocols are playing a crucial role in transmitting data and controlling the server to deliver video to viewers.

The streaming equation = a tradeoff triangle between latency, scalability and quality.




→ The required bandwidth is soaring to new heights with the future implementation of 5 G and full HDR (4k being 4.5 times bigger compared to 720p), it is time to improve streaming protocol to cut bandwidth without compromise latency, scalability and quality

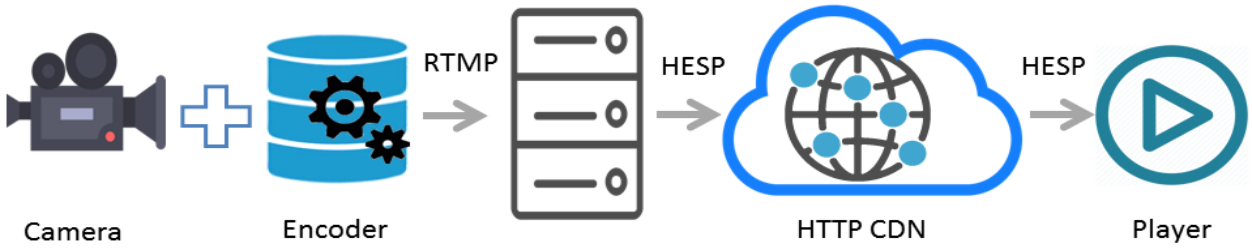
Sources:

- Cisco Visual Networking Index Complete Traffic Forecast (2017–2022)
- Data centres and energy – from global headlines to local headaches? – IEA 2019 report

### Solution

A new High Efficiency Streaming Protocol (HESP) embedded in playback player, has been designed to generate a well balanced response to the streaming' trade off triangle by delivering cost, user experience and environments benefits. HSE can replace standard /low/real-time latency streaming protocols (e.g. CMAF-CTE) to deliver:

- Improved performance ;
- High scalability ;
- Reduced cost ;
- CO2 mitigation.




## AV industry application

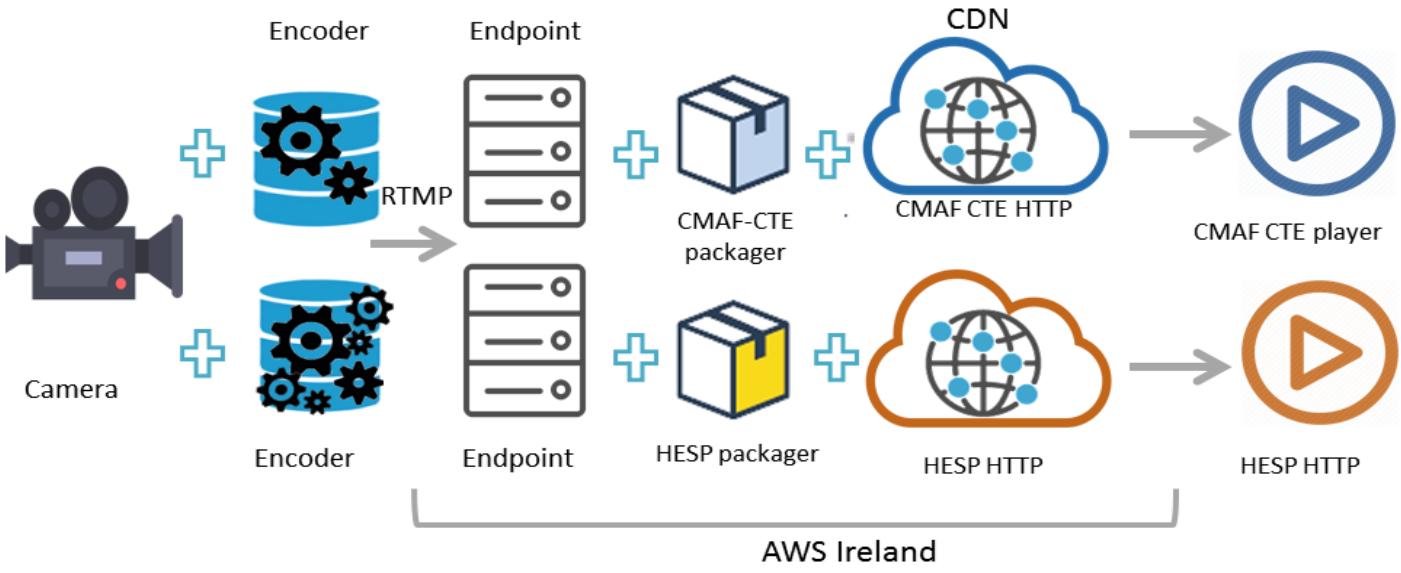
- OTT/IPTV broadcast.

## Key features

- Shortening zapping times to about 100ms to allow for similar to traditional broadcast experiences;
- Bringing down bandwidth costs and optimizing viewer bandwidth usage up to 20% (average 10-15%);
- Scalable using HTTP CDNs, allowing for virtually endless scaling in a cost efficient manner;
- Deliver a low latency stream which can dynamically adapt to viewer environments (platforms/devices/network);
- Designed to support adaptive bitrate switching = allows immediate switching to alternative renditions.

## Impact mitigation

- Comparing bandwidth usage at the same latency- test set-up: CMAF-CTE vs. HESP




- Estimated carbon mitigation for 1 hour of video streaming/viewer at 720 p resolution and 15 MBps -file of 1, 787GB- from video test encoder Meridian…, at low latency (2,33s)= **-1,44 g $CO_2$** i.e.= **- 10,04%**
- Main sources:
  - Shehabi, A., Walker, B. and Masanet, E., 2014. "The Energy and Greenhouse-gas Implications of Internet Video Streaming in the United States." Environmental Research Letters, 9(5), p.054007.
  - Aslan, J., K. Mayers, J.G. Koomey, and C. France. 2017. "Electricity Intensity of Internet Data Transmission: Untangling the Estimates." Journal of Industrial Ecology.

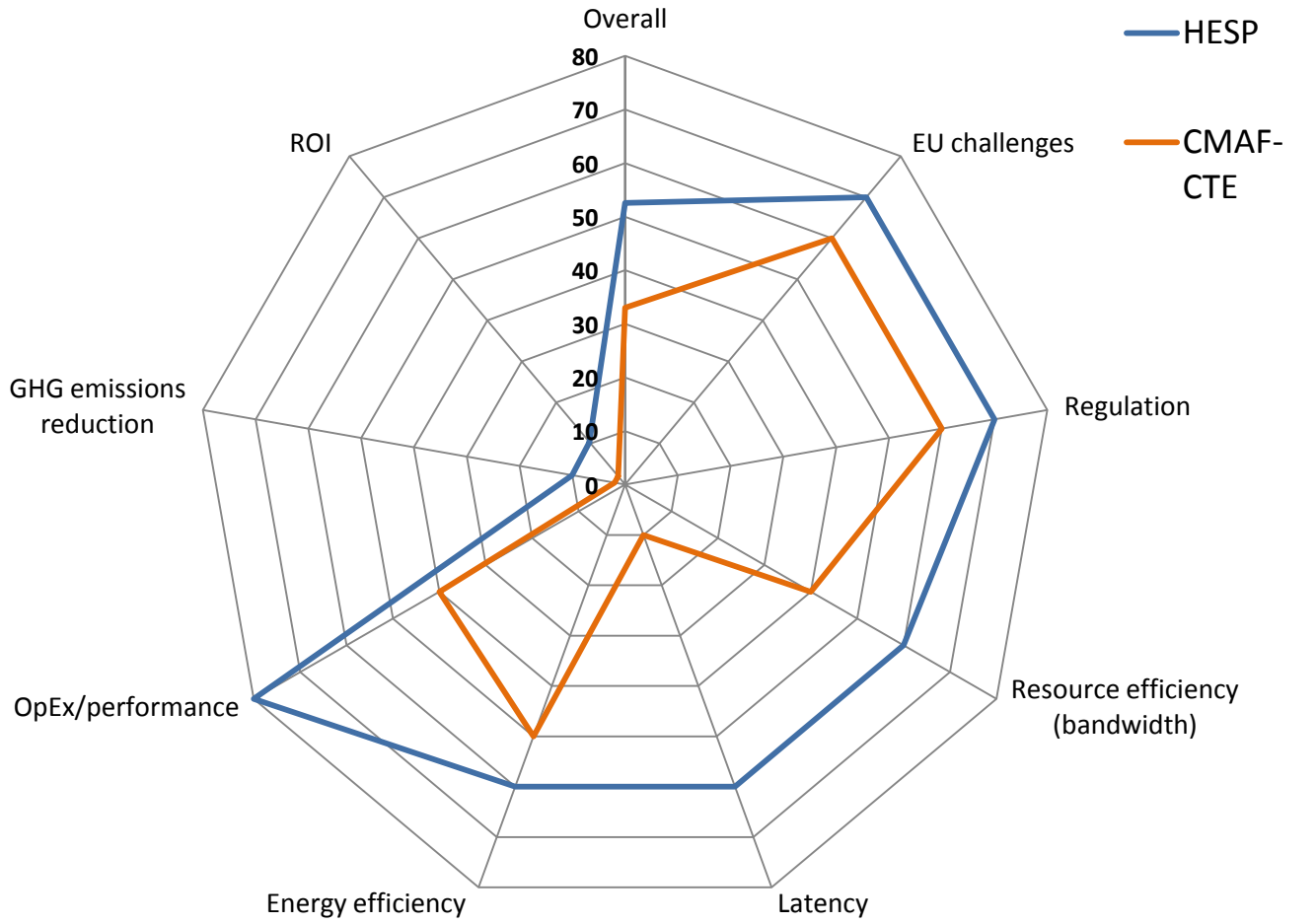
## Profitability

- Assessment made with bandwidth pricing of Amazon CloudFront (AWS CDN) - Data Transfer Out (**Origin**) = 0, 018€/ GB.

- ROI HESP for 1 hour streaming/viewer with a CDN = **10, 34%%.**

→ The mitigation by hour of stream per end-user may seem small: - 1, 44 g CO2 at same latency (2,30s, which is below IPTV broadcast), but considering the huge volume of video streaming (79% of the traffic), the potential reduction in carbon emissions is very significant.

## Comparison to conventional streaming protocol CMAF-CTE




## Conclusion

→ *Innovation that can help to mitigate the impact of video streaming and the future 4k and 5G implementation*

# 4. Broadcast IPTV/OTT - Hybrid content delivery network (CDN)

## Context

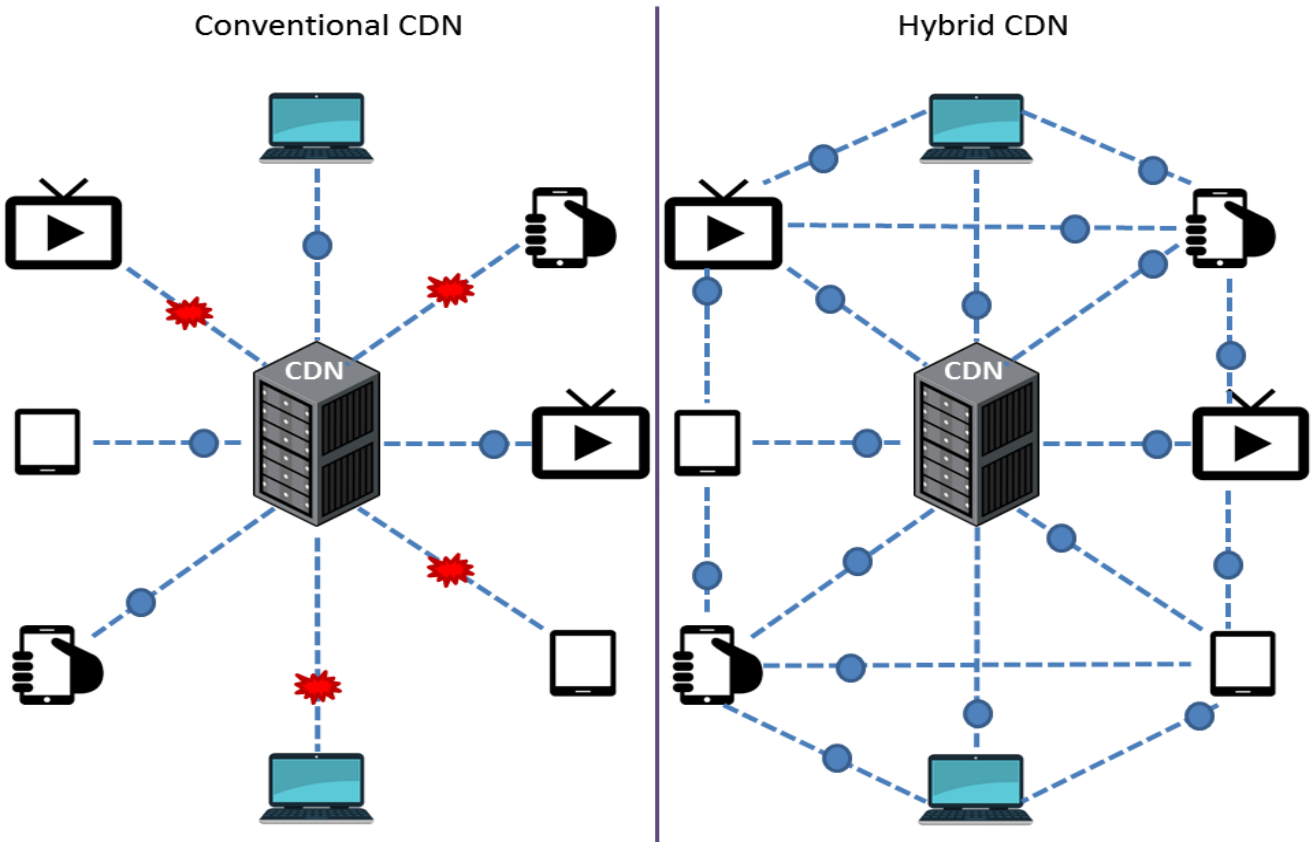
Global internet traffic reached 1.6 zettabytes in 2018, 56% of that traffic is carry through content delivery networks (CDNs) = standard unicast delivery. **Annual global IP traffic will reach 4.8 ZB per year by 2022**, CDNs will carry 72% of this traffic.
In addition, video streaming is accounting **for 79% of global IP traffic (82% in 2022)**. This explosion of IP traffic and video content will make it difficult for content delivery system providers to manage scalability and meet service level agreements.

Sources: Cisco Visual Networking Index Complete Traffic Forecast (2017–2022)

→ In this context, it is essential to design **new broadcasting solutions** to improve the quality of experience: cancel the buffering and limit the negative impact of this digital consumption: exponential growth of the datacenters infrastructure and its **associated environmental impacts**: GHG, use of rare earth elements and CRMs materials, land take…

## Solution

Disruptive hybrid solution combining standard unicast delivery (CDN) model with Peer-to-Peer (P2P) adaptive streaming mode = viewers obtain first segments from the servers and the rest directly from each other = http adaptive streaming +P2P




→ This solution is turning large audience's devices: Set-Top –box (STB), mobile, and computers… into broadcasting resources.

## AV industry application

- OTT/IPTV broadcast.

## Key features

- This solution combines client/server and viewer to viewer communication with a set for algorithms to manage the quality and cost of streaming = turnkey OTT end-to-end solution that covers the whole streaming spectrum of features.
- Bandwidth can be cut by up to 70% for video contents and up to 90% for audio content (when there is a large audience).
- Broadcasting benefits: improved QoE, QoS and reducing costs (bandwidth).

## Impact mitigation

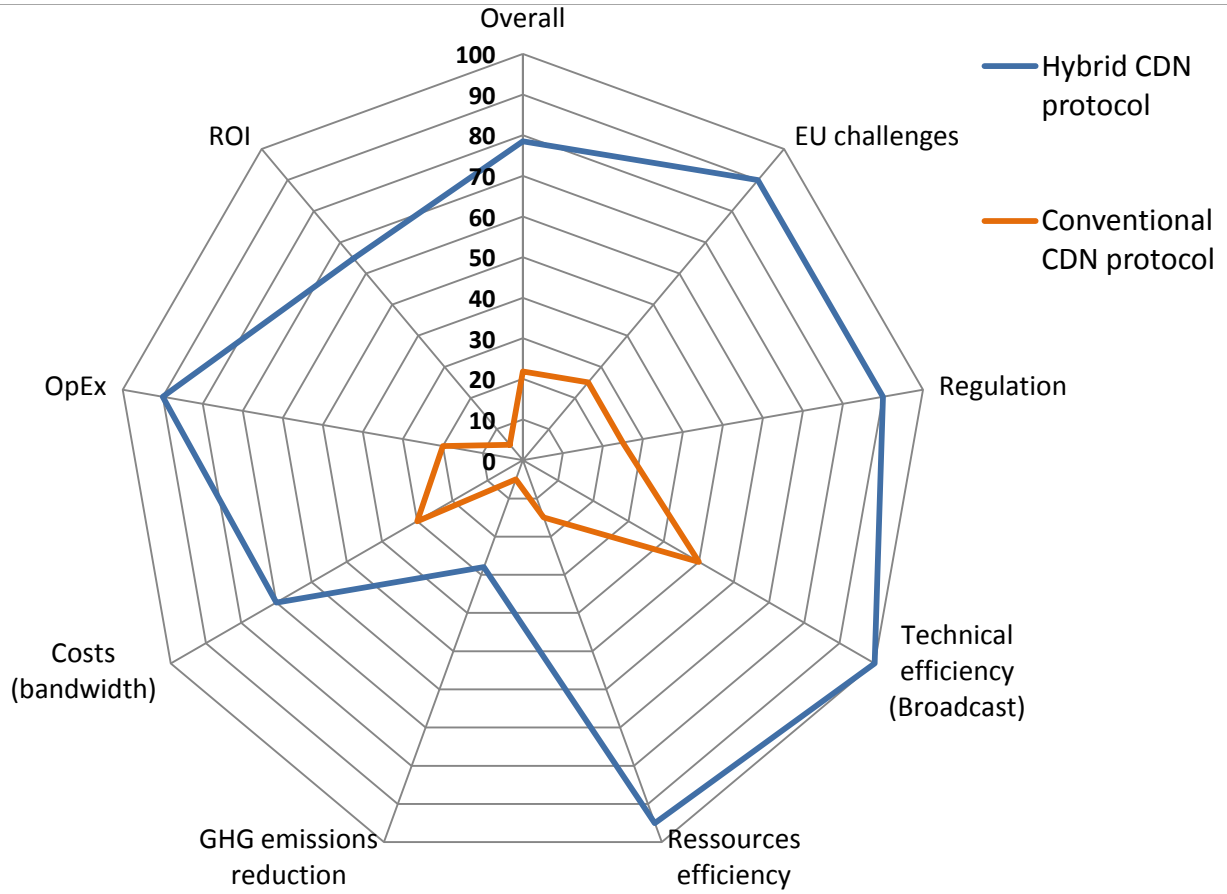
- Estimated carbon mitigation for 1 hour of video streaming/viewer at 720 p resolution and 15 MBps -file of 1, 787GB- from Netflix test encoder Meridian…, at low latency (2,33s)= **-0,082g CO2** i.e.= **- 28%**
- Main source: Shehabi, A., Walker, B. and Masanet, E., 2014. "The Energy and Greenhouse-gas Implications of Internet Video Streaming in the United States." Environmental Research Letters, 9(5), p.054007.

## Profitability

- Assessment made with bandwidth pricing of Amazon CloudFront (AWS CDN) - Data Transfer Out (Internet/**Origin**) = 0, 018€/ GB.
- ROI for an HD streaming video of 1h50 (football match) with hybrid CDN = **64, 81%.**

→ Thanks to its cost-efficiency this solution is going to spread fast.

## Comparison to conventional CDN low latency streaming protocol




## Conclusion

→ *Hybrid CDN protocol greatly increases the flow at constant data center infrastructure for a reduced cost.*

## 5. Building/on-site energy generation – Thermo-digital micro cogeneration

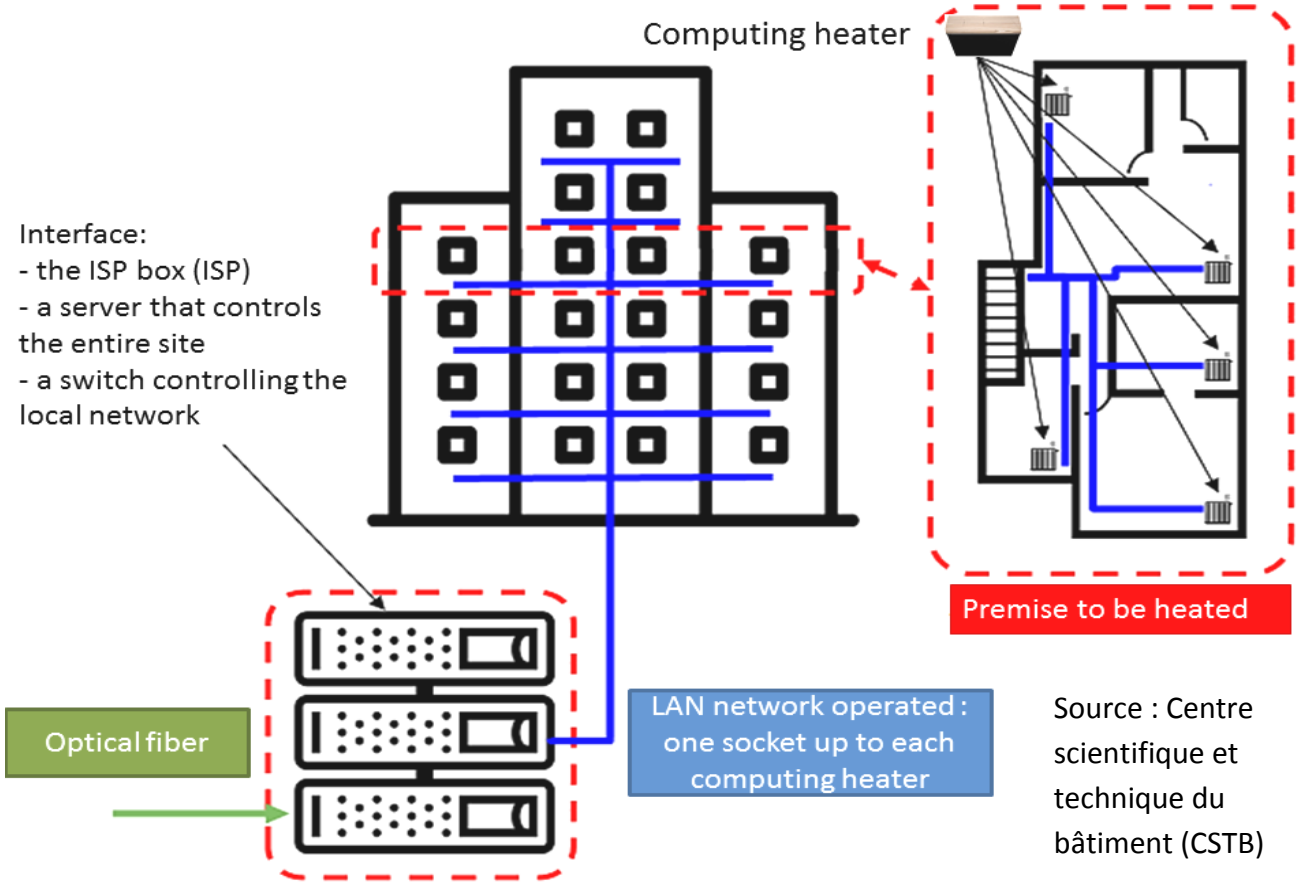
### Context

Digital technologies such as the "cloud", the Internet of Things (IoT), big data, e-commerce, social platforms, require more and more are energy-hungry processing and storage infrastructures: the data centers (DC). In 2016, 3% of global electricity is consumed by data centers and estimates predict a share of 13% by 2030.

→ Since most of this energy is released into the atmosphere in the form of wasted heat that fuels the global warming, the problem arises of its recovery / reuse.

### Solution

In parallel, with the development of micro data centers (Edge DC) that decentralizes servers in small units, installable anywhere; thermo-digital micro cogeneration has emerged in recent years.
These solutions can be implemented directly into buildings at low cost to provide heating and hot water; this improves the energy efficiency of the buildings. One of these solutions is the computing heater, i.e. **servers embedded in a heater.**




Source : Centre scientifique et technique du bâtiment (CSTB)

→ The operating principle of the process is to recover the fatal energy of computer servers, dedicated to calculations, and their power supply via an extruded aluminum heat sink to diffuse the heat. The process operates without a fan = no noise.

### AV industry application

- Additional heating solution.
- Computing capabilities available immediately without hardware investment e.g. for an animation, post-production studios.

### Key features

- The computing heaters are linked together by optical fiber to create a virtual datacenter.
- The regulation of the system is achieved by allocating more or less activities to the according to heating needs that depend on the seasons (**seasonal variability**).
- **In non-heating period** computer calculations are transferred to conventional data centers, or other computing infrastructures not occupied e.g. a warehouse.
- This solution also includes automation features provides by sensors incorporated = Smart building management (air, hygrometry, energy metrics, actimetry…)
- European Standard EN 15232 ("Energy Performance of Buildings - Impact on Building Automation") describes **methods for assessing the impact of automation and building management on energy consumption** = with computing heater sensors.

## Impact mitigation

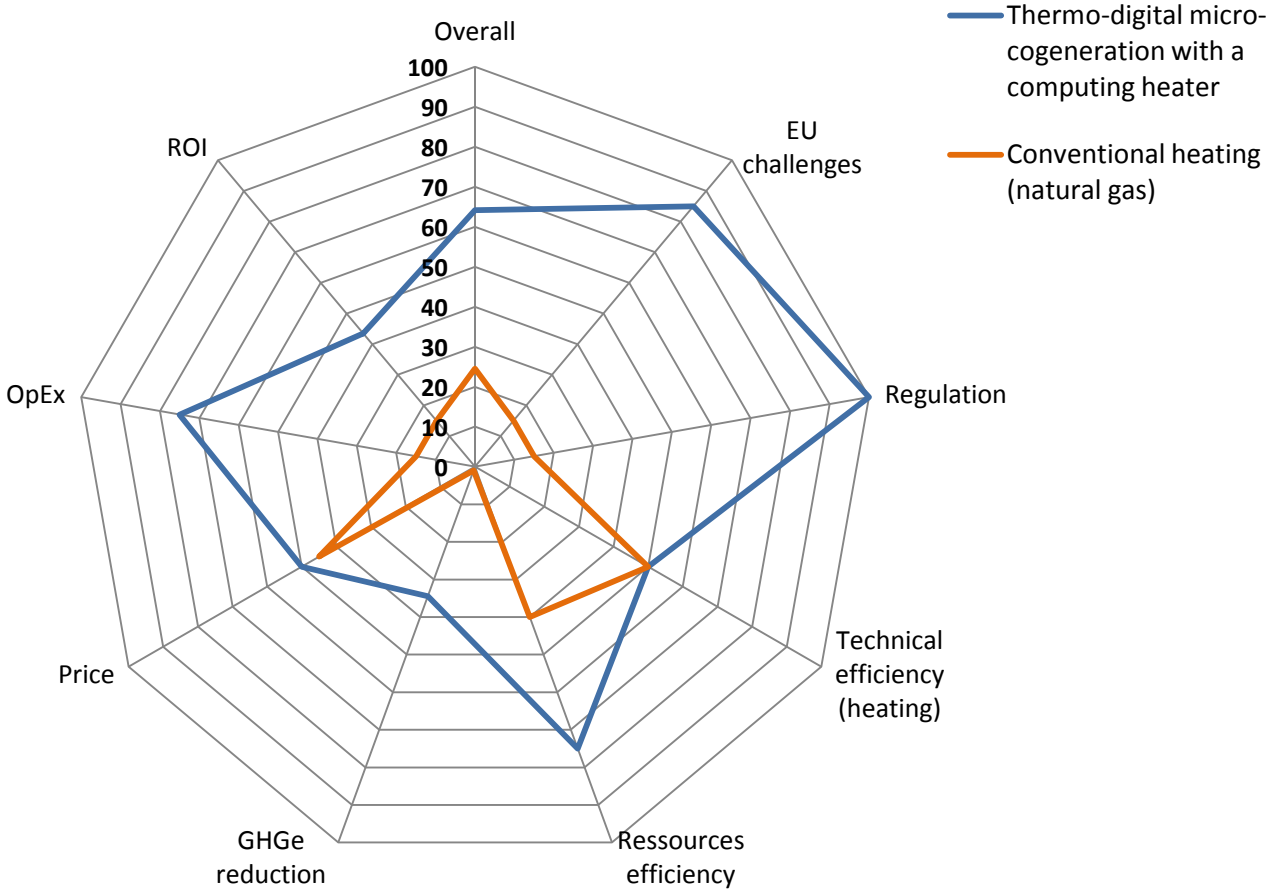
- If we take into account the carbon footprint of the computing compared to a conventional datacenter and the implementation of automation, the GHGe for heating is significantly lower than natural gas heating = - 2,305 kg $CO_2$/m2/year = - 34,5%.

## Profitability

- Electricity bill are paid back = SME will not suffer the price increases of electricity.
- Freely replaced every 5 years.
- ROI for a life cycle of 10 years = 43, 5 %

→ As electricity is repaid, the higher the price per kWh, the higher the ROI will be.

## Comparison to conventional heating (natural gas)




## Conclusion

→ *This solution is better suited for northern European countries.*

# 6. Building/on-site energy generation - Glass BIPV (building integrated PV)

## Context

The most common and promising renewable energy source is photovoltaic (PV). Interest in the building integration of photovoltaic, where the PV elements actually become an integral part of the building, is growing worldwide.

→ After integrating PV to the facade and the roofs, the last available space is the windows one.

## Solution

PV glass incorporates transparent semiconductor-based PV cells; cells are sandwiched between two sheets of glass. PV glass is not perfectly transparent but allows some of the available light through.

→ PV glass is available with a variety of options including different colors, gradient and patterns as well as double or triple-glazed.

## AV industry application

- PV glass is an adaptive tech that can achieve a better energy efficiency for AVP industry' buildings= all the electricity generated can be:
  - consumed on site e.g. by light points,
  - store in an energy storage system (ESS) to be consumed at night
  - send to the grid to earn additional revenue

## Key features

- Compared to conventional glass and PV module, PV glass has many advantages :
  - Selective Infrared Filter
  - Selective UV filter
  - Solar heat gain coefficient (SHGC)
  - Natural lighting
  - Thermal transmittance (U-value)
  - Accoustic performance
  - Electricity generation
- PV Glass can also be customized in shape, color, size (up to 8 Square meter), thickness, and semi-transparency degrees, easing its integration within any project and design.
- Develop the energy efficiency of the building and its energy autonomy.
- Production of electricity decreases with the degree of transparency (low density of PVcells) = find a balance between natural lighting & electricity generation.

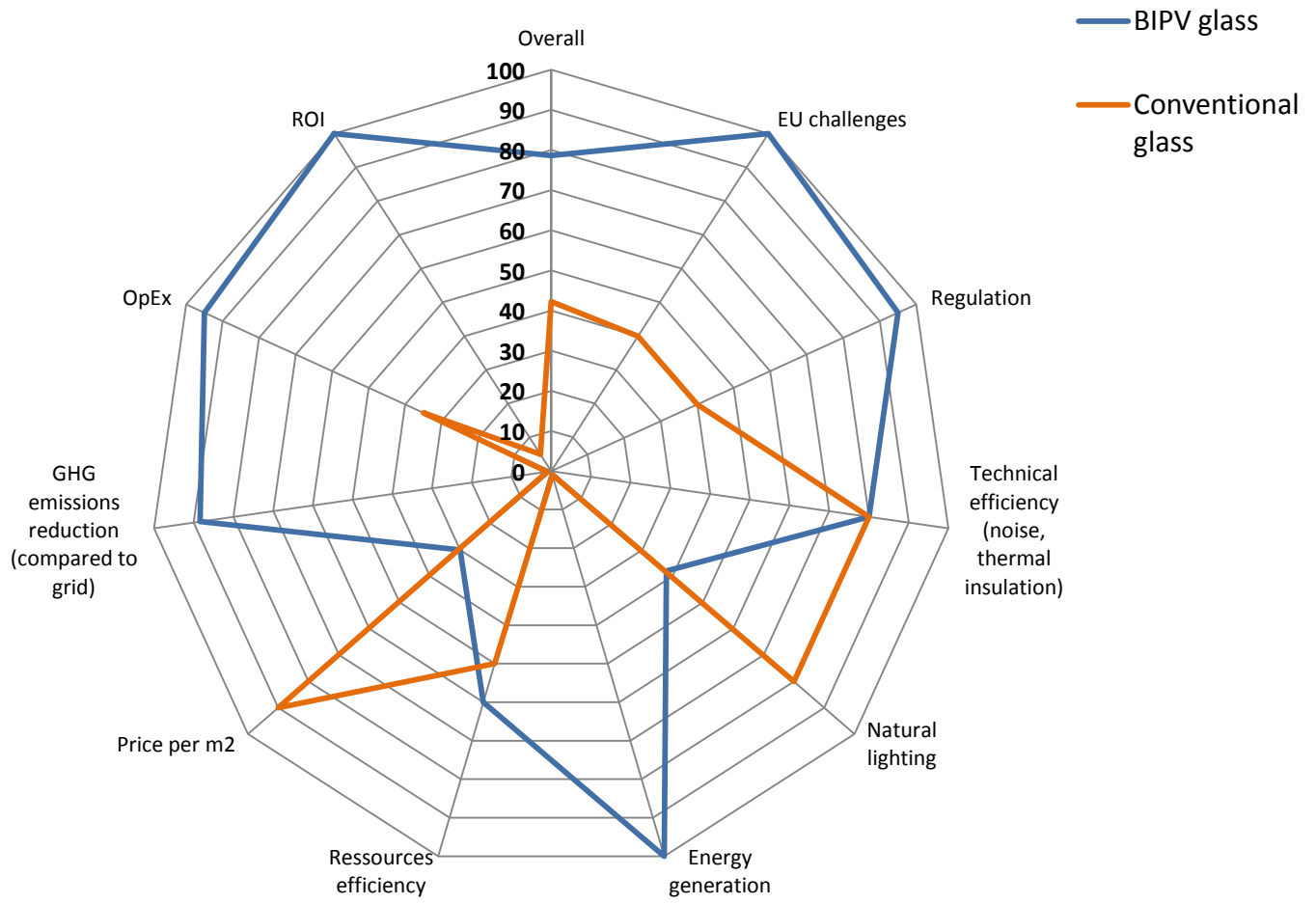
## Impact mitigation

- Avoided GHGe compared to grid per kWh generated:
  - - 261,5 g $CO_2$ eq /kWh = - 88,4 %

## Profitability

- PV Glass maximizes the performance of the building's envelope; it is able to completely offset the energy demand for indoor air conditioning.
- The main economic advantage lies in reducing the cost per kWh and its fixity in the long run =0, 03 € to 0, 01 €/kWh with a life cycle of 30 years.
- A-SI cells with a transparency degree of 30% + 1/2" air chamber + clear glass - ROI in 30 years = 44 %.
- The ROI partially depends on the incentives for the energy transition.
- ROI will be higher or lower depending on geographical location = better in southern Europe, lower in northern Europe.

## Comparison to conventional glass (double-glazed)




## Conclusion

→ *Long-run investment that mitigates the effects of grid' future increased tariff.*

# 7. Building office/studio HVAC management - Photocatalytic paint for solar energy reflectance

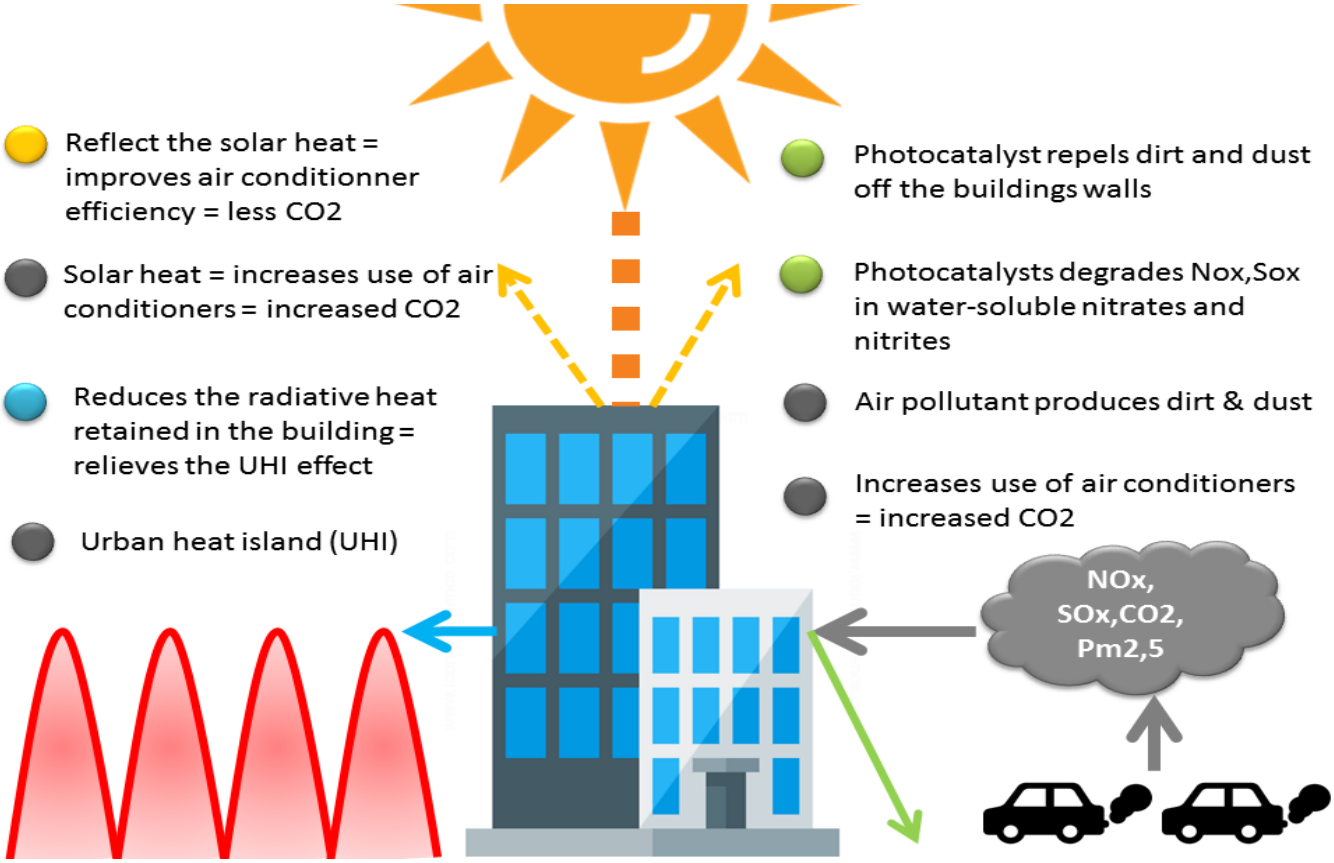
## Context

A warming world will result in energy demand for cooling overtaking that for heating by 2050. Energy use for air conditioning, refrigeration and other cooling appliances will jump 90% on 2017 levels posing a tremendous challenge for energy grids and efforts to curb climate change. Source: Green cooling initiative.
Moreover, cooling can be major contributor to the heat island effect, as well as a consequence. Cooling by means of an AC, which simply moves heat around, requires the evacuation of hot air to the outside of buildings. It is estimated that **air conditioning can raise temperatures by more than 1°C overnight in some cities**. Higher outdoor temperatures in the summer increase the overall need for cooling, leading to more hot air, higher temperatures and increased use of cooling in a classic **feedback loop**.

→ the 2030 Climate & Energy Framework sets a target to reduce carbon emissions 40% below 1990 levels = the mitigation of carbon emissions from cooling systems is one of the key European challenges.

## Solution

Photocatalytic paint, which is a technology based on the photocatalytic oxidation effect of Titanium dioxide (TiO2), purify air **and downsize the buildings cooling needs**, by reflecting sunlight.




→ The **solar reflectance** determines the fraction (%) of the solar radiation incident from all directions that is diffusely reflected by the surface back into the atmosphere.

## AV industry application

- Reduces the cooling needs for offices, studios, render-farms/server room...

## Key features

- Reflect the solar radiation but also the heat = increases heating energy consumption during winter = this solution is suitable for southern Europe or dedicated technical building e.g. data center.
- Building resilience & reducing vulnerability to climate-related disasters: heat-waves.
- Very efficient **thermal shielding =** 89 % of solar radiation are reflected with this solution.

## Impact mitigation

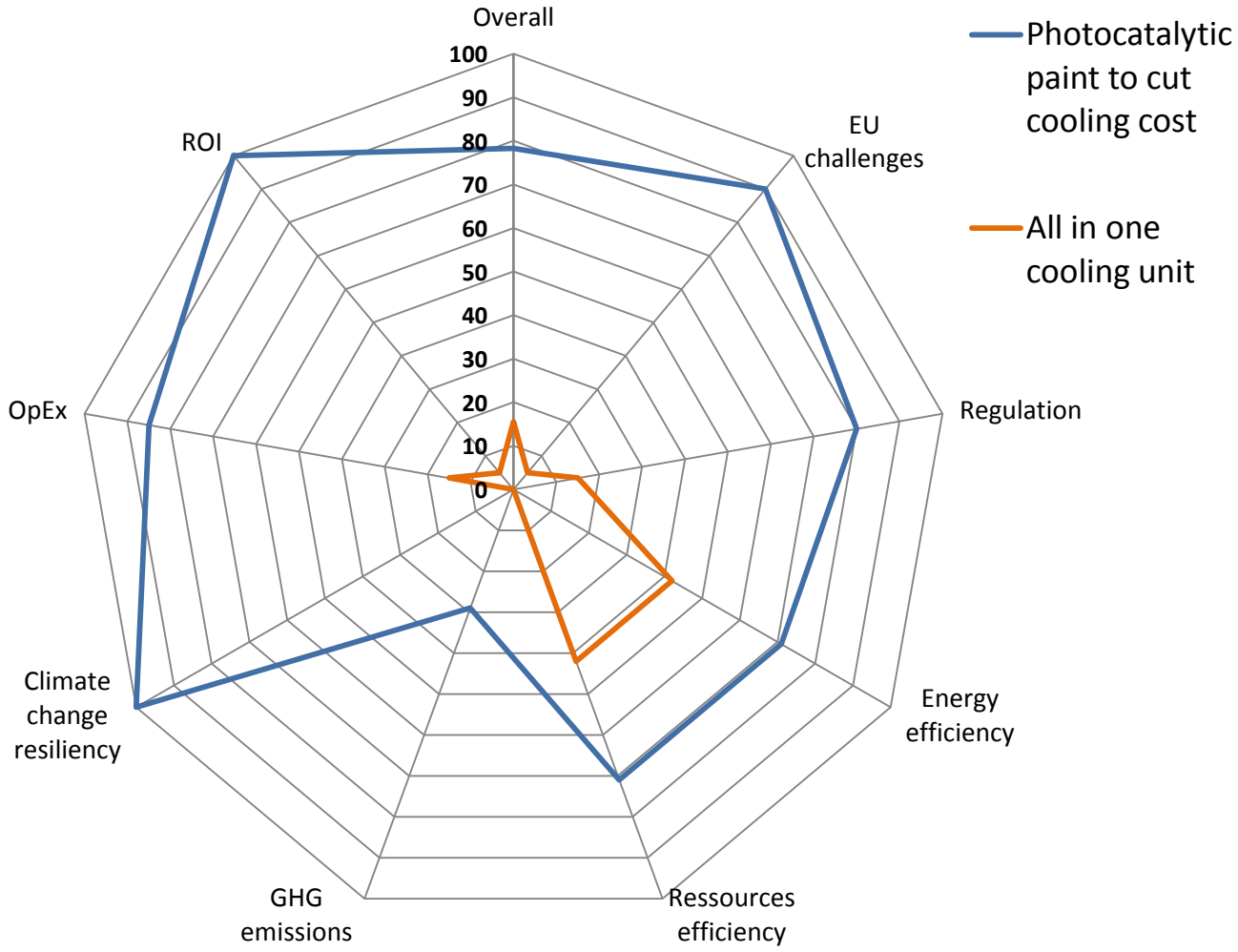
- Up to 29 % Cooling energy savings for a render farm/server -room =
  - -224,895 kWh/m2 /year
  - - 66,37 kg$CO_2$/m2/year

  Source: data from iSERVcmb project (final report)- SERVcmb Measured Energy Consumption Data by HVAC Component and Activity: European Union as a whole - Intelligent energy Europe initiative.

## Profitability

- ROI for a 300 m2 premise which include a server room/render farm + a high density IT suite = 865 %.
- The realization of this ROI will depend on the geographical position of the building and its exposure to solar radiation

## Comparison to all-in one cooling system




## Conclusion

→ *This solution is easy to deploy and very cost-efficient.*

# 8. Building office/studio HVAC management - HVAC smart management

## Context

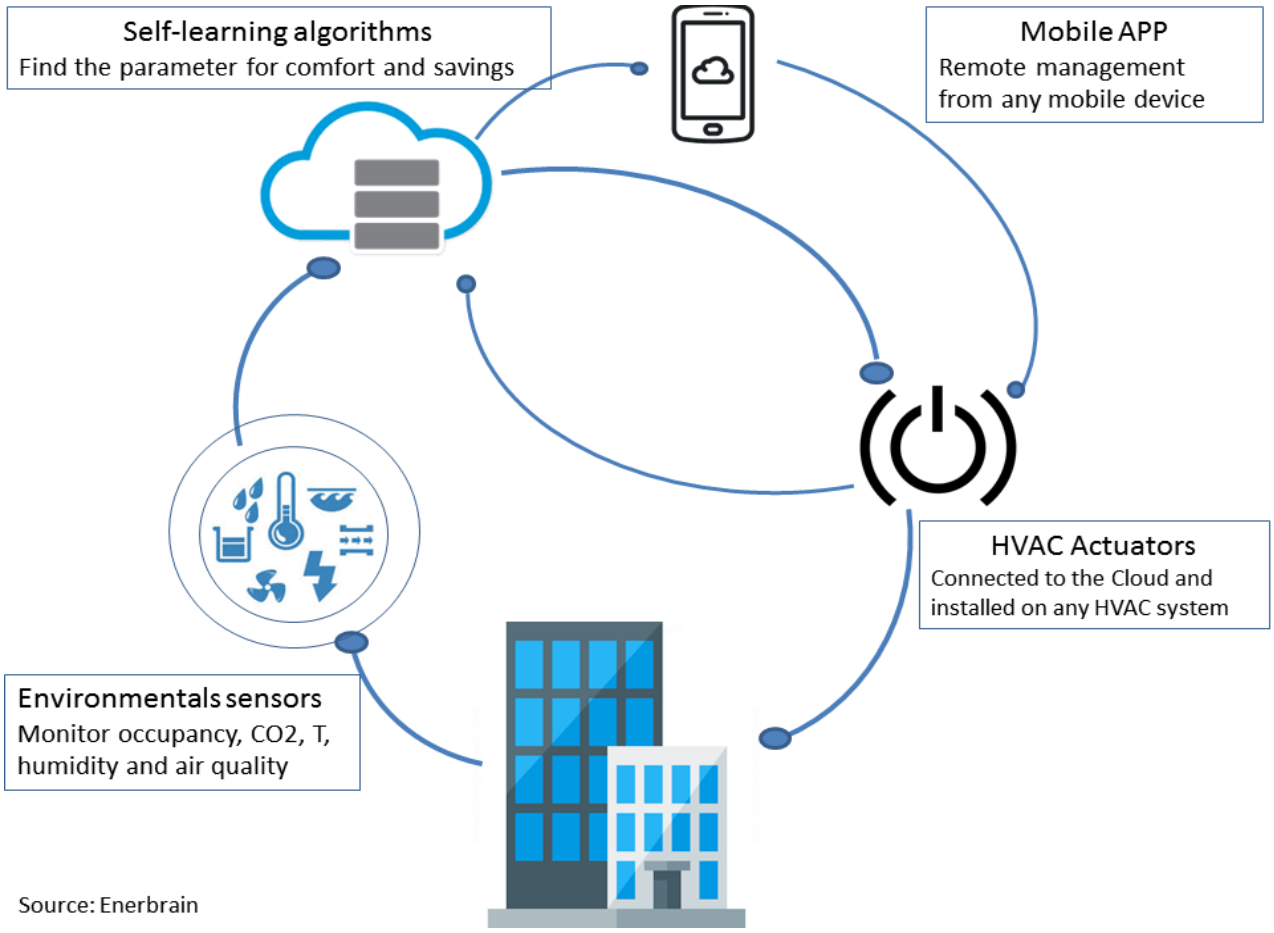
Buildings are responsible for approximately **40% of energy consumption and 36% of CO2 emissions in the EU**. Currently, about 35% of the EU's buildings are over 50 years old and almost **75% of the building stock is energy inefficient**, while only 0.4-1.2% (depending on the country) of the building stock is renovated each year. Therefore, more renovation of existing buildings has the potential to lead to significant energy savings - potentially reducing the EU's total energy consumption by 5-6% and lowering $CO_2$ emissions by about 5%.

Source: EU building stock observatory

→ There are solutions to improve the energy efficiency in buildings (EEB).

## Solution

Among all the retrofit solutions to improve EEB, building automation system are the easiest to deploy and the most cost efficient = its implementation doesn't require any costly renovation work.




→ Dynamic regulation of HVAC systems (heating, ventilation & air conditioning) that allows improving the indoor comfort and reducing consumption.

## AV industry application

- This solution can be applied to all types of buildings whatever their purpose and allows energy savings without modifying existing systems.

## Key features

- Wireless and battery-powered sensors (plug & play) that constantly monitor temperature, $CO_2$, relative humidity, VOC, pressure in strategic areas and send data to the Cloud.

- **Actuators** on the adjustments of the air handling units, on the circuits of the radiant panels, to the valves of heating systems…
- Installation takes few hours until 2 days.

## Impact mitigation

- Depending of the building, its destination and HVAC systems, this solution reduces energy consumption in average by - 35% compared to manual HVAC management (semi-automated) =
  - - 19,25 kWh/m2/year
  - - 5,69 kg $CO_2$/m2/year

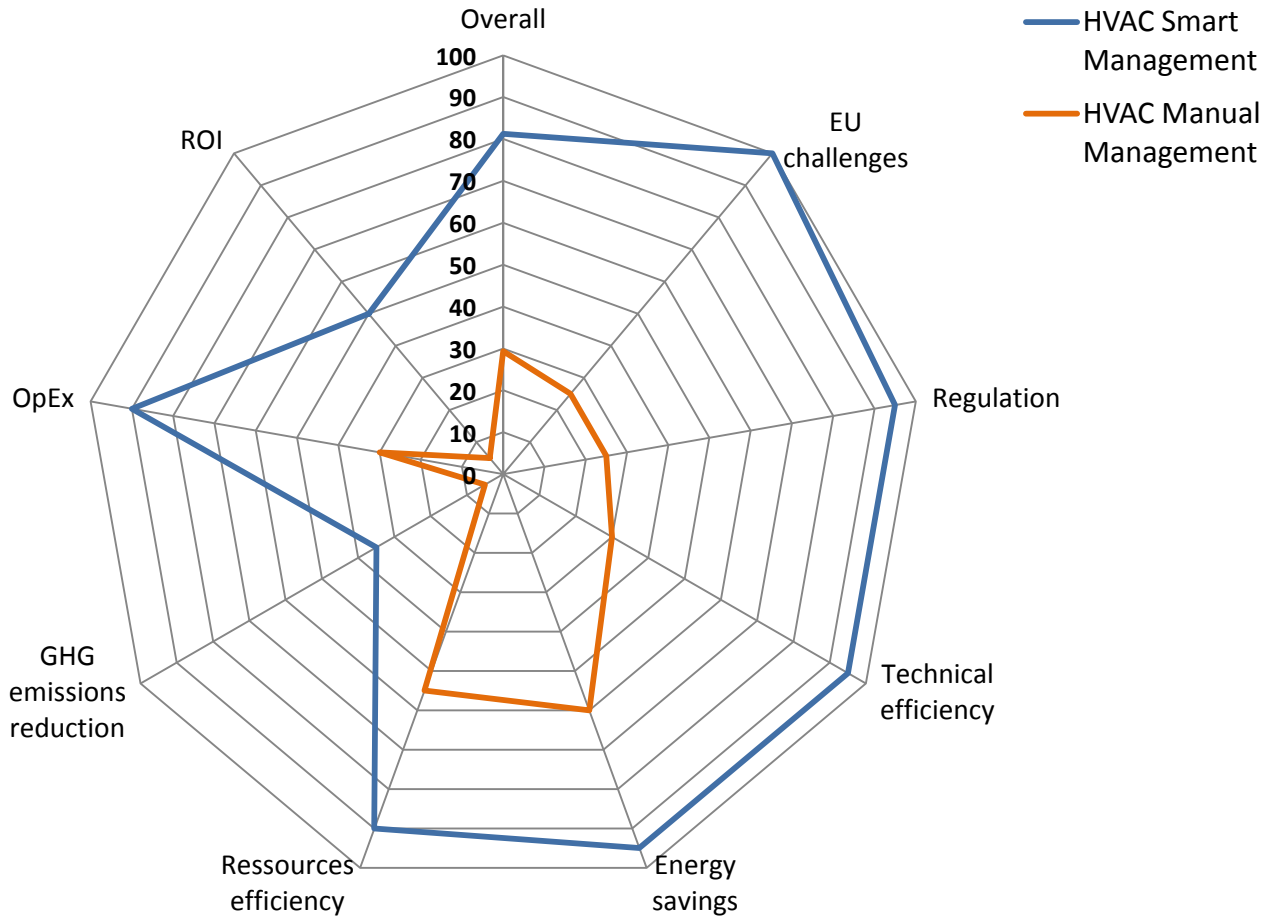
Sources: data from

- HARMONAC (final report) - Harmonizing Air Conditioning Inspection and Audit Procedures in the Tertiary Building Sector -EASME - Intelligent energy Europe initiative.
- iSERVcmb project (final report)- SERVcmb Measured Energy Consumption Data by HVAC Component and Activity: European Union as a whole - EASME - Intelligent energy Europe initiative

## Profitability

- Energy performance contracting = share of the energy savings and its inherent risks as a result of the implementation of energy efficiency measures i.e. the cost is based on energy savings results = 30 to 50 %.
- ROI per year/m2=17, 46%, it's a cost efficient service without any risk thanks to the EPC contract.

## Comparison to manual HVAC management (semi-automated)




## Conclusion

→ *Low cost solution to decrease building operational cost while mitigate its carbon footprint.*

# 9. Building office/studio HVAC management - Passive thermal storage as cooling complement

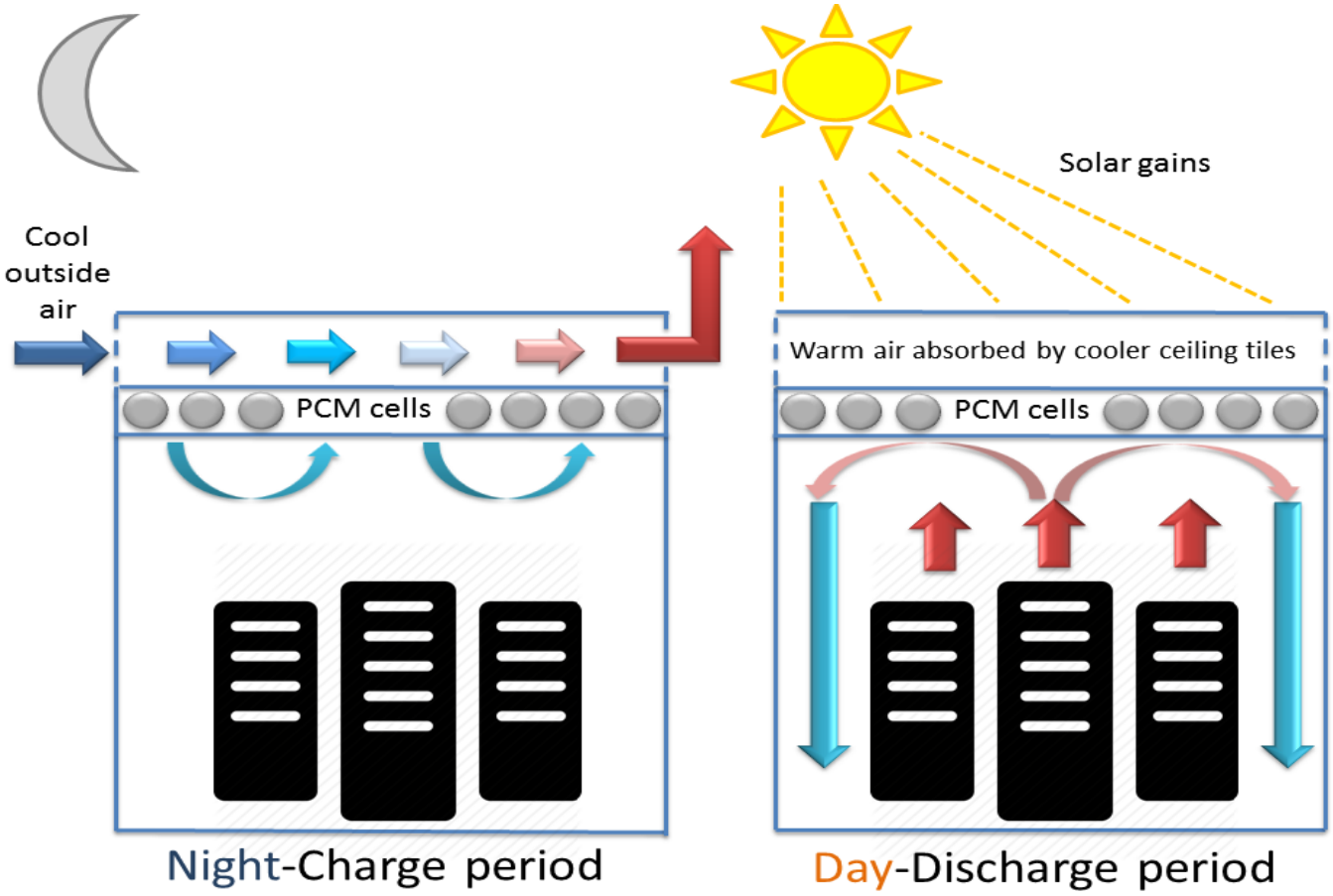
## Context

Since 1990 to 2016 the energy devoted to cooling systems has already increased by ≈ **337%.** Source: The Future of Cooling International energy agency (IEA)

→ the 2030 Climate & Energy Framework sets a target to reduce carbon emissions 40% below 1990 levels = the mitigation of carbon emissions from cooling systems is one of the key European challenges.

## Solution

Phase-change materials (PCMs) e.g. alcohol, wax, sugar, water, salt, are materials that, when they change phase (melt or freeze), absorb or release heat at a nearly constant temperature, and by doing this can be effectively used to store heat or cold. At the operational level PCMs can store heat or coolness (thermal storage), similarly to how electrical energy is store in batteries, using charging and discharging phases.
For the majority of applications (heat and cold/positive or negative temperature), PCMs have to be encapsulated in sealed containers/cells. Passive cooling relies on naturally occurring night and day time temperature swings. The cool energy available over-night is stored within the PCMs cells and later the stored energy is used to absorb the internal and solar heat gains during day-time for an energy free passive cooling system.




→ **This passive solution can be use as a cooling complement i.e. in conjunction with a conventional cooling system.**

## AV industry application

- This passive cooling solution can provide energy savings for many applications in AVP industry e.g. as a:
  - Back-up cooling for server-room/render farm during the 6 hot months of the year = Render farm continuity of service in case of a power shutdown

- Cooling complement for server-room/render farm during the 6 hot months of the year i.e. without running the chillers

## Key features

- Suited for any climate: PCM systems freeze over night, even in desert climates.
- Flexible System= the TES capacity can be exactly matched to system loads.
- Downsize cooling systems.
- As a cooling complement, helps to maintain the safe temperature limit (18/27 °c) in a render farm/ server room

## Impact mitigation

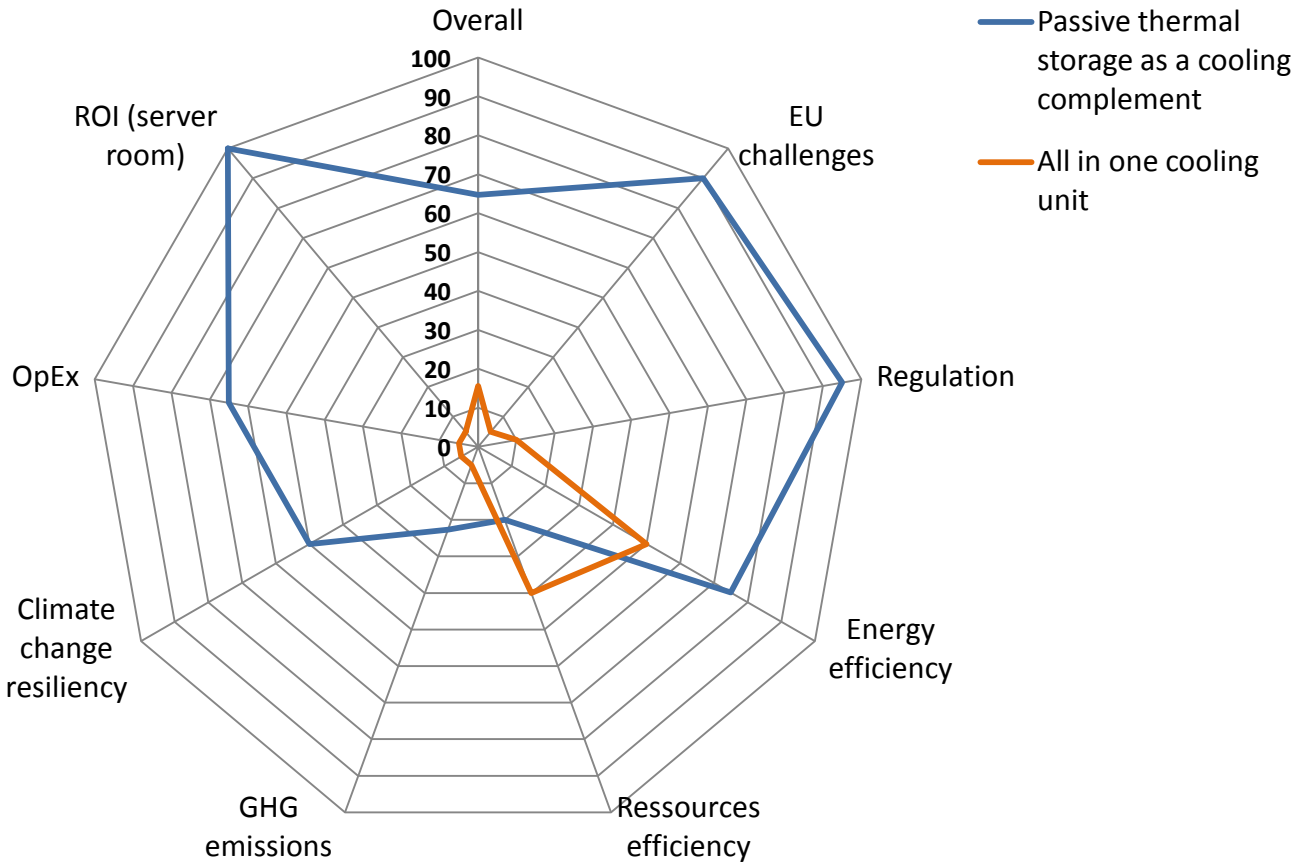
- Energy savings provided as a cooling complement compared to all in one cooling unit:
  - - 193,875 kWh/m2 / year
  - - 51,95 $kgCO_2$/m2/year = - 22,72 %

Source: data from iSERVcmb project (final report)

## Profitability

- ROI = 210 %, cost effective solution for additional cooling in a server room / render farm, however the ROI is negative for other spaces like High density IT suite, Meeting room, Open Plan Office Area…

## Comparison to all in one cooling unit




## Conclusion

→ *As a cooling complement, this solution should be reserved for spaces that have the highest cooling energy consumption = render-farm / server-room.*

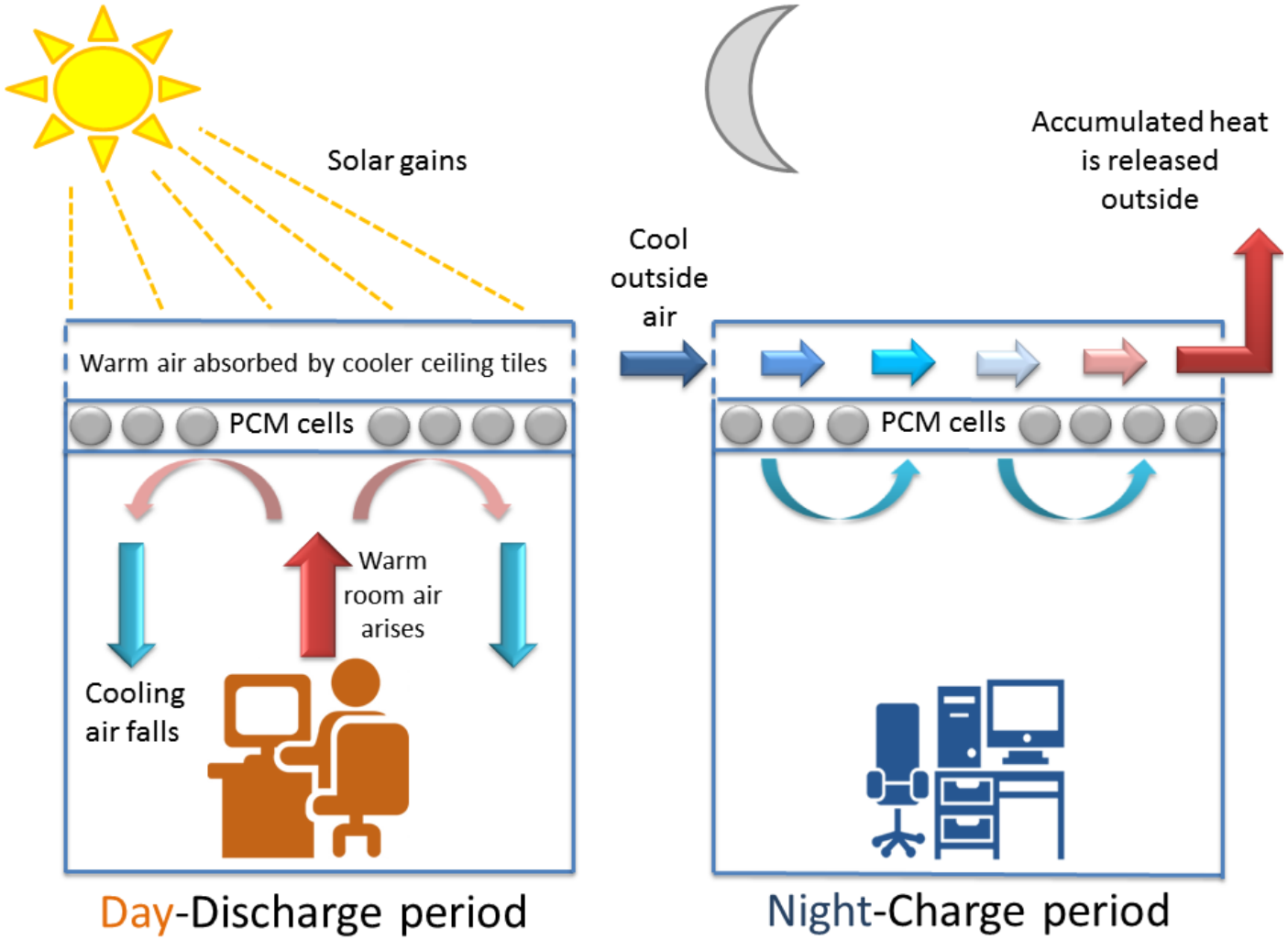
# 10. Building office/studio HVAC management - Passive thermal storage as free cooling

## Context

The 2030 Climate & Energy Framework sets a target to reduce carbon emissions 40% below 1990 levels = the mitigation of carbon emissions from cooling systems is one of the key European challenges.

## Solution

Phase-change materials (PCMs) e.g. alcohol, wax, sugar, water, salt, are materials that, when they change phase (melt or freeze), absorb or release heat at a nearly constant temperature, and by doing this can be effectively used to store heat or cold. At the operational level PCMs can store heat or coolness (thermal storage), similarly to how electrical energy is store in batteries, using charging and discharging phases.
For the majority of applications (heat and cold/positive or negative temperature), PCMs have to be encapsulated in sealed containers/cells. Passive cooling relies on naturally occurring night and day time temperature swings. The cool energy available over-night is stored within the PCMs cells and later the stored energy is used to absorb the internal and solar heat gains during day-time for an energy free passive cooling system.




→ **This passive solution can be used as free - cooling system i.e. as the sole source of cooling/ in replacement of air handling unit.**

## AV industry application

- Can be a retrofit solution for buildings/spaces that don't incorporate yet a cooling system e.g.:
  - Free cooling in equipment storing warehouses to protect batteries, electronics, cameras from the heat of the summer = for services/rental companies
  - Cool working spaces without machinery = Meeting room, Open Plan Office Area, catering room…

## Key features

- Retrofit solution to improve energy efficiency in buildings (EEB).
- Protect the building and the employees against the heat-waves.
- Decrease Heat island effect = none fatal heat rejection.
- Suited for office, open plan office, meeting room, lounges.
- Immune to electrical peak and power shutdown.

## Impact mitigation

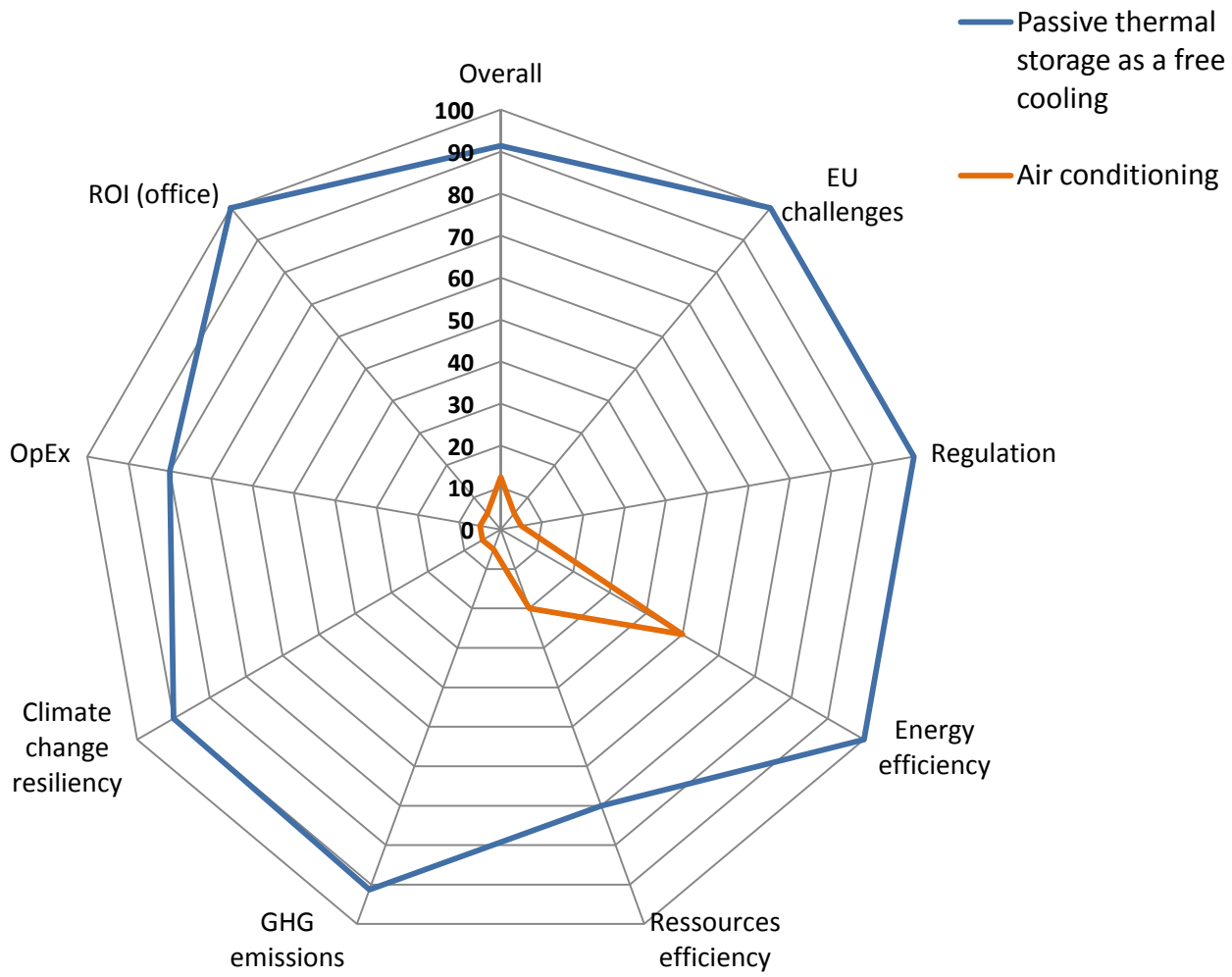
- Use as a free cooling in replacement of air conditioning (air handling unit), this solution greatly attenuates the carbon footprint due to its **lack of electrical consumption and refrigerant (HFC)** :
  - - 279,78 kg $CO_2$/m2/year (open plan office, meeting room…) = - 91,31%

Source: data from Clim'Foot European project - EASME - LIFE programme

## Profitability

- ROI for an office cooling = 141 %, i.e. comparison between this solution cost (installation) and an air-conditioning unit (installation and energy consumption costs for 10 years).

## Comparison to air conditioning system (air handling unit)



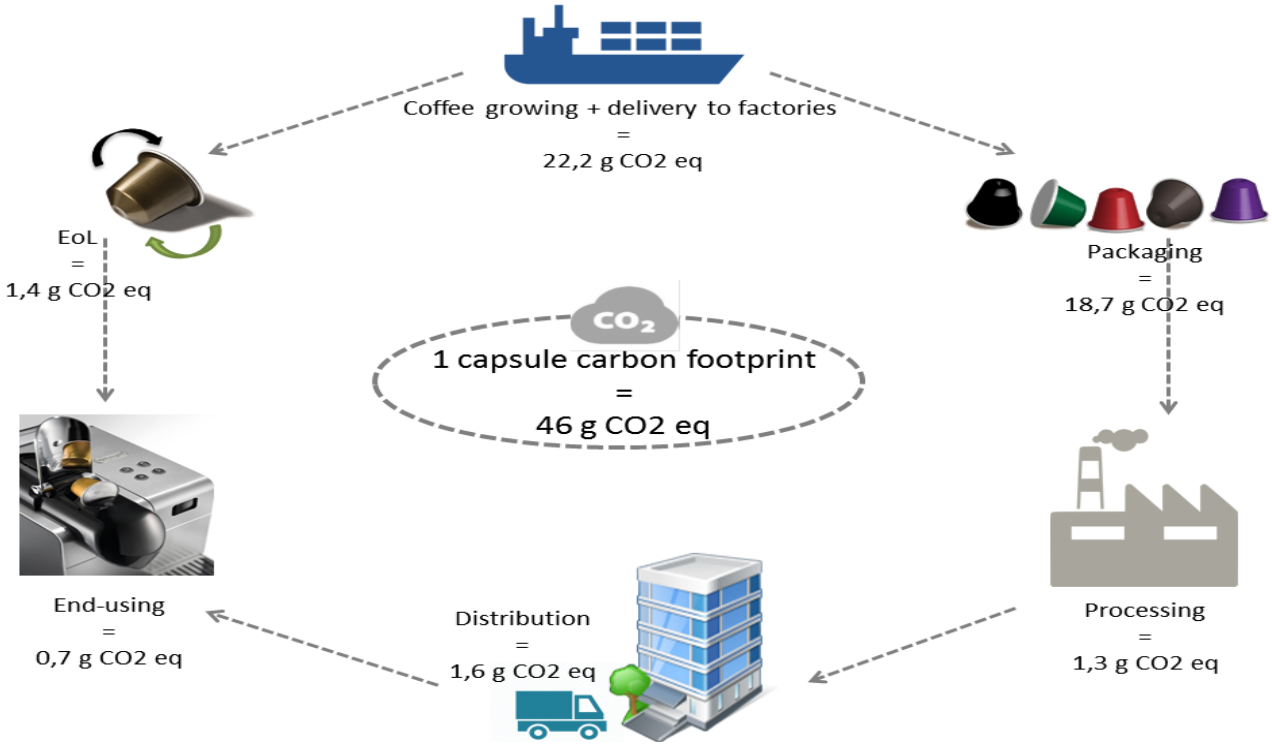

## Conclusion

→ *Passive thermal storage - free cooling is enough to cover cooling needs in office, meeting room and lounges.*

# 11. Catering - Percolator coffee machines fed with coffee beans for office and base camp

## Context

In 1995, the invention of the coffee capsule has revolutionized coffee drinking, fuelling the increasing popularity of espresso. Today in offices and bases camps, coffee is overwhelmingly delivered by capsules machines. Yet this craze for espresso hides an exorbitant economic and environmental cost: carbon footprint, low recyclability and much higher cost.




→ Today in offices and bases camps, coffee is overwhelmingly delivered by capsules machines. On a movie set around 8 000 coffee are consumed, with a capsule weighing 11,4 g including 5 g of coffee inside, it **represents 91,2kg of waste** = aluminium, paper, plastic & coffee ground.

## Solution

A 60 year-old technology: percolator coffee machines fed with coffee beans that generates no waste except coffee grounds, which is biodegradable.

## AV industry application

- 2 applications :
  - Stationary use = Office & Studio
  - Mobile use = Base camp

## Key features

- Coffee ground is fully recoverable:
  - Usable as biomass or in a digester to produce methane
  - Up-cycling in circular economy logic to make sustainable ink, cosmetics, bio-based raw material…
- A built-in grinding wheel generates noise: 60 dB i.e. equivalent to a dishwasher.
- Due to mechanical part: ceramic/metal grinder; the maintenance is heavier than capsule machine one.

## Impact mitigation

- Lower waste generated especially if the coffee bean come from a local roaster = recyclable packaging in paper/cardboard = - 6, 4 g per cup of coffee = -56, 14%.
- Help to preserve health :
  - Doesn't contains any aluminium particulates which are neurotoxic
  - Lower concentration in furan which is carcinogenic = - 74 ng/ml = - 72%

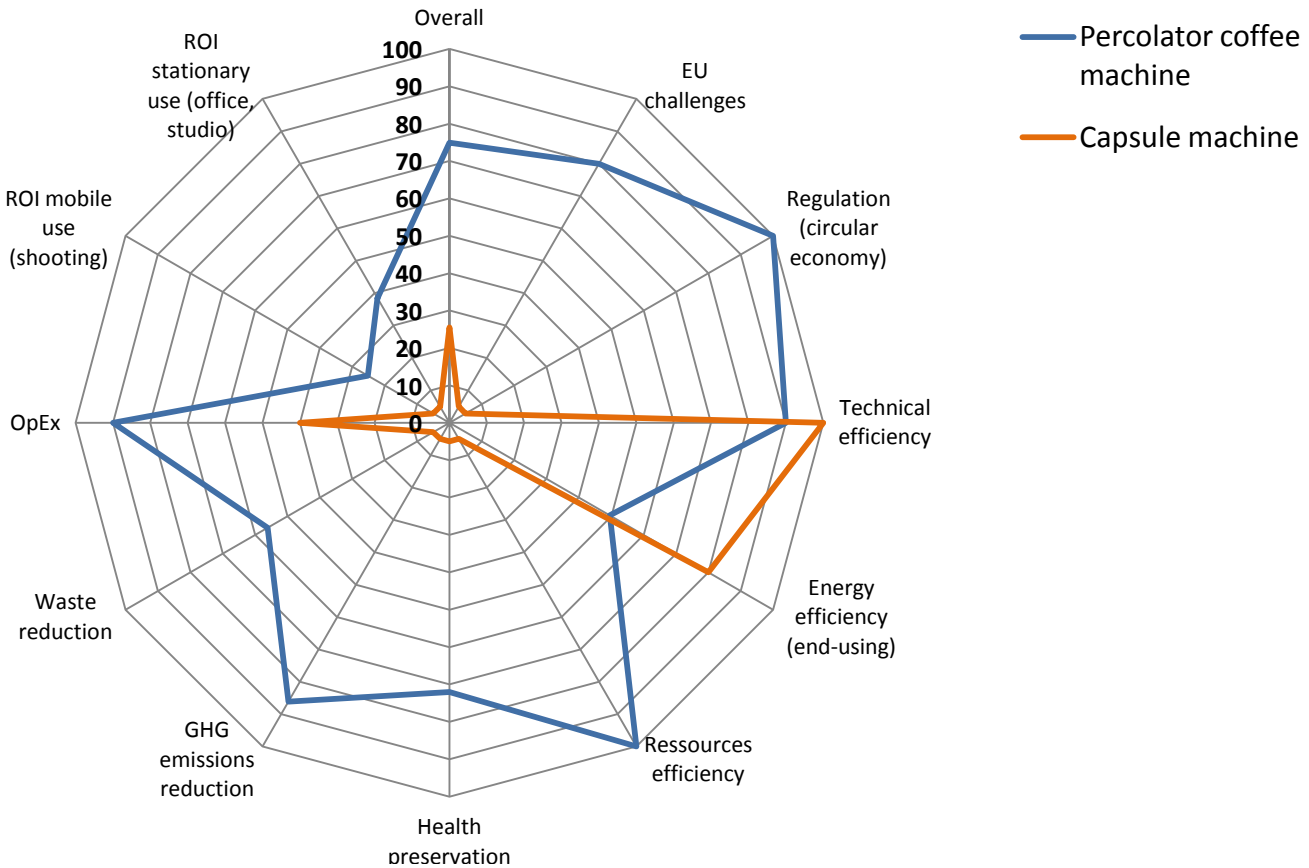
  Source: Occurrence of furan in coffee from Spanish market: Contribution of brewing and roasting - Barcelona University chemistry department.
- Mitigate cup of coffee $CO_2$ footprint compared to coffee in capsule = -21,1 g $CO_2$ eq = - 86,12%

  Sources:
  - Life Cycle Assessment of coffee consumption: comparison of single-serve coffee and bulk coffee brewing- Quantis prepared for Packaging consortium.
  - Bilan Carbone et Empreinte Hydrique d'une tasse de café - BCO2 engineering - France TV

## Profitability

- ROI - office & studio coffee consumption = 38, 45 %.
- ROI - coffee consumption on shooting location = 25, 15%.

## Comparison to capsule coffee machine



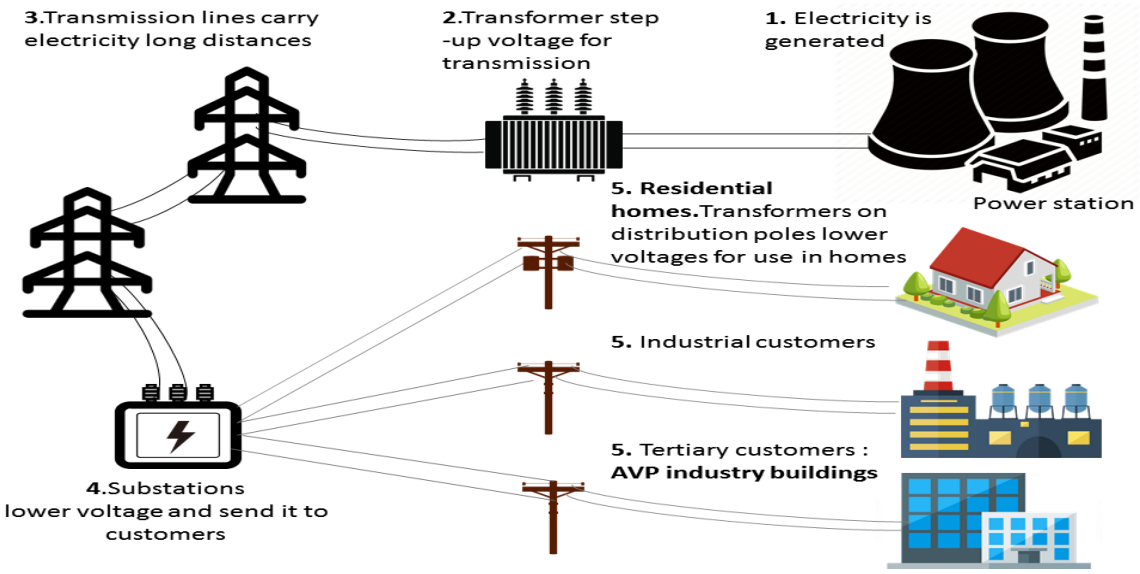

## Conclusion

→ *Basic mean for the AVP industry to reduce its impacts: waste + carbon footprint.*

# 12. Energy Management/ Storage/ Back-up - Voltage optimisation

## Context

In general, power from the National Grid is supplied at a higher voltage than necessary due to old electrical distribution networks in place which were designed to operate at higher voltage levels = higher energy consumption.



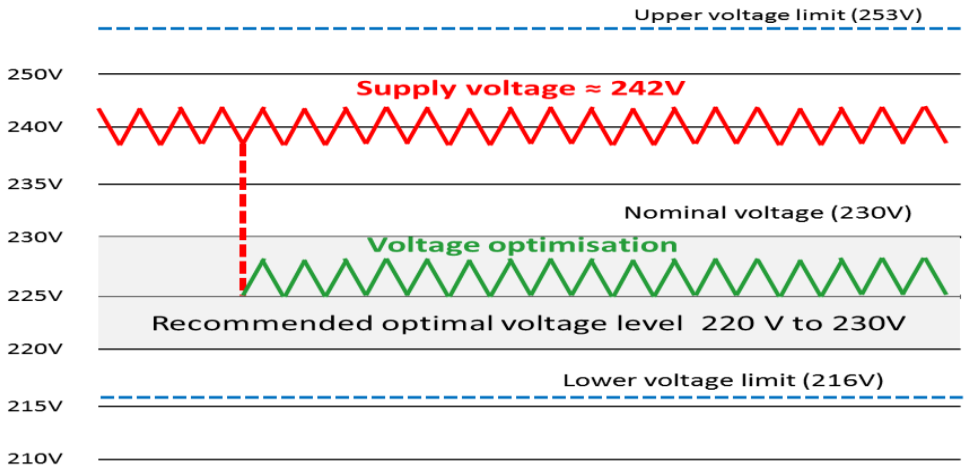

In average the power supplied by a national grid is 242 volts while the recommended voltage is between 220 and 230 as the equipment manufacturers are configuring their equipment to operate within this range.

→ It increases the energy consumption of voltage sensitive equipment :

- **Voltage sensitive =** Power consumption and/or output of an appliance varies depending on the voltage supplied
- **Voltage non –sensitive =** Appliances designed to have a fixed power consumption and output, irrespective of the voltage supplied

## Solution

A solution to mitigate this voltage sensitivity is an energy saving technology: Voltage optimisation that is used to regulate, clean and condition the incoming power supply in order to reduce the voltage supplied to the optimum level for the on-site electrical equipment and appliances.




→ Decreases the energy consumption and improve life-span of voltage sensitive equipment.

## AV industry application

- Suitable for AVP industry specific equipment which are voltage sensitive e.g. :
  - Motors –linear (fixed) speed (small) for studio crane
  - HMI – DC arcs

- Render-farm server rack if they are not interfaced with Uninterruptible Power Supply (UPS)
- HVAC system - flow uncontrolled

## Key features

- Contribute to power quality management.
- Delays the renewal of certain equipment such as HVAC systems.
- Increases the resiliency to electrical peaks.
- The energy savings results will depend of the voltage sensitivity equipment share.

## Impact mitigation

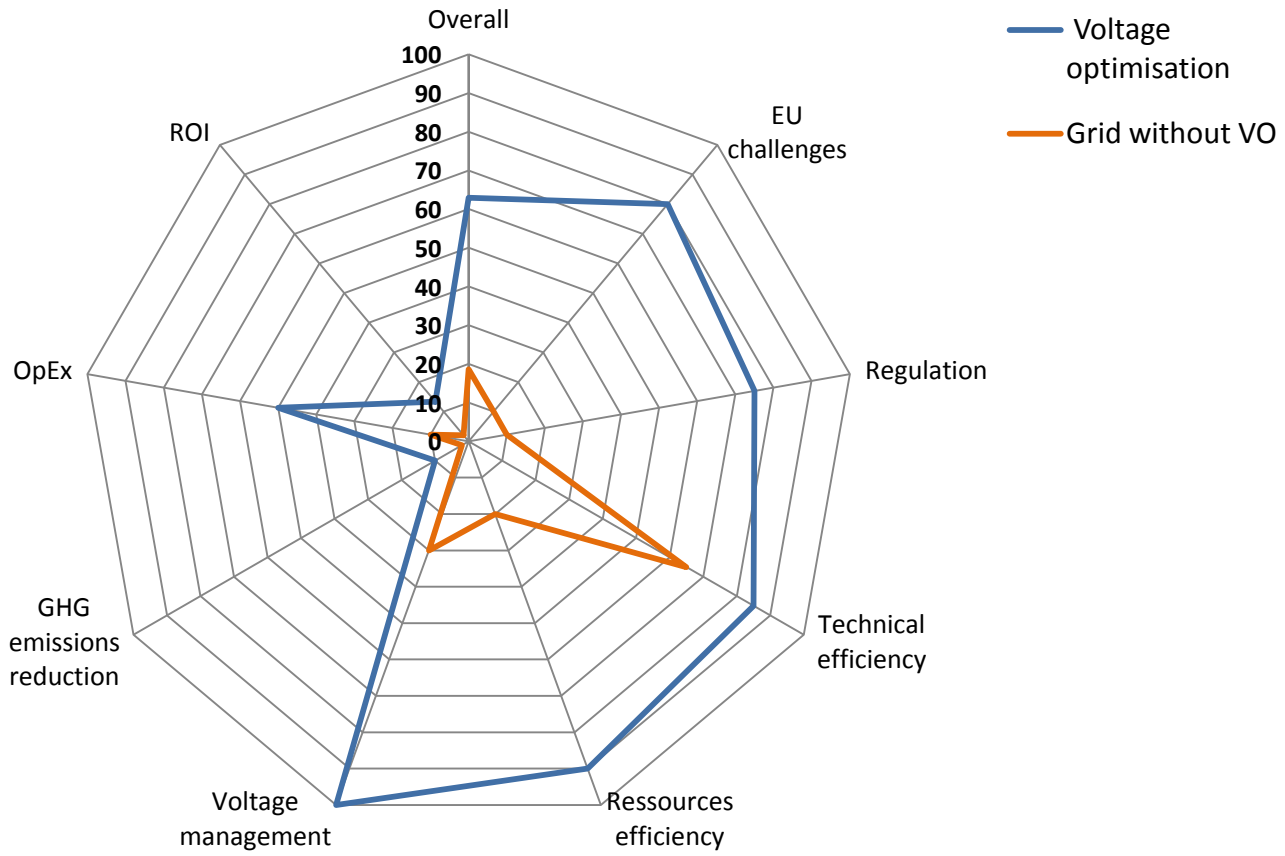
- Energy consumption by equipment with voltage sensitivity = 41, 66 % of energy consumption = average for a building office with an HVAC system.
- In average 10% saving on voltage sensitive equipment energy consumption from the grid:
  - 0,1 kWh saving / kWh
  - 2,958 E-02 $kgCO_2$/kWh

  Source: i am your guide to voltage optimisation: is it right for you? - NSW government -Office of environment & heritage

## Profitability

- Energy performance contracting = share of the energy savings and its inherent risks as a result of the implementation of energy efficiency measures i.e. the cost is based on energy savings results = 30 to 50 %.
- ROI per year for an office building =13, 33%, it's a cost efficient service without any risk thanks to the EPC contract.

## Comparison to energy supply from grid without voltage optimisation




## Conclusion

→ *This solution can be tailored to the energy supply requirement of studios, offices or technical premises.*

# 13. Energy Management/ Storage/ Back-up - Energy storage system (ESS) Behind-the Meter (BtM)

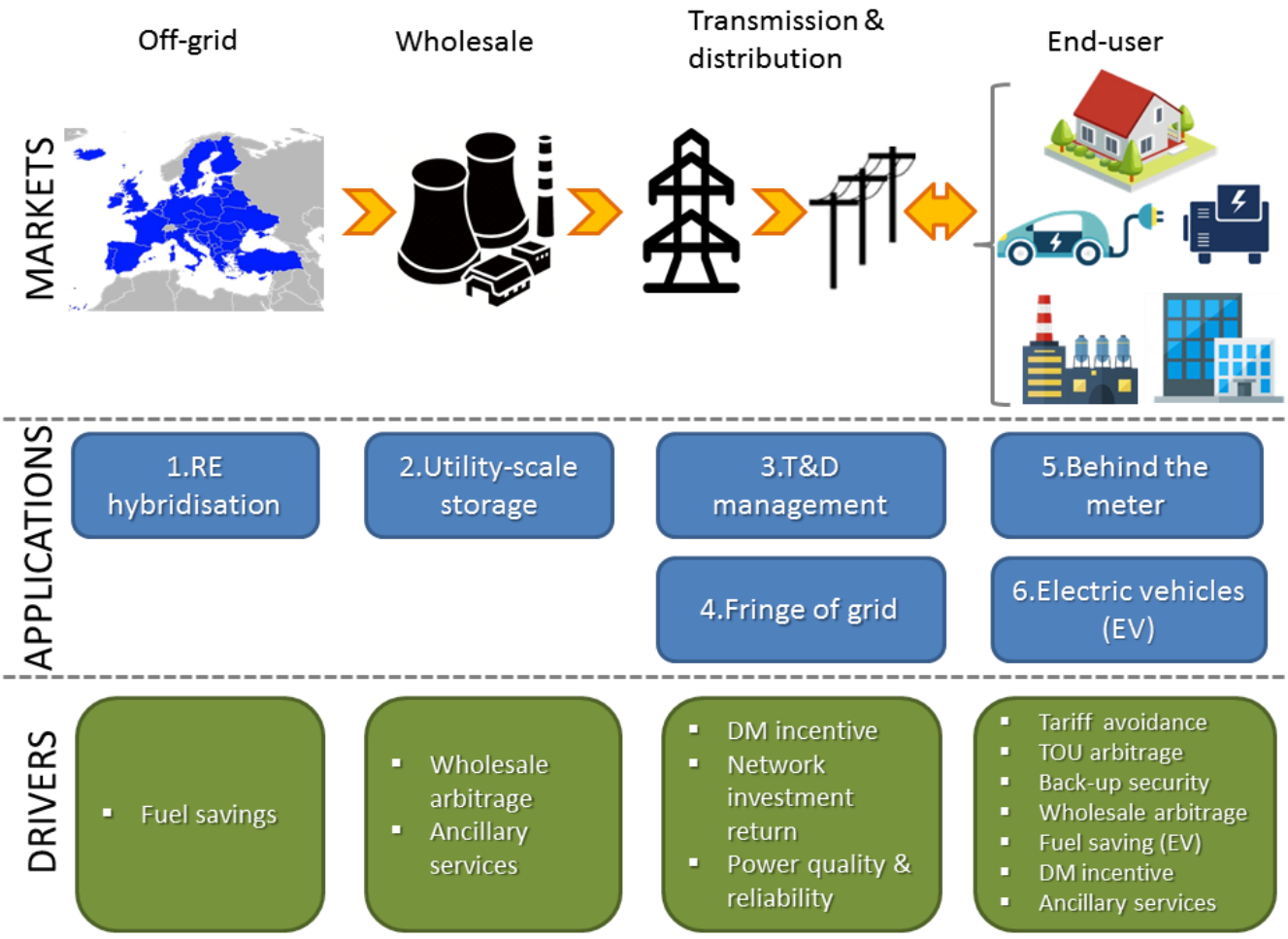
## Context

At any moment in time, the consumption of electricity has to be perfectly matched with the generation of electricity. The growing incorporation of intermittent renewable into energy mix and consumption peaks makes this balance precarious:

→ For the end-user, it means Increased prices & possible energy supply shutdown during peak hours

## Solution

Energy storage technologies have a diverse range of applications across each of the different technical and commercial functions of the electricity market, including transmission, distribution, end-user, off-grid, and transport and generator market segments. In each of these market segments, storage technologies can simultaneously fulfill multiple roles varying from load shifting, to spinning reserve and power quality.

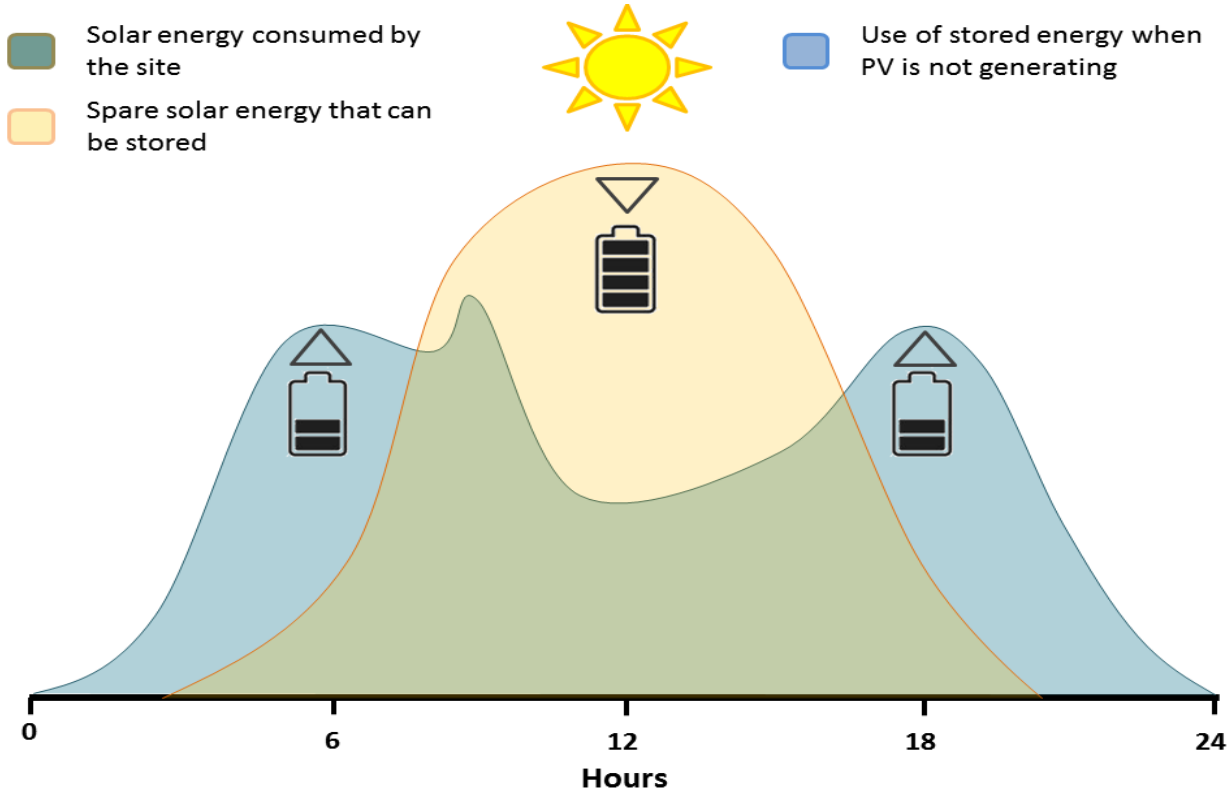



→ Energy storage system (ESS) can provide load shifting, peak shaving, back-up and renewable pairing services to end users. Coupling solar PV with storage can enable larger PV installations and **increase the behind-the-meter (BtM) use of intermittent renewable generation**.

## AV industry application

- ESS can be deployed on:
  - site e.g. for a studio = energy management/micro grid application/back-up system
  - on premise for an animation company = energy management/back-up system
  - location e.g. for a film shooting = mobile off-grid power supply

- For an AVP industry SME with a PV installation, energy storage technology will maximise renewable generation to reduce, or in some cases completely remove, reliance on the grid and other carbon intensive energy sources and speed-up ROI on its PV infrastructure.




## Key features

- Lithium-ion NCM (nickel, cobalt, manganese) batteries is the core equipment for this energy storage solution.
- Provide energy supply resilience at a site-wide level = UPS + back-up
- Peak shaving/Time shift = Users can store energy provided by the National Grid during off-peak periods, where there is usually excessive electricity generation (low cost) and use it during peak hours (high cost) to provide cost savings.
- Maximise existing on-site generation.
- Demand Side Response (DSR) = additional revenue thanks to the national grid incentive.

## Impact mitigation

- 25% energy savings for 1 MWh supply with an ESS compared to grid :
  - - 250 kWh
  - - 73,95 kg$CO_2$ eq

  Source: Data from Comparative Life Cycle Assessment of Battery Storage Systems for Stationary Applications - EWE Research Centre for Energy Technology at the University of Oldenburg - German energy mix

→ ESS can reuse second-life electric vehicle battery that are not longer at 100% of their efficiency

Source: ELSA - energy local storage advanced system - H2020 project

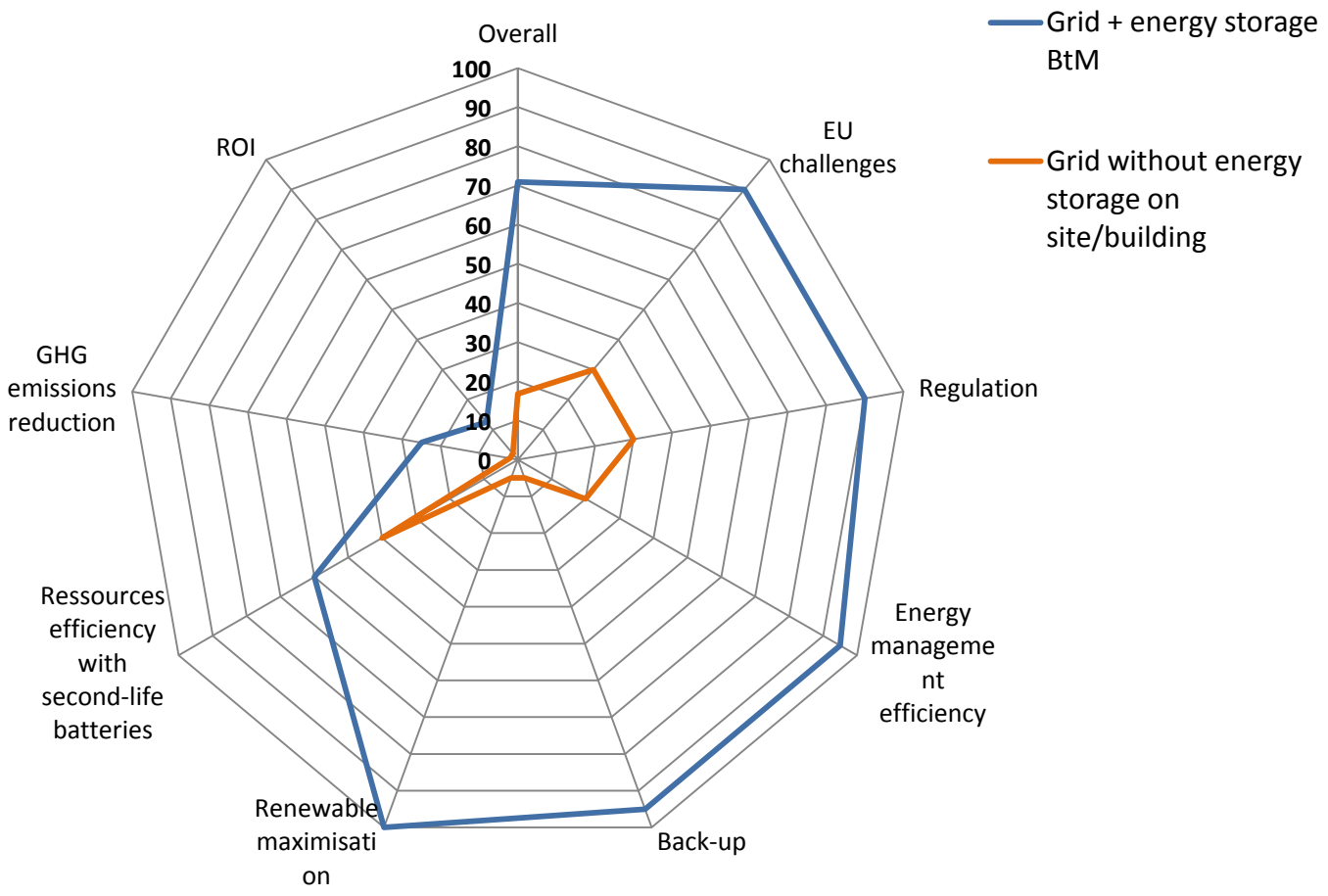
## Profitability

- Funding options:
  - Storage as a service = pay for the service provision based on energy savings done without any capital outlay.

- Revenue sharing agreement = share of all the benefits associated with improved energy efficiency and energy storage without any capital outlay.

- ROI storage as a service = 12, 5%.

## Comparison to energy supply from grid




## Conclusion

→ *Efficient solution to reduce energy bills, maximize renewable generations and cut CO2 emissions.*

# 14. Lighting - LED lighting to replace Tungsten/HMI soft light

## Context

Increasing energy efficiency is a major objective of the EU. A crucial policy instruments for achieving the 2020 and 2030 EU climate and energy targets is the setting of minimum efficiency requirements for products through **eco-design**, in combination with informing customers about their energy performance –through **energy labeling**.

For the AVP industry, the current texts, and in particular Regulation (EU) No 1994/2012, **exempt a large number of halogen lamps** in order to take into account the specific needs related to particular sectors of activity. For this purpose, European regulations provide for **several exemptions in the film and audiovisual sector** with regard to the use of halogen lamps in film and television studios, stage performances, concert halls and others.

→ However, the revised regulation for 2020 **will question these exemptions**= The Eco-design regulations would ban the sale of lighting fixtures that do not meet a set standard of **energy efficiency (85lm/W), this threshold is still in discussion (will probably be increased).**

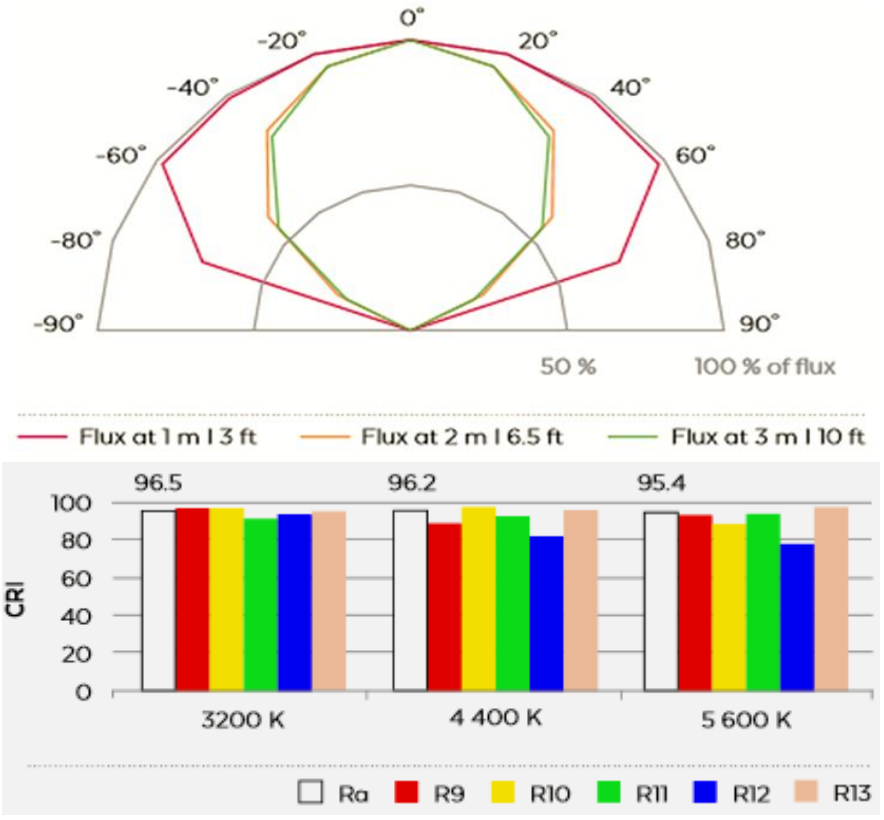
Sources:

- Ecodesign Working Plan 2016-2019
- 2nd feedback from entertaining industry - CNC

## Solution

Led lighting can be an efficient technical alternative for tungsten soft light with:

- Required energy efficiency
- Large radiation pattern
- Color rendering index (CRI) > 95 can be an efficient technical alternative for tungsten soft light.




→ LED has numerous advantages & disadvantages compared to HMI and tungsten = lower lighting qualities but higher operational qualities + regulation compliance.

## AV industry application

- Soft lighting

## Key features

- Newest generation LED = technology dynamic white with a bi-color LED array.
- Diffuse illumination, with a wide angle of diffusion at 120 °.
- Color temperature of 2,700 to 6,500 K and is completely dimmable.
- Flicker-free = prevents any discomfort or eye strain and improves the quality of the shots.
- Increased life-span = 50 000 hours > 1000 -2000 hours for tungsten lights > 750 hours for HMI.

## Impact mitigation

- 93,077 % of energy savings for 20 mega lumen (Mlm)-hours of lighting service compared to Tungsten lights :
  - -3 361 kWh
  - - 994,,18 kg $CO_2$

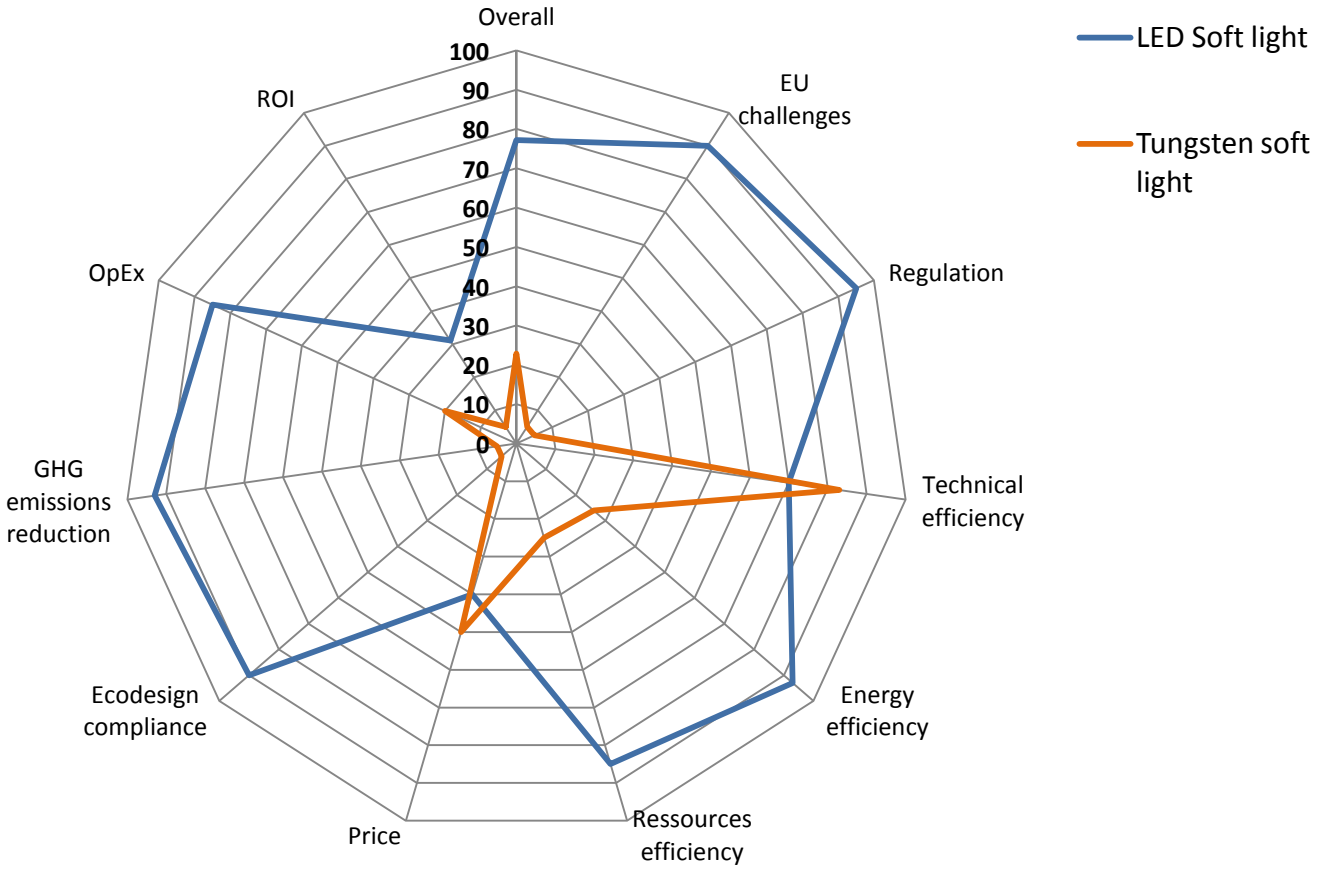
Sources: data from

- Lighting Metropolis - Interreg project - The Life Cycle of LED A review by IIIEE & Lighting Metropolis
- Solid State Lighting Annex: Life Cycle Assessment of Solid State Lighting – International energy agency (IEA)
- Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products- US department of energy (DOE)

## Profitability

- ROI for 20 000 hours of service lighting = 31,13 %

## Comparison to Tungsten soft light




## Conclusion

→ *State of the art LED technology*.

# 15. Logistic - Warehouse RFID & IoT tracking solution

## Context

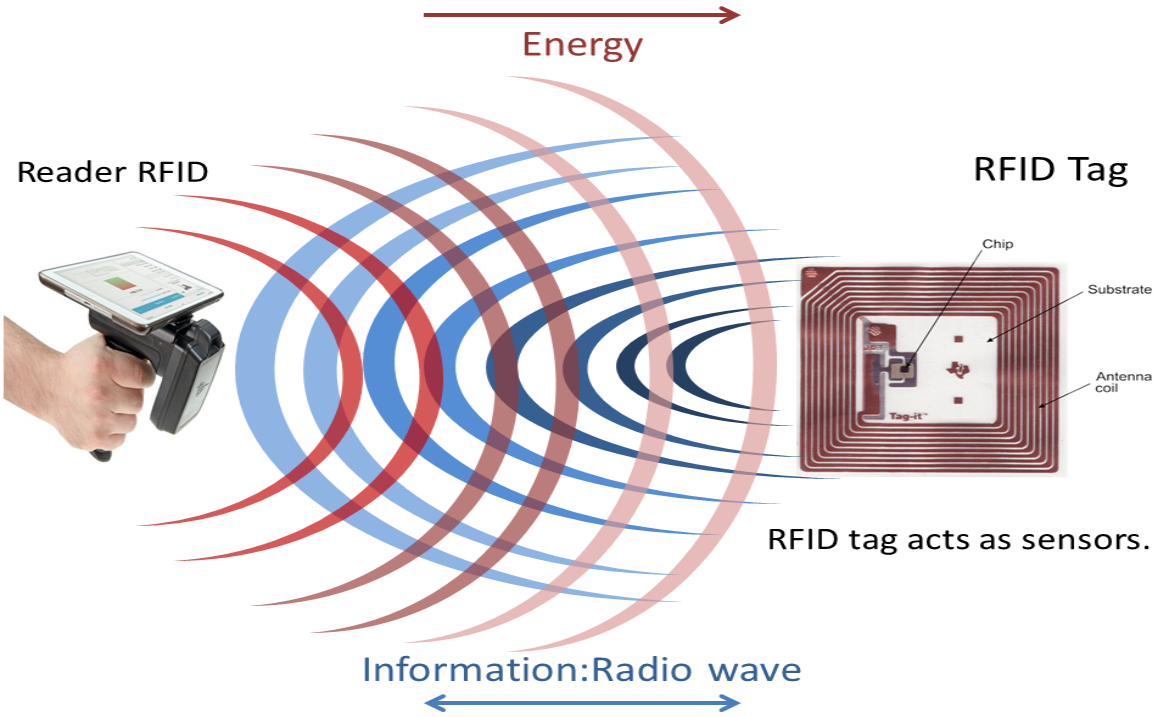
The data based tracking solutions are widely used in the management of e-trade warehouses e.g. Amazon. This makes it possible to follow in real time the state of their stocks (audit) and to manage the inputs / outputs. This optimizes their logistics and the security of their warehouse.

→ AVP industry can be inspired by these data based tracking solutions to improve their warehouse management.

## Solution

RFID systems drive with an IoT platform =

- Automatically analyze flows and equipment availability: cameras, lights, machinery, gensets....
- Have a trace of the flows: from the stock, to the exit for rental and the return after rental.
- Benefit from an accurate real-time inventory.
- Demand predictability = less site to site equipment transfer




→ Installation in 3 steps:

- Takes the building blueprint, floorplan or design
- Installs all necessary hardware = reader, antenna, local Server, switch, router, active RFID tags (wireless active one)
- Build of the virtual 2D or 3D IoT or RFID infrastructure and synchronizes it with the physical infrastructure (hardware)

## AV industry application

- For services/rental companies:
  - Inventory & auditing
  - Asset entry/exit
  - Real time location in the cloud & tracking

## Key features

- View, monitor and surveillance assets at anytime, anywhere, in real-time.
- Equipment availability inventory for a whole warehouses network = multi-sites management.

- Demand predictability thanks to the data collection = allowed less site to site equipment transfer.
- In and out shipping & receivables.
- Zone movement optimization & analysis.
- Global data from 1 location.
- The tags contain copper (antenna) and silicon (chip), At EoL, they are e-waste, and their recycling is not operational yet = environmental issue.
- The tags are powered with printable organic PV cell = no batteries

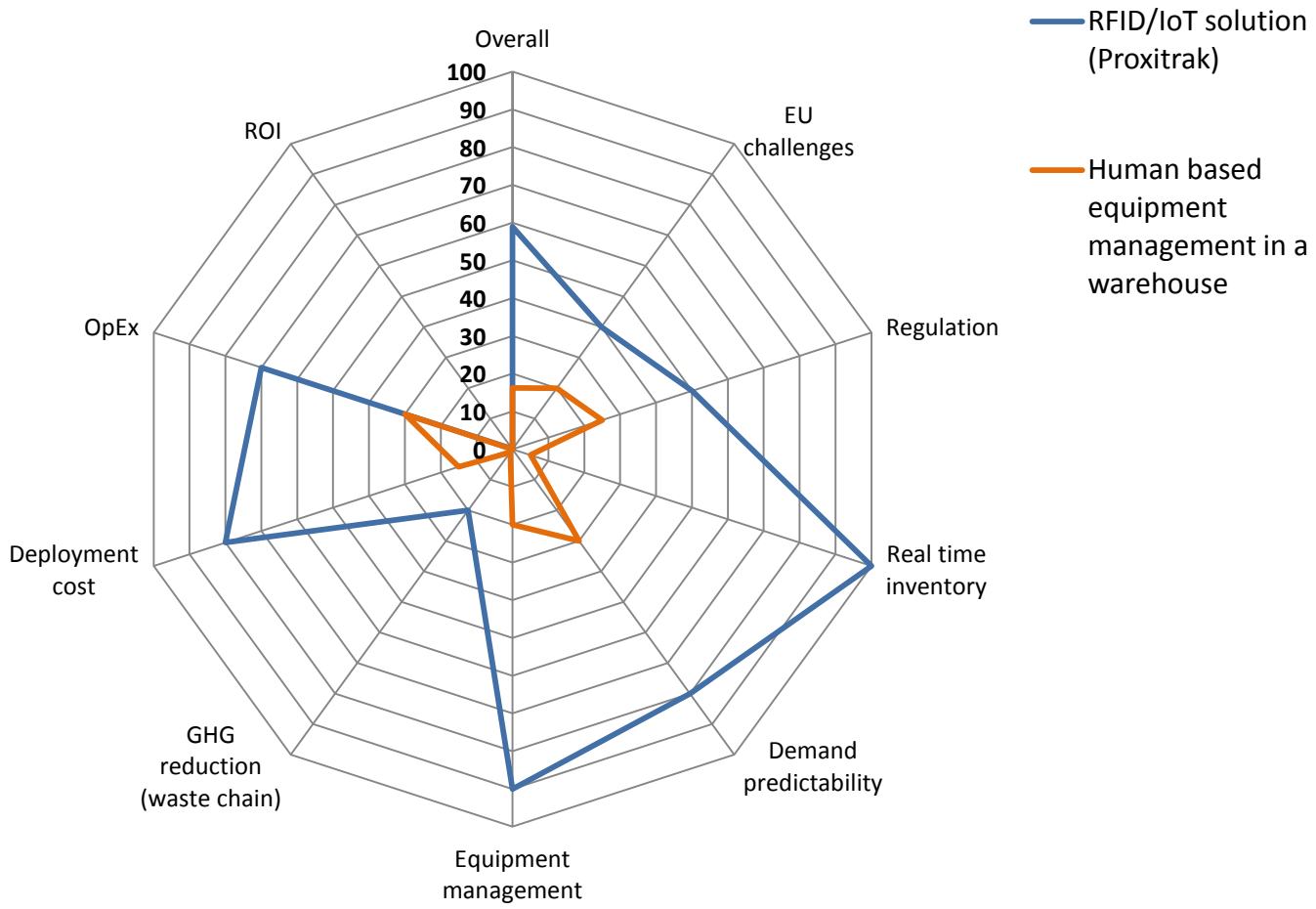
## Impact mitigation

- Carbon footprint mitigation compared to non data driven warehouse management :
  - - 113, 37 kg $CO_2$ eq/ton of equipment (pre-rental equipment dispatching between warehouse sites - distant of 300 km) = - 20 %

## Profitability

- The RFID tag must be renewal every 3 years.
- ROI for a 200 m2 warehouse after 8 years = 6, 57 %.
- This ROI is probably higher important as some benefits are difficult to model: loss prevention, better use rate, improved warehouse security ...

## Comparison to human based warehouse management




## Conclusion

→ *Efficient solution for warehouse management performance, that cut costs & carbon footprint (transports savings & equipment loss).*

# 16. Off-grid power supply/genset - Vegetable oil genset

## Context

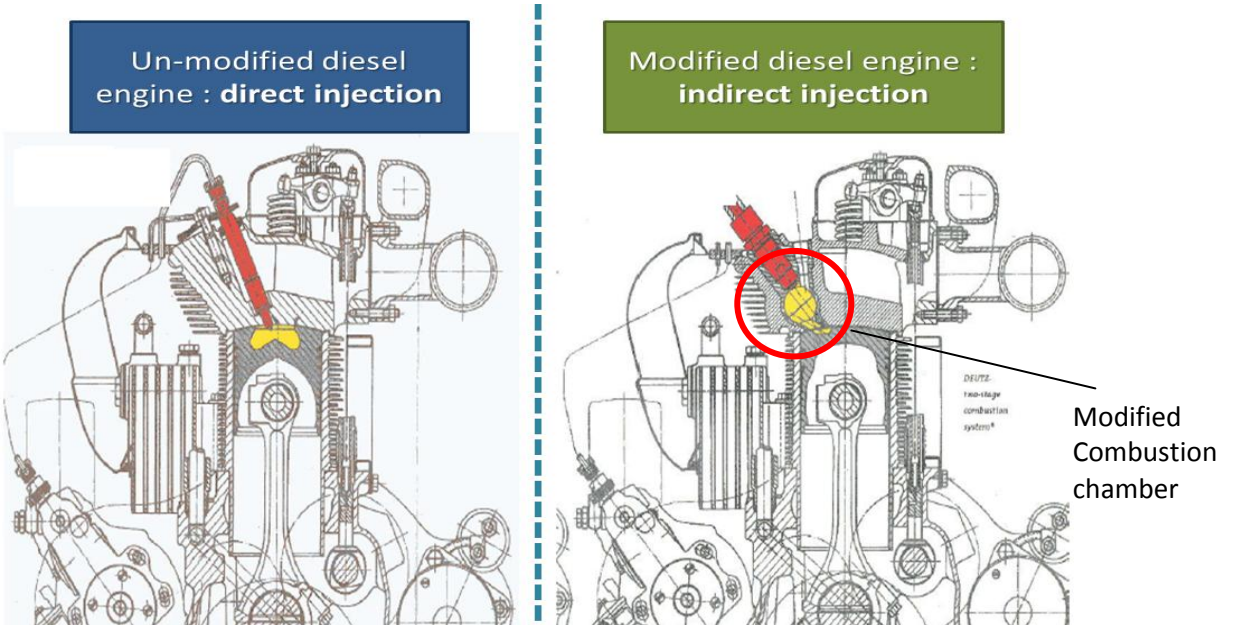
As a backup or as the primary source of electrical power, the conventional mobile off-grid solutions are diesel and liquefied natural gas gensets. These 'fossil' genset generate major environmental impacts from fuel combustion:

- $CO_2$ emissions
- $NO_x$ (nitrogen oxide) = NO (nitrogen monoxide) + $NO_2$ (nitrogen dioxide)
- $SO_2$ (sulfur dioxide)
- $PM_{2.5}$ = made of black carbon and highly hazardous heavy metals - copper, cadmium, barium, nickel, chromium, manganese, lead, zinc

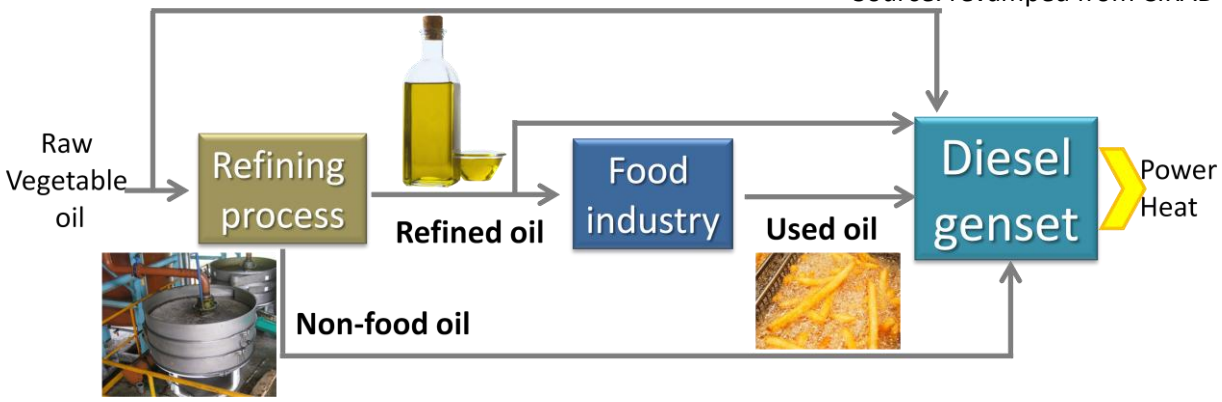
→ Therefore for the AVP industry, it is a priority to deploy energy supply alternatives less harmful.

## Solution

One of the solutions is the modification of diesel genset engine = retrofit the direct injection by indirect injection (combustion in 2 steps); **it allows diesel fuel substitution by raw, pure or recycled vegetable oils.**




Source: revamped from CIRAD-ADEME




→ Hybrid genset (vegetable oil + diesel) and bi-carburetion kit are available on the market; an embryo of vegetable oil supply line is set up.

## AV industry application

- Shooting in location: urban area, natural & protected area = No restriction of use.

## Key features

- Can be fed with all raw vegetable oil: cocoa, rapeseed, sunflower…
- Used cooking oil can be use after filtration.
- Vegetable oils do not contain lead, benzene or sulfur, which reduces the presence of carcinogenic particles
- Calorific value close to diesel.
- Improved life-span = x2.

## Impact mitigation

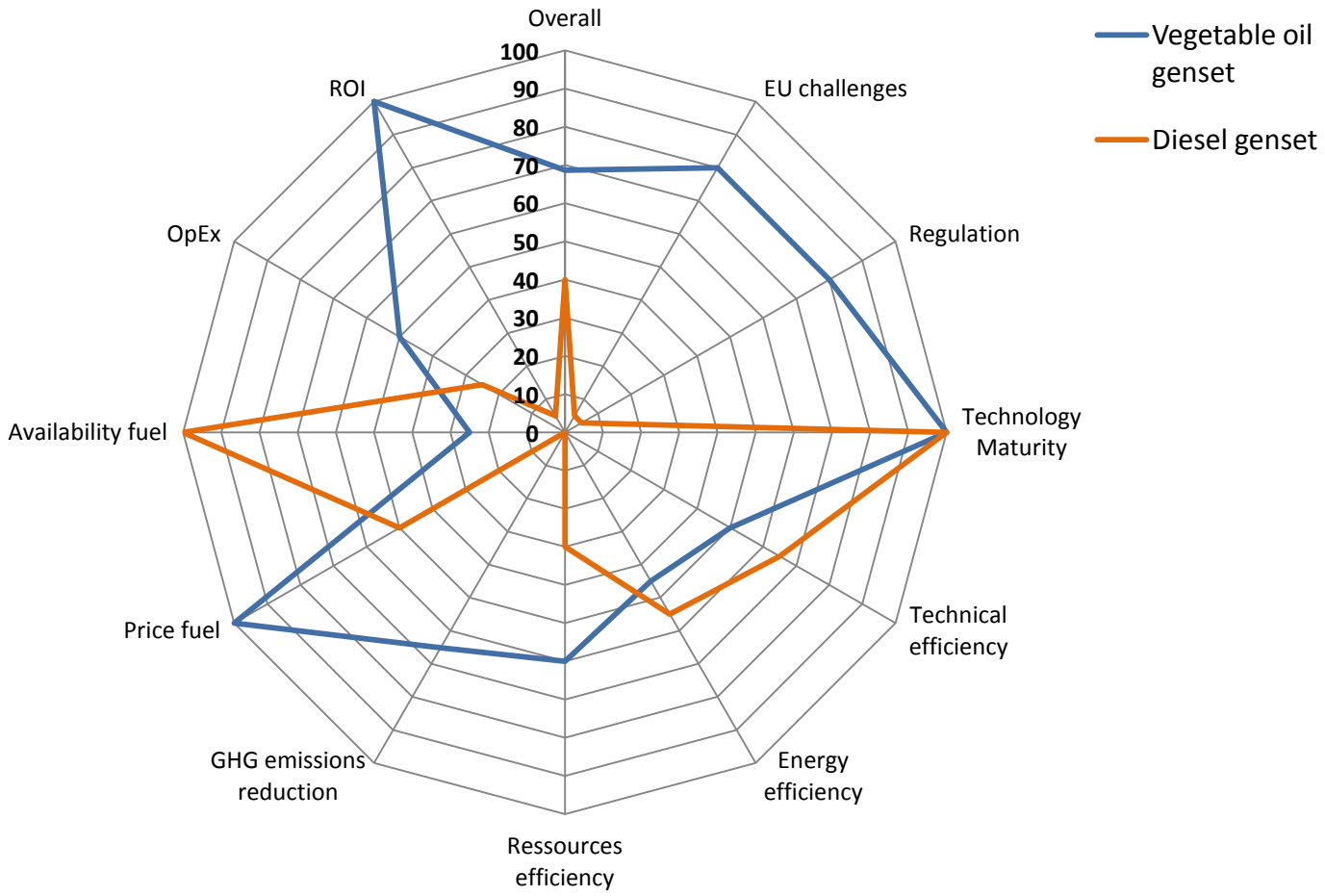
- Mitigate carbon footprint per mega joule (MJ) compared to diesel fuel combustion :
  - -0, 0596 kg $CO_2$ eq/MJ = -65, 2 %.

  Source: data from Bilan énergétique et émissions de GES des carburants et biocarburants conventionnels - ADEME

## Profitability

- Vegetable oil is cheaper than diesel per liter – French prices including taxes(€):
  - Used cooking oil = 0,30
  - Rapeseed raw vegetable oil = 0,80
  - Sunflower raw vegetable oil = 0,90
- There aren't vegetable oil stations, SMEs have to source locally from farmers, local authorities (used cooking oil) = as a result SMEs must have a tank to store the oil in their premise.
- ROI = 126 % = Bi-Carburetion kit is a very profitable investment with a very short time to value = 3 months.

## Comparison to human based warehouse management




## Conclusion

→ *Low cost solution to retrofit diesel genset, which provides regulation, economic and environmental benefits.*

# 17. Off-grid power supply/genset - Thermoelectric generator

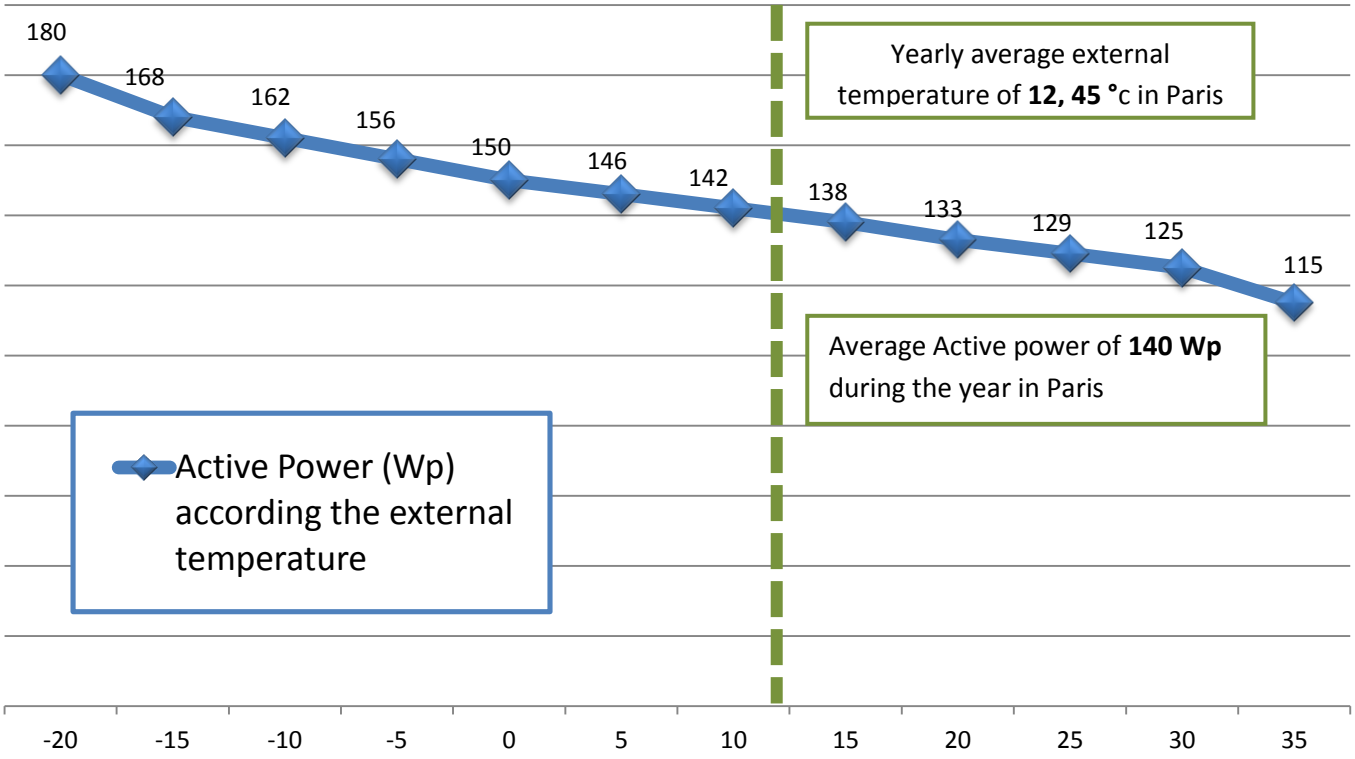
## Context

The principle of thermal engine (or diesel engine or genset) electricity generation is quite simple. An electric thermal generator is a device that converts mechanical energy obtained from an external thermal source (fuel combustion) into electrical energy as the output.

→ Beyond emissions of GHG and air pollutants, the main drawback of diesel engines is that of large part of its primary energy **is wasted into heat dissipation**.

## Solution

It is possible to use heat directly instead of mechanical energy to produce electricity through the technology of thermoelectricity i.e. when two metals (conductors) are placed together (thermocouple) and cold is applied to one side and hot to the other (temperature gradient), electricity is produced(Seebeck effect).
A TE energy-harvesting system i.e. a thermoelectric generator (TEG): takes advantage of any temperature difference between its two surfaces i.e. the greater the difference in temperature with ambient air, the more efficient the module.




→ A 300 -150 Wp thermoelectric generator can be implemented into any diesel engine (stallholders vans, campers, trucks and boats), to recover lost heat to produce electricity.

## AV industry application

- A TEG can be used to power: freezers, mobile phones, microwaves, conditioners, TV, lap top, talkies walkies, coffee machine…so it can be a side energy supply solution for the shooting base camp.

## Key features

- TEG can be interfaced with solar panels (thermal), to create an integrated system able to use the best energy source.
- TEG can manage two batteries: priority to the engine battery one then to the services battery (AGM/gel/lithium -Life PO4).
- Operating temperature**:** -20°c…+30°c.

- Active power (Wp):
  - max 150 Wp with an external temperature of 0°c
  - 140 Wp during the year in Paris with an average external temperature of 12,45 °c
- This solution efficiency is improved in winter.

## Impact mitigation

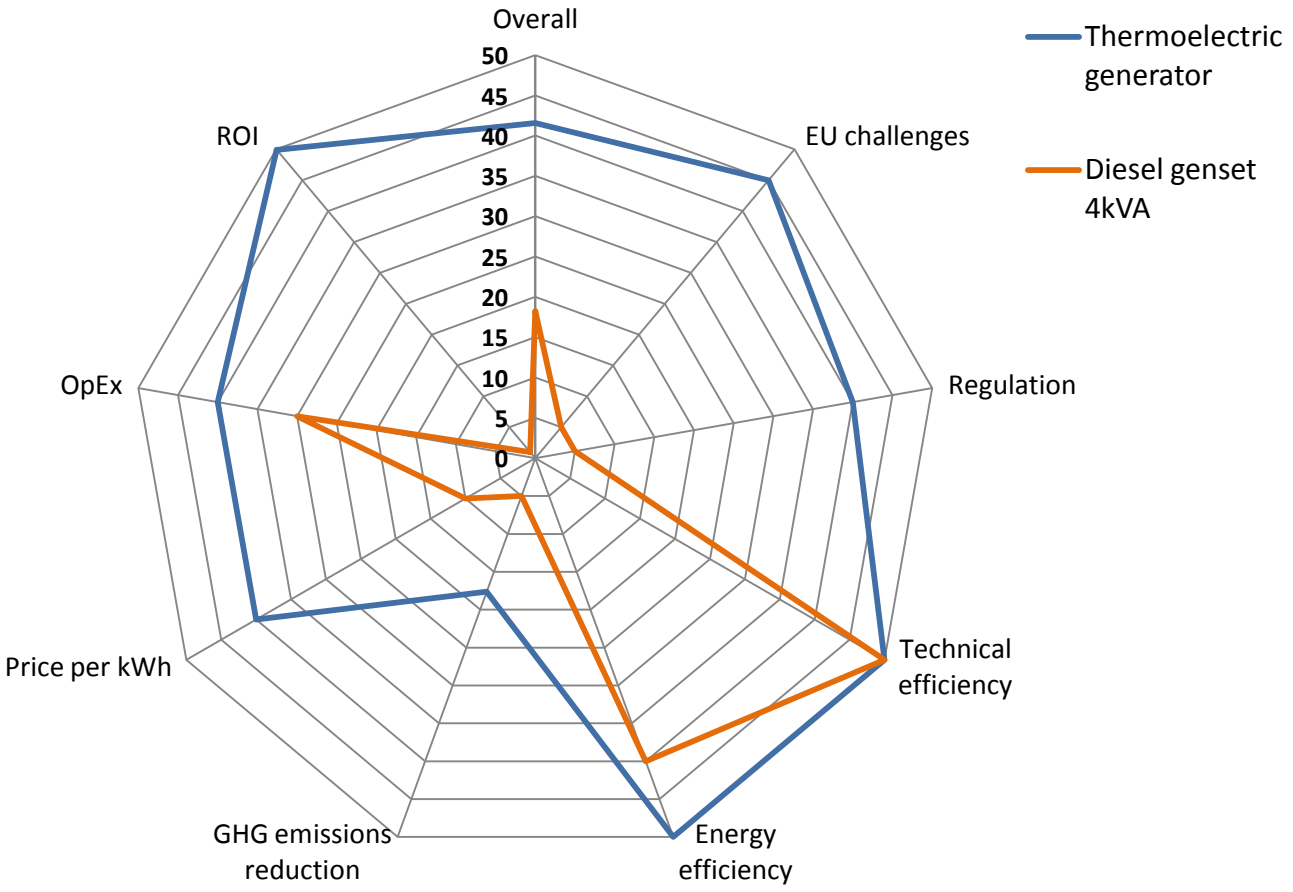
- At end of life this TEG produces  hazardous waste : bismuth telluride (semi-conductors) = it's an issue
- Diesel fuel for genset are relevant to Euro 2 standard, whereas diesel fuel for vehicles is relevant to euro 5,6 standards, much less emitting for NOX and Particle matter.
- Impacts mitigation to produce electricity compared to diesel fuel combustion :
  - - 0,195 kg $CO_2$ eq/kW = - 17,64%
  - - 5g $NO_x$ /kW = - 71,42%
  - - 0, 13 g PM /kW = - 86,67%

  Source: Euro emission standards - A technical summary of Euro 6/VI vehicle emission standards-International council of clean transportation (ICTT)

## Profitability

- ROI for 10 years = 49, 91**%** with an average generation of 3 kWh per day.

## Comparison to diesel genset



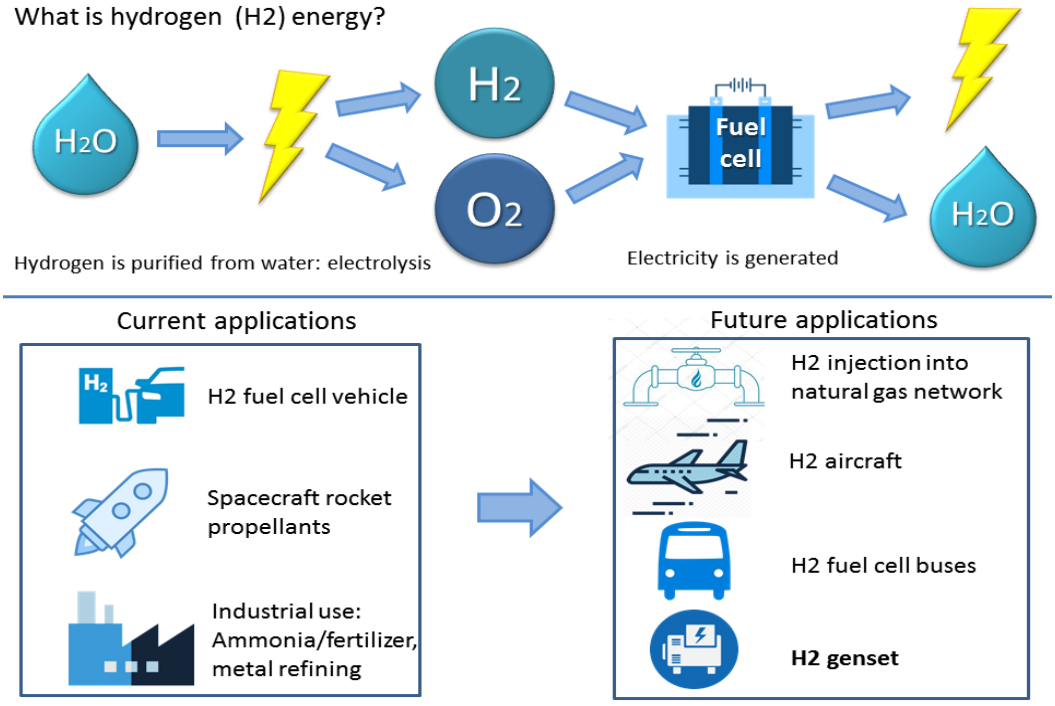

## Conclusion

→ *It's a technology more calibrated for Northern Europe countries as the efficiency depend of the external temperature: the cooler, the better.*

# 18. Off-grid power supply/genset - Hydrogen genset

## Context

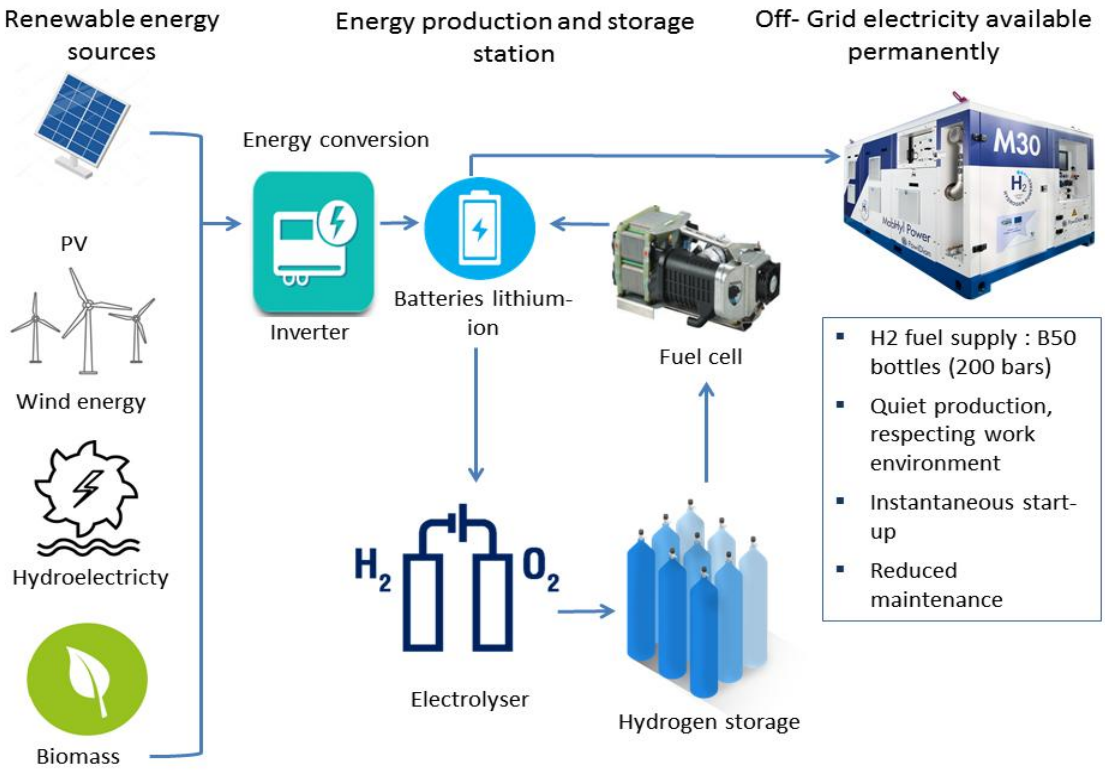
Hydrogen ($H_2$), which contains about three times more energy than diesel, is considered the "fuel of the future". Used with a fuel cell, to produce electricity, hydrogen can be used as an "energy carrier" for transportation, power generation and energy storage.




→ Hydrogen is the most promising mean for storing intermittent renewable energy.

## Solution

For AVP industry, the $H_2$ genset will be, within 3 to 5 years, the disruptive technology that will replace diesel genset.



→ For now it is an emerging technology that has not reached the industrial scale, however AVP industry SMEs must anticipate its arrival on the market.

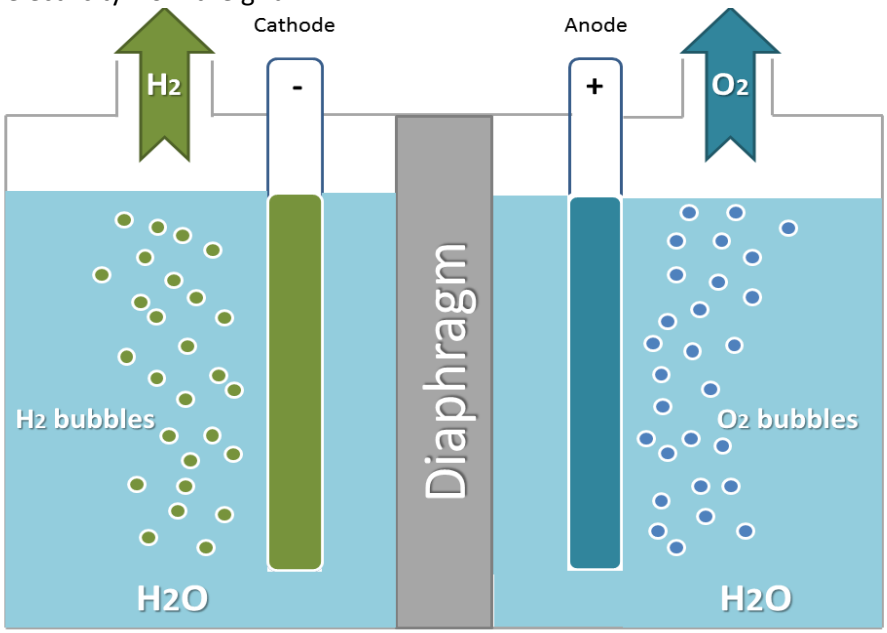
## AV industry application

- Disruptive alternative to diesel genset for shooting on location

## Key features

- Silent operation.
- Doesn't emit pollutants solely oxygen, water & heat.
- Reduced maintenance = robustness and over 25,000 hours lifespan.
- $H_2$ is not at risk for an outdoor application = $H_2$ is about 57 times lighter than gasoline vapor and 14 times lighter than air. This means that if released in an open environment, it will dilute and disperse rapidly in the surrounding open air.

  Source: HIAD - Hydrogen Incident and Accident Database – EU science hub
- Consumes bottles of $H^2$ in bottles (B50 compression 200 bars) =
  - Grey $H_2$ = non-decarbonized from fossil fuel vaporization
  - Green $H_2$ = decarbonized resulting from the **electrolysis** of water produced with renewable energy: PV, wind energy or electricity from the grid.




- Production of green $H_2$ is growing fast due to:
  - Dedicated fund at European level ' Fuel cells and H2 (JU FU)' joint undertaking
  - Massive investment in hydrogen from big corporate companies
  - Public development plans in Germany, US, France, Japan, China…
  - the first origin certification of the green $H_2$ - JU FU Project CertiHy

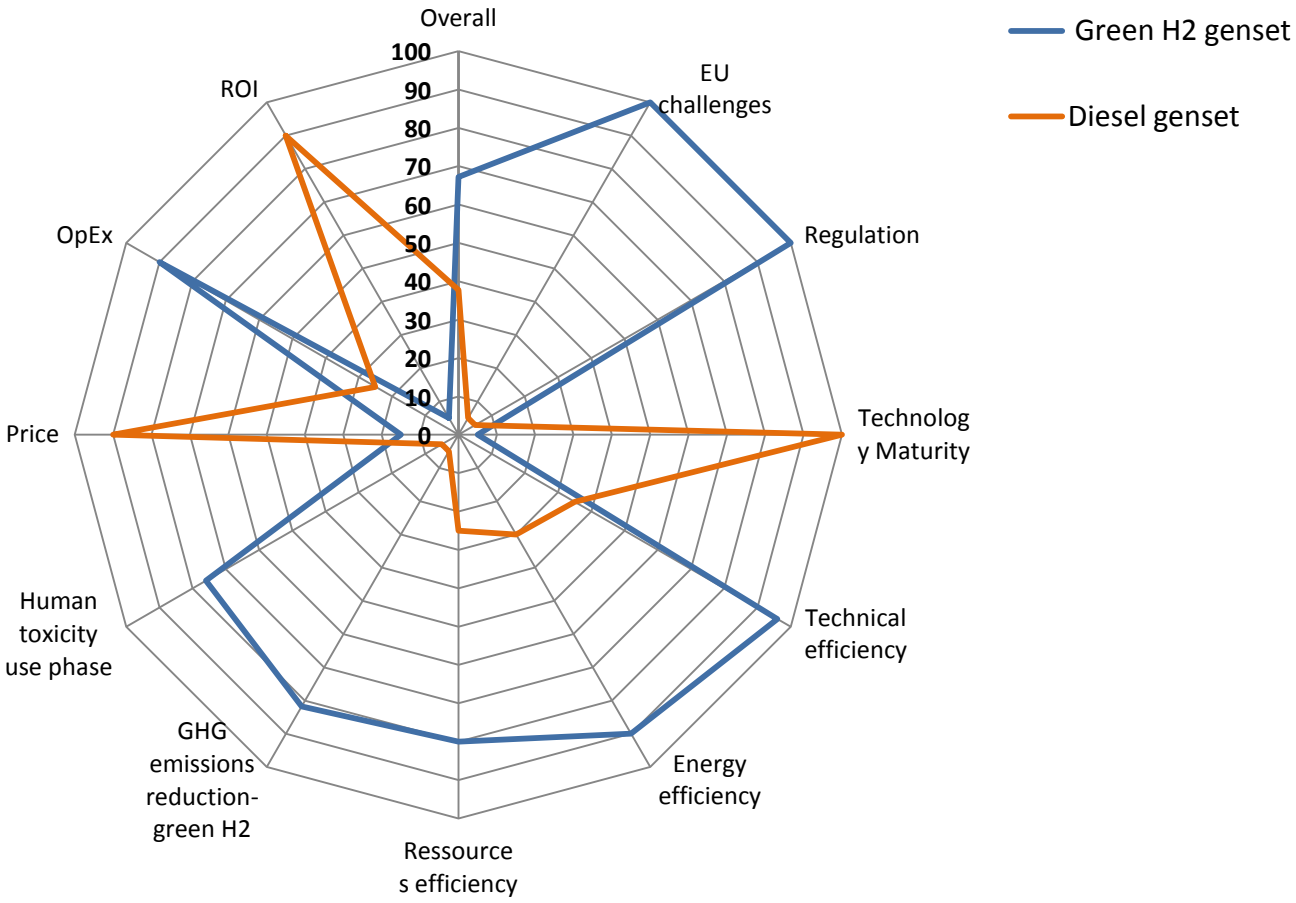
## Impact mitigation

- Upstream, there is solutions for the $H_2$ devices recycling - JU FU Project HYTECHCYCLING = design for recycling conception.
- Impacts mitigation provided by green $H_2$ (PV based electrolysis) compared to diesel fuel combustion:
  - -8,98 $kgCO_2$ eq by kg = - 81,79%

## Profitability

- This technology will be cost efficient with industrial scale, i.e. within 3 to 5 years.

## Comparison to diesel genset




## Conclusion

→ *Hydrogen is the disruptive technology that will supplant diesel genset for electricity generation on shooting location (& for heavy-duty vehicle).*

# 19. Off-grid power supply/genset -Mobile and self-towed energy storage

## Context

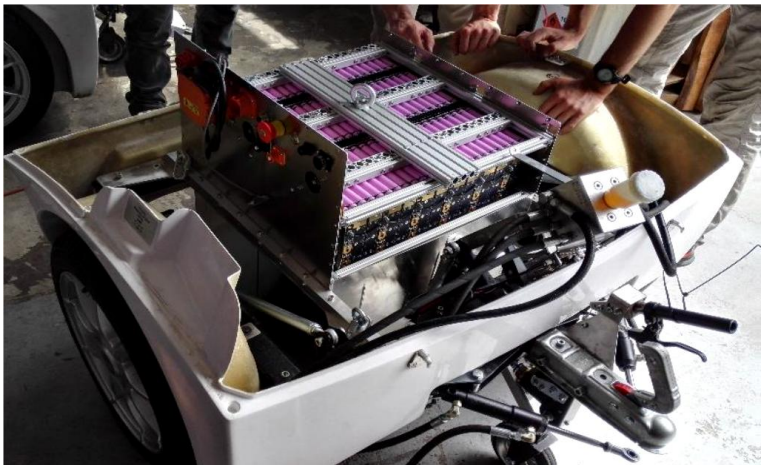
Spreading of Electric vehicle (EV) has 2 issues a:

- Small autonomy due to the limited battery capacity
- Large stream of used EV batteries; their decreased energy density at 80%/90% is no longer suitable for EV.

→ There is a solution that mitigates these 2 problems while being able to be used as energy supply on a shooting.

## Solution

The range extender is a trailer with a storage capacity of 40/50 kWh implemented with second life EV batteries. This device can extend EV autonomy but also provides off-grid power = zero noise and emission genset**.**



→ This mobile energy storage system (ESS) can be exchanged with a charged one in a minute or be recharge in the 22 428 charging stations in Europe:

- 2815 in Paris region
- 667 in Berlin
- 262 in Brussels
- 233 in London
- 182 in Malmö
- 44 in Malaga
- 34 in Bratislava

… Source: [ChargeMap]


## AV industry application

- Suitable for shooting everywhere :
  - Ultra Low Emission Zone (ULEZ), e.g. in central London
  - Natural / protected area

## Key features

- Higher storage capacity than most other nomad solution.
- Silent operation.
- Li-ion NCM (nickel, cobalt, manganese) batteries

- AC power supply 1 phase
  - DCDC boost-buck 200V-500V 25 kW
  - Power = > 9 kVA
- Storage for self consumption = can be interface with PV panels on the set.
- Available where demand is = the trailer is self-steering when backing = can easily move on the set.
- User interface on tablet or smartphone (range, target battery level at destination, state of operation).

## Impact mitigation

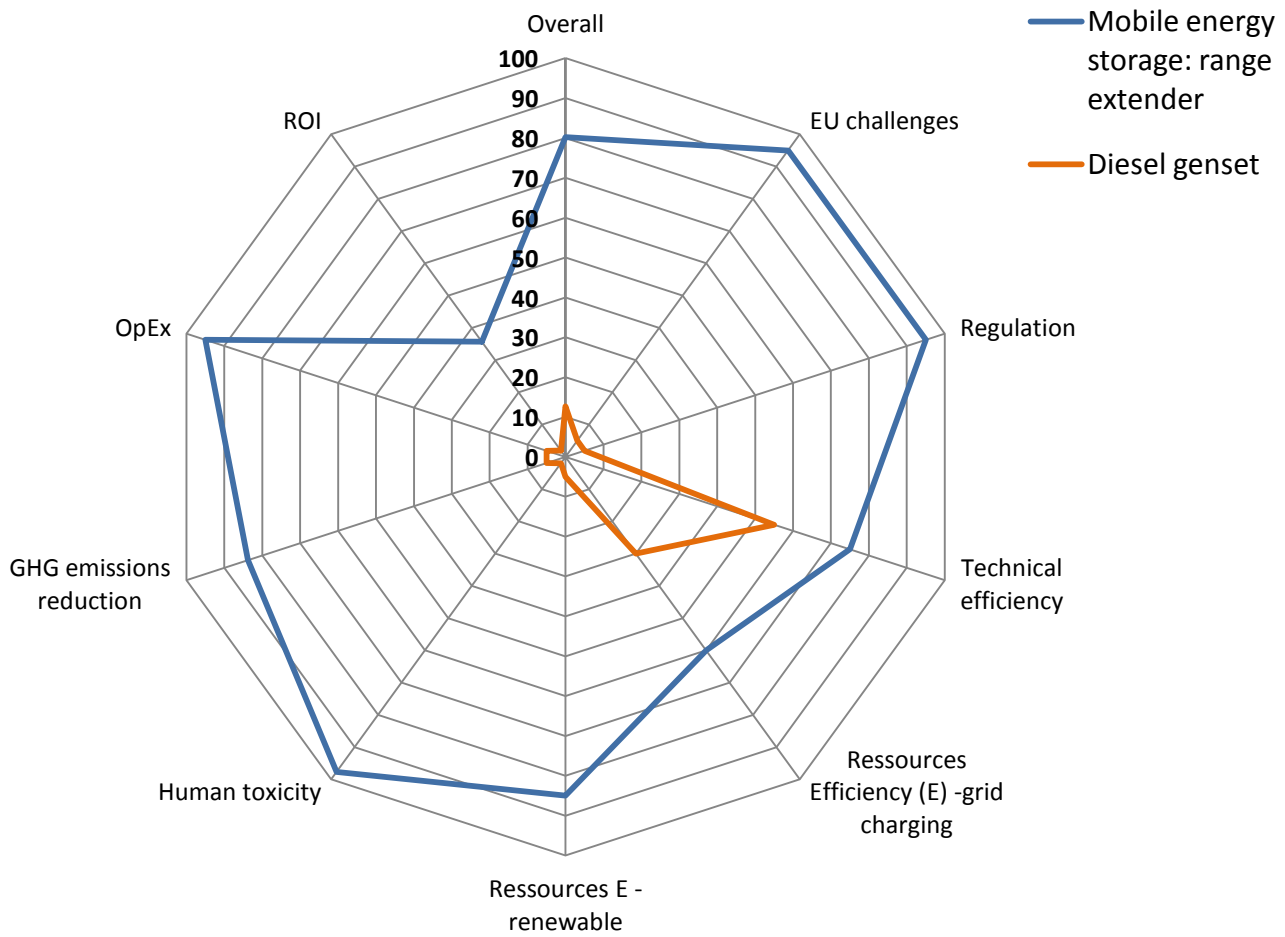
- Carbon mitigation for 50MJ energy supply (13,9 kWh) compared to diesel fuel combustion:
  - - 3,83 kgCO2 eq

  Source: Majeau-Bettez, G.; Hawkins, T.R.; Strømman, A.H. Life cycle environmental assessment of lithium-ion and nickel metal hydride batteries for plug-in hybrid and battery electric vehicles p32

## Profitability

- Batteries as a service (BaaS) = rental
- ROI by kWh for a volume of 114 kWh supply (2 re-charge in 24 hours) with a range extender = 35,7%

## Comparison to diesel genset



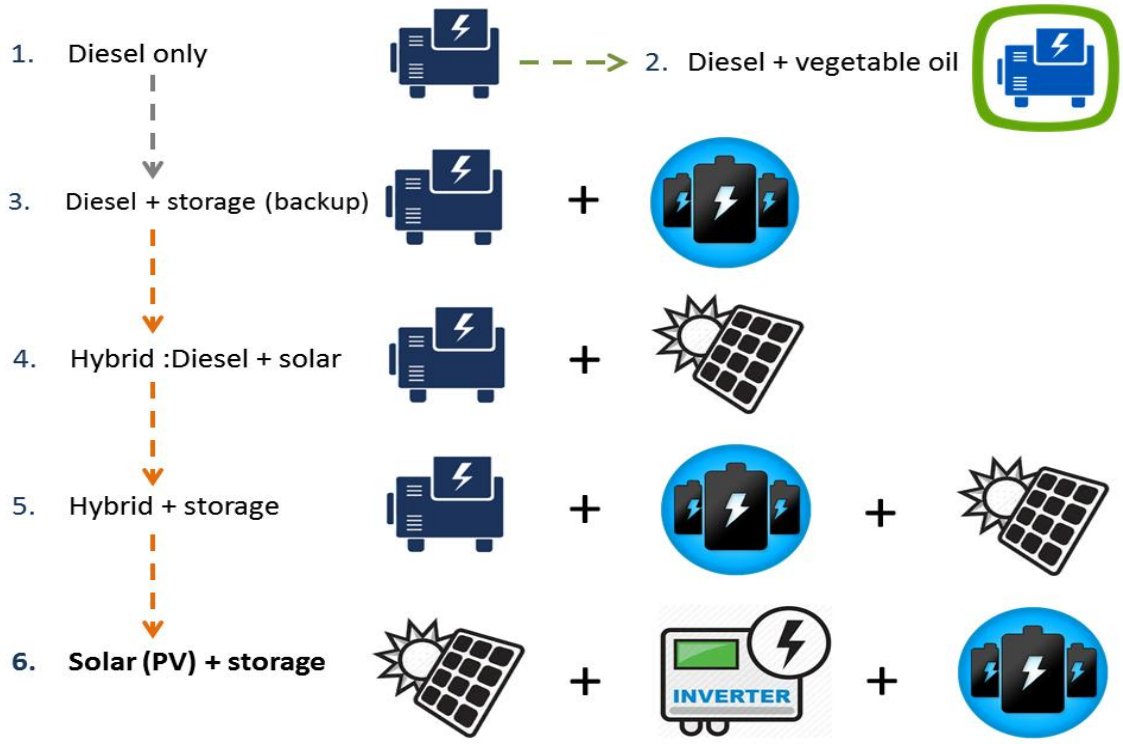

## Conclusion

→ *Range extender is a low cost & low carbon off-grid energy supply solution for small and medium shooting.*

# 20. Off-grid power supply/genset - Mobile PV off-grid (solar genset) - high load

## Context

Off-grid diesel generator installed capacity reached worldwide 82 GW6 per year in the period 2013-2018, adding to the environment an average rate of 55.8 M tons of CO2. However some gensets solutions which incorporate renewable energies are starting to emerge.

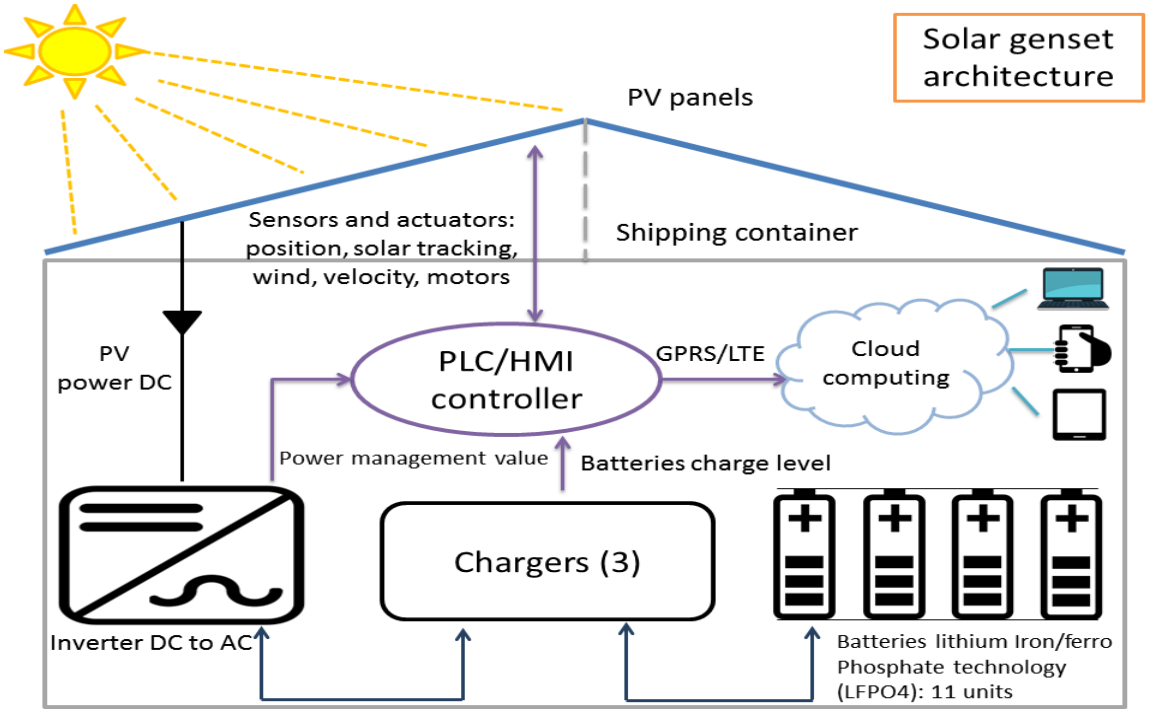



→ The solar genset is developing; nevertheless 3 concerns arise for its massive use:

- Performance
- Cost
- Mobility

## Solution

- Next generation of solar genset = based on a packaged solar photovoltaic system which is fully automated.



→ This solar genset is embeds in a container.

## AV industry application

- Off-grid energy solution for AVP industry especially for shootings located in southern Europe and in remote location such as natural protected area/ desert.

## Key features

- Mobility, intermittency and conversion efficiency are ones of renewable energies boundaries: this solar genset intends to overtake them:
  - Mobility : a turnkey PV system into a container
  - Intermittency : smart management of a storage system (charger and batteries)
  - Conversion efficiency: solar tracker (sensors + actuators) to move the PV modules according to the sun
- Lithium Iron/ferro Phosphate technology (LFPO4) batteries known as 'safe lithium'.
- Safety (risk of fire) + costs (per kWh) + life cycle (charge/discharge cycles) = LFPO4 > Li-ion NCM.
- Mono-crystalline SI modules (60 m2).
- Total conversion efficiency = ≈23 % = best in class.
- Active power 10 kWp max = reached between midday and 2 o'clock
- The production efficiency is subject to non-controllable parameters: geographical, year period location, hour of the day:
  - 52 kWh/day, average in southern Europe.
- Life span = 25 years
- The energy decreases by 35 % after 15 years

## Impact mitigation

- Impact mitigation per kWh generated compared to diesel fuel combustion:
  - - 1,25 kg$CO_2$ eq = -96,154 %
  - - 6, 957 g $NO_x$ = - 99,386 %
  - - 0,15 g PM = - 100 %

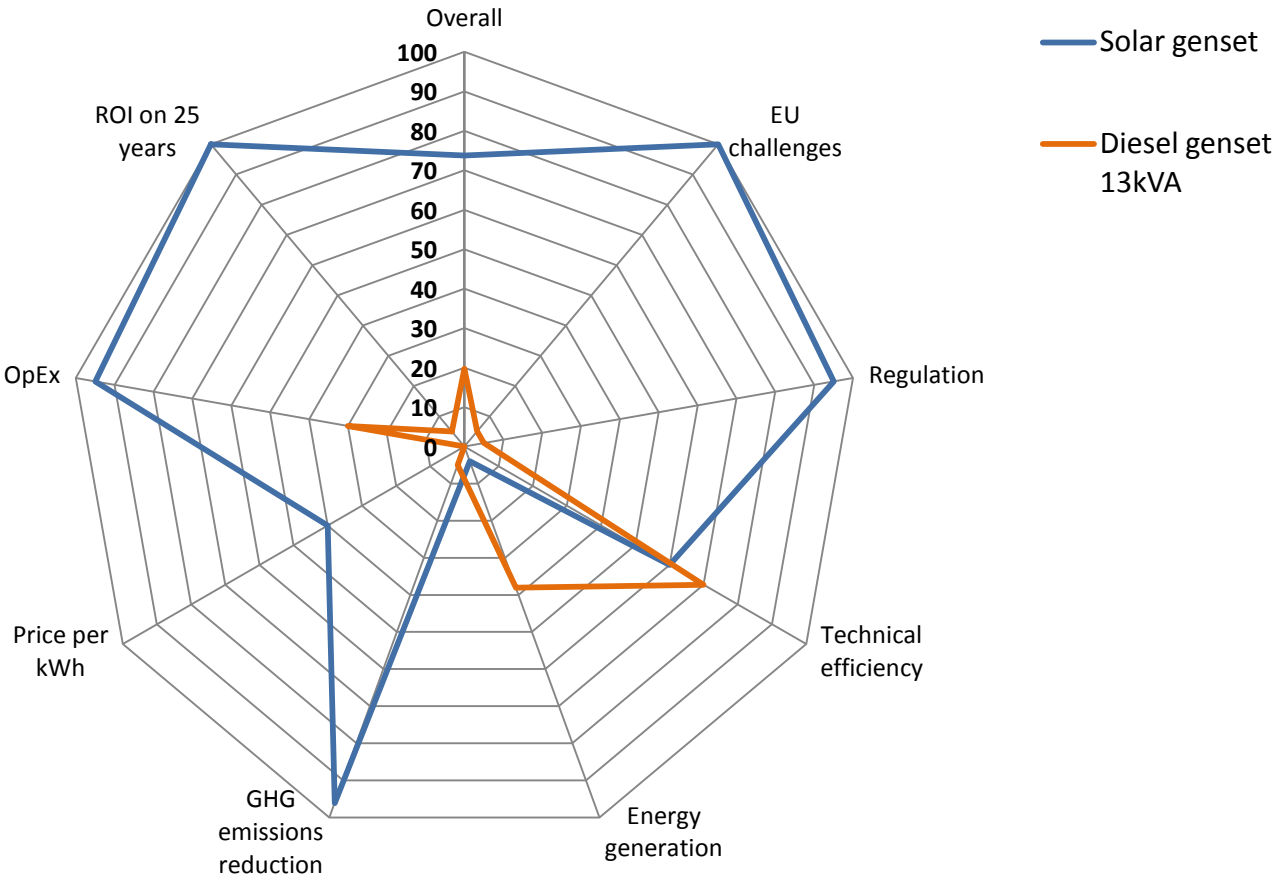
  Source: Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems -IEA (international energy agency)

## Profitability

- Compared to stationary PV station, the:
  - Installation cost is much higher than = **4,25 €/W** vs. 1€/W
  - Price per generated kWh is lower = **0,33 €/kWh** vs. 0,38 €/kWh
- Compared to kWh generated with a diesel genset ( fuel + maintenance cost), the:
  - Price is lower = **0,33 €/kWh** vs. 0,56 €/kWh
- With a gain difference with diesel kWh of 0, 23 €/kWh and continuous energy production during 25 years, ROI = 221 %

## Comparison to diesel genset

- This solution vs. 13 kVA diesel genset



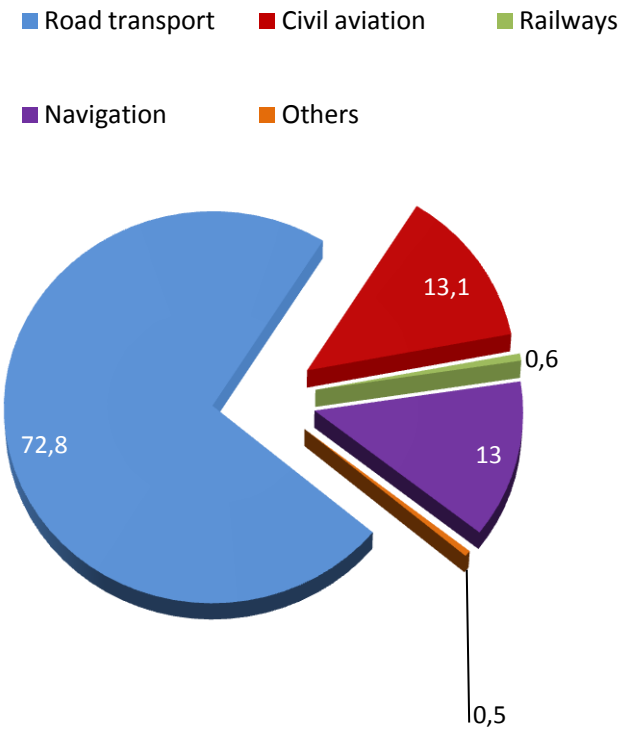

## Conclusion

→ *At the state of the art it's the best available solution for mobile PV off-grid generation. However it will become obsolete in a few years with H2 genset.*

# 21. Extended reality (XR) visualization & collaboration - Virtual meeting

## Context

Transport represents almost a quarter of Europe's greenhouse gas emissions and is the main cause of air pollution in cities. The transport sector has not seen the same gradual decline in emissions as other sectors: emissions only started to decrease in 2007 and still remain higher than in 1990. Within this sector, road transport is by far the biggest emitter accounting for more than 70% of all GHG emissions from transport in 2014; however Plane is by far the most emitting transport mode.




| Mode of transport | Grams of CO2 per passenger per kilometer |
|---|---|
| Urban and Peri-urban Transport | |
| Tramway | 3,3 |
| Subway | 3,8 |
| City train | 5,8 |
| Motorbike | 110,7 |
| Urban Bus | 132,1 |
| Peri-urban passenger car | 161,7 |
| Urban passenger car | 206 |
| Transport at national scale | |
| High-speed train | 3,2 |
| Train | 10,2 |
| Bus | 58,5 |
| Passenger car | 85,5 |
| National flight | **144,5** |
| Transport at international scale | |
| International flight Europe | **244,09** |
| International flight World | **≈289** |

In AV industry, the rise of coproduction has drive to an inflation of meeting, which means increased travels by flight to attend face to face meeting. Some of these meetings are replaced with distant conference, thanks to video conferencing software.

→ However there is still a potential issue with video conferencing software: Video conferencing can help share ideas and 2 D plan but not manipulate operational process in 3D e.g. set/stage visualization and engineering which limits the extension of this solution.

Source:

- Transport emissions – European commission
- Specific CO2 emissions per passenger-km and per mode of transport in Europe – European Environment Agency

## Solution

There is a new solution that overcomes this setback: Extended reality (XR) visualization & collaboration = XR removes distance barriers, allowing remote employees to seamlessly access and manipulate 3D data from anywhere in the world.

## AV industry application

- VR/AR allows the team to visualize literally anything and—more importantly—interact with the visualized objects. For AV industry it can be stage/set/scene configuration or to plan a sequence shot. E.g. Disney (parks) use this virtual meeting to test new attraction without prototyping

## Key features

- AR/VR can offer many benefits over face-to-face communication = being face to face but also being able to instantly materialize and interact with any information = **VR & collaboration in real-time**
  - Compatible with 250 3D applications= the software is tailored to function with a specific 3D application
  - Top level data security with no exchange of model information
  - Tolerate high network latency and low bandwidth
  - +500M triangles 3D res, can now be rendered with human-eye resolution
- By bringing together teams from any location into a single virtual space, VR and AR technology may also accelerate set/stage design without prototyping.
- Technically easy to implement but it's a disruptive change in set/stage design process= A well documented demonstrator will help for an uptake.


## Impact mitigation

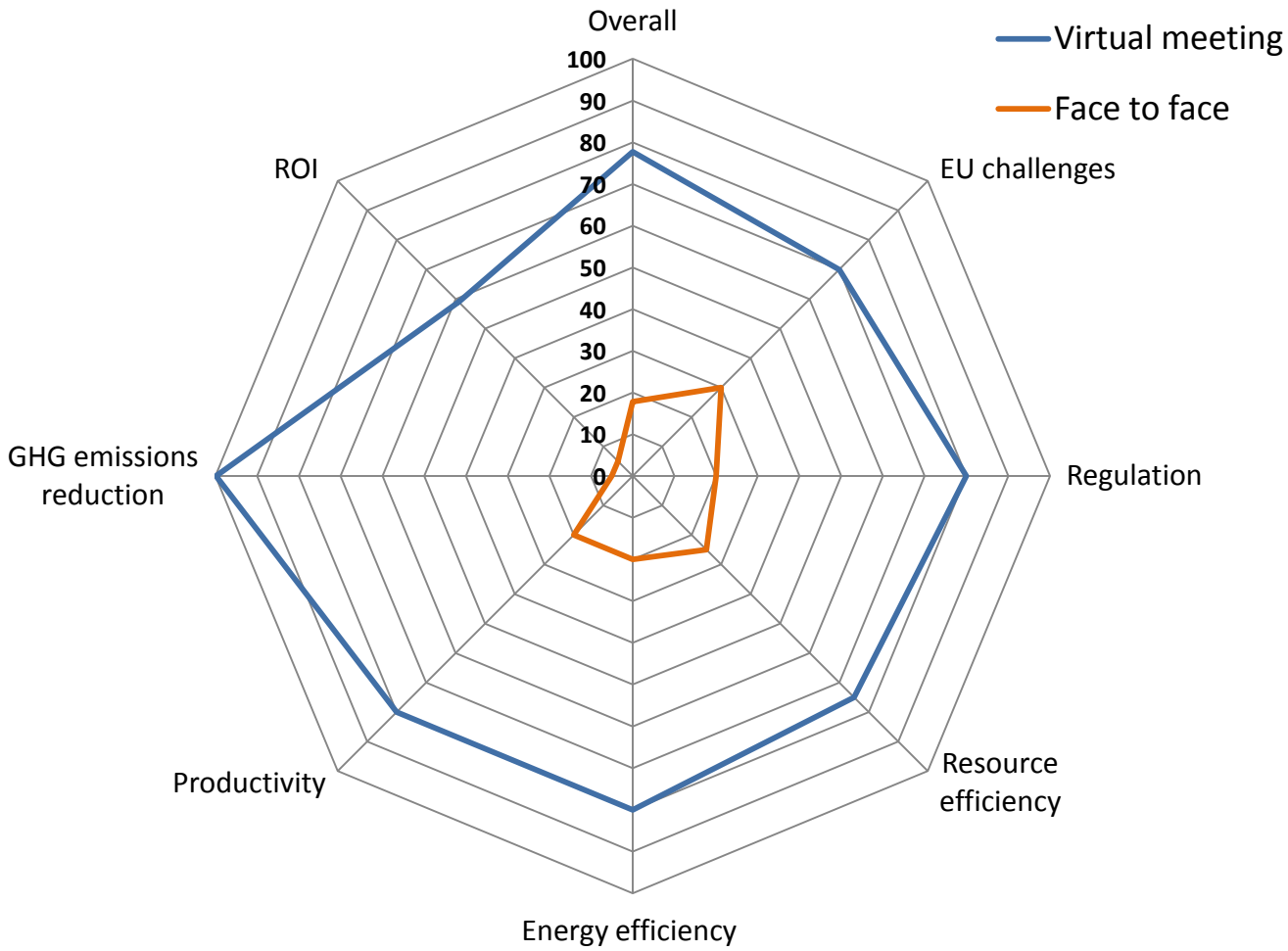
- In terms of carbon emission between Virtual meeting and face to face meeting, there is a massive difference due to flights travel cuts, e.g. for Meeting of 3 days/2 nights in London for a project review**,** 6 attendants: 3 from USA, 2 from UK, 1 from Australia :
  - virtual meeting emission= **14,39 kg CO2/ meeting**; **2,398 kg CO2/attendant** = **0,123%** CO2e of face to face meeting
  - face to face meeting = -**11,70 t CO2/meeting ; 1,94 t CO2/attendant**
- Source:
  - Flight emission calculator – Carbon footprint ltd
  - Carbon footprint of conference travel 2016 – PL research
  - Lean ICT – towards digital sobriety 2018 – The Shift project
  - Green Gaming: Energy Efficiency without Performance Compromise 2018- **VR** p47,55,56,127,137 **-** Evan Mills, Norm Bourassa, Leo Rainer, Jimmy Mai, and Arman Shehabi, Lawrence Berkeley National Laboratory

## Profitability

- Break-even threshold over a 4 years life span = 3,12 uses by year
- ROI Virtual meeting over face to face meeting for set / stage / cyclo design review = **+ 59,49 %**
- Very high ROI, however depending the solution chose there might be some maintenance fee ( correlated update of the 3D applications supported)
- Payback period = depends of the meeting pace, in the study case = ≈15 months

## Comparison to face to face meeting

- Virtual meeting vs. face to face meeting for set / stage / cyclo design review




## Conclusion

→ *Virtual meeting thanks to VR & collaboration software in real-time is a very cost-efficient solution and can save tons of carbon emissions related to flights and transport in general.*

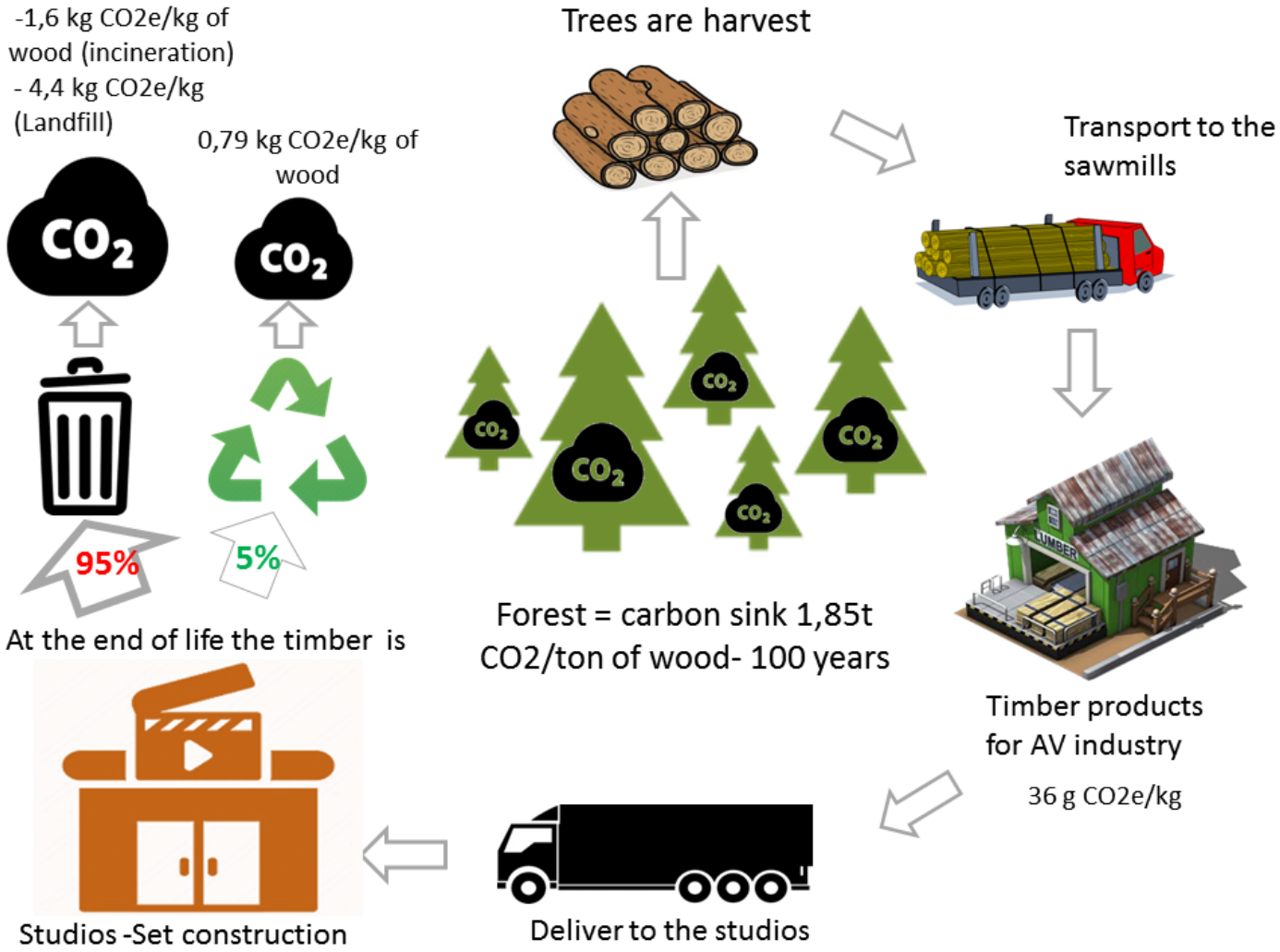
# 22.Set construction - Reusable wood module

## Context

Atmospheric concentrations of the greenhouse gas were 414.8 parts per million in May 2019, which was 3.5ppm higher than the same time last year, according to readings from the Mauna Loa observatory in Hawaii, where carbon dioxide has been monitored continuously since 1958.
Scientists have warned for more than a decade that concentrations of more than 450ppm risk triggering extreme weather events and temperature rises as high as 2C, beyond which the effects of global heating are likely to become catastrophic and irreversible. Despite these warnings, the annual growth rate of $CO_2$ is still increasing.

This growth of co2 in the atmosphere is the result of emissions greater than the natural storage capacity of $CO_2$: carbon sinks = ≈280 Mt of annual carbon sequestration capacity in Europe (1 ton of Timber allows per 100 years the sequestration of 1 850 kg Carbon eq) while the emissions were of ≈4, 5 Billions of tons in 2018 (15 times more).

In the AV industry, we use notably wood for the set construction frame; most of the time wood from set construction is landfill or burned into incinerator thus releasing their incorporated $CO_2$. Even if the wood is recycled, its transportation and processing require energy, so it emits CO2 also but in smaller quantity.




→ This production scheme requires constantly cutting new trees which can no longer fulfill their carbon sink functions. We must find a way to increase or at least preserve the carbon sequestration capacity of these carbon sinks by using less wood in our industry.

Sources:

- Annual Mean Growth Rate for Mauna Loa, Hawaii – National Oceanic & Atmospheric Administration (NOAA)
- Key Climate Figures - France, Europe and World 2020 – General commission for sustainable development, Institute for climate economics I4CE- French government
- Carbon base ADEME p170

## Solution

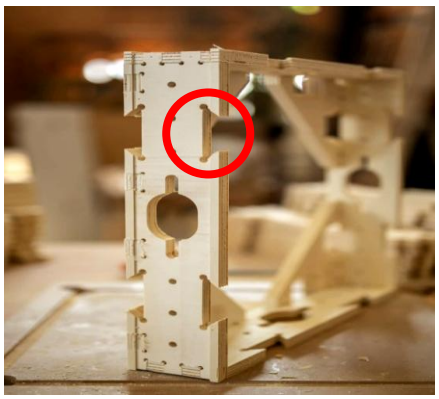
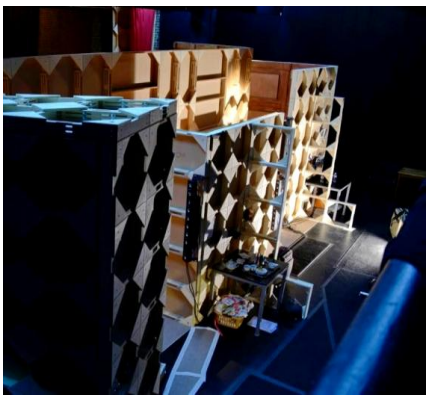
Reusable wood module with a long life cycle can be use to replace wood consumables for set construction frame. These wood modules and their accessories are thought to be very easy to assemble and disassemble and to be able to be reused many times (60 use in average).

## AV industry application

- Replace wood consumables for set construction frame

## Key features

- Their extreme modularity will allow them each time to adapt to the temporary structure imagined: walls, floor, and ceiling. Thus, the same stock of modules can be converted over time into a counter, podium, partition, bar ... or any other structure **without glue, silicone or nail** because it is very complicated to disassemble.
- The panels covering these partitions hold themselves in place thanks to their own weight via a nesting system which rests on small wooden trapezoids= simple and effective.

- The principle is to be able to remove and replace them easily.
- Improves the set construction productivity = no framework construction.
- Increase the studio use rate = short time for assembly & de-assembly.
- Reduce the space needed for timber workshop= this gain in square-meter can be use as storage space for the module.
- These modules are part of circular economy logic.
  On the one hand because they replace temporary disposable or little reusable solutions e.g. disposable wood leaf for set construction and on the other hand, because part of their production uses waste (scrap wood from carpentry) as raw material.

## Impact mitigation

- Even with an improved scenario at EoL :Recycling 50%, landfill 5%, incineration 45% at EoL, avoided impacts wood module vs. disposable wood for 60 use = **- 297,82 kgCO2eq /m2 i.e. - 97,51%**
- Sources:
  - Carbon base-Ademe
  - Impacts base- Ademe
  - Impacts base- data documentation category wood - Ademe

## Profitability

- For purchase, the wood modules during its lifespan decreases hugely the cost of set construction frame even at the most expensive cost = **-532€/m2**

- Beyond sourcing cost, the wood module generates additional savings:

On one hand:

- There is considerably less waste management compared to disposable wood = less waste produced for 60 uses/m2 = **4 kg/m2 against 60*3 = 90 kg/m2** = reduced waste fee.
- Fast assembly without glue, silicon, nails = decrease workforce cost (machinist constructor/carpenters) and workshop space.
- Fasten de-assembly = improved availability of the studio.

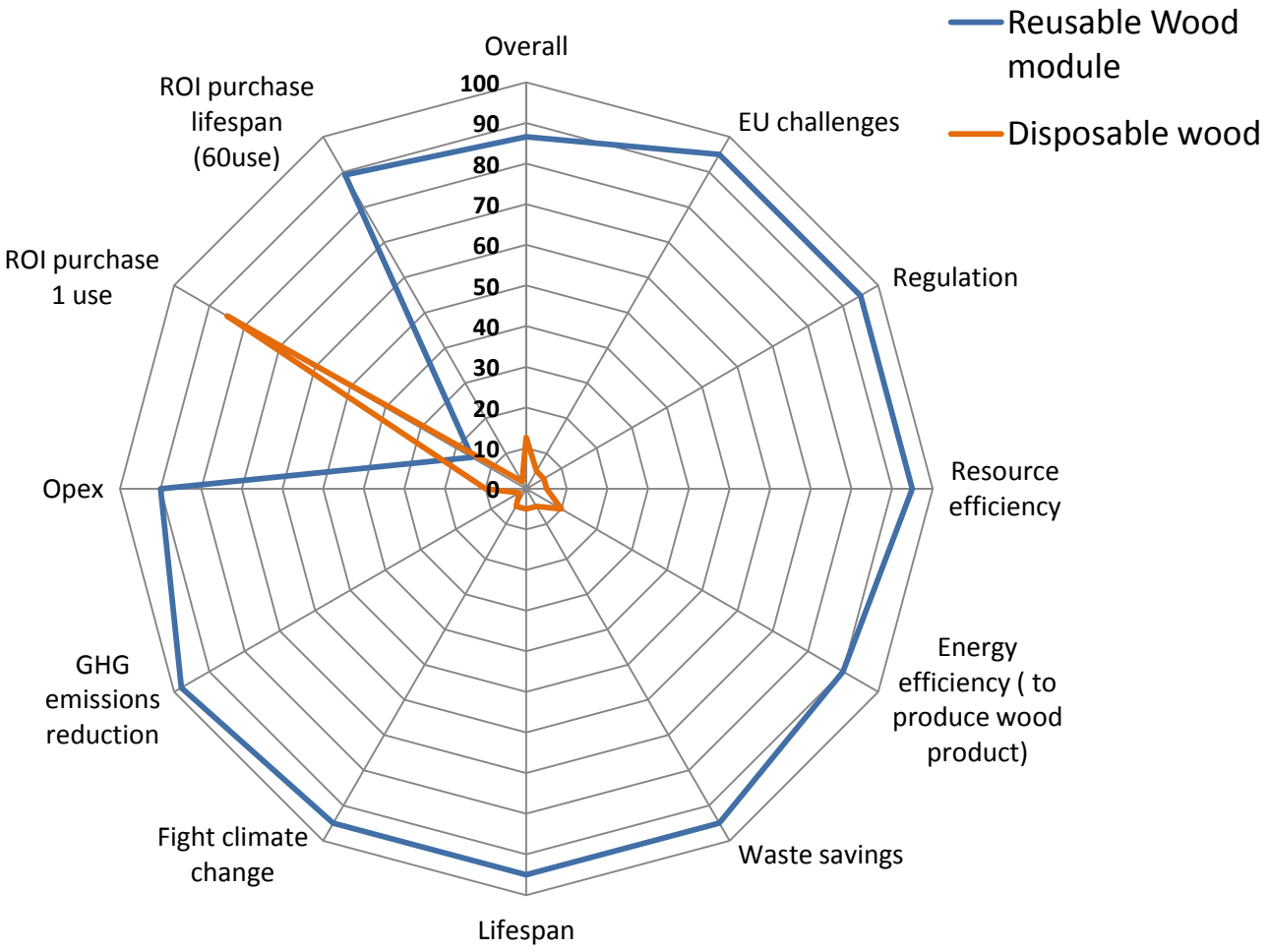
On the other hand:

- Storage space is needed; however the saving space in the workshop can be dedicated to the modules storage without extra cost.

- Wood module ROI per m2 compared to disposable wood = **+ 682, 35%**
- The time to value the purchase of wood module is very short: 6, 47 use =10% of the average lifespan.
- Solely for the sourcing the ROI is yet very high: **+ 682, 35%**
- The storage cost will be largely overcome by the sourcing gain and others savings sources: reduced consumable (e.g. nails), workforce and waste management + gain of space (workshop)+ improved availability of the studio (shorter time of de-assembly).

## Comparison to disposable wood

- Reusable Wood module vs. Disposable wood for set construction frame




## Conclusion

- *Wood reusability is the key to significantly decrease CO2e, from set construction frame, while preserving the main carbon sink( with soil): the forest*

# 23. Transport - Electric van and its charging infrastructure

## Context

Beyond global warming and geopolitical upheavals, oil reserves are melting like snow in the sun.
Peak production of conventional oil (inexpensive and easy to extract) was overcome in 2008, today the production increase is relying from unconventional oil from the parent rock (USA) and oil sands (Canada).

This unconventional oil requires 5 times more energy to be extracted than conventional oil and open wells in 2013 in the US are starting to decline.
This situation combined with the lack of new discoveries of conventional oil (see chart below) will lead to a supply crisis as early as 2025.
The International Energy Agency (IEA) announces a shortage of 13 million barrels of oil per day (on a consumption of 92M / day in 2019) = 1 barrel of oil = 159 liters of crude oil = 2.067 billion trillion liters missing a day = **this supply crunch will worsen from year to year**.

- Thermal vehicles have no future

Sources:

- World energy outlook 2018,2019 - IEA
- Energy outlook - BoombergNEF 2017,2018,2019

## Solution

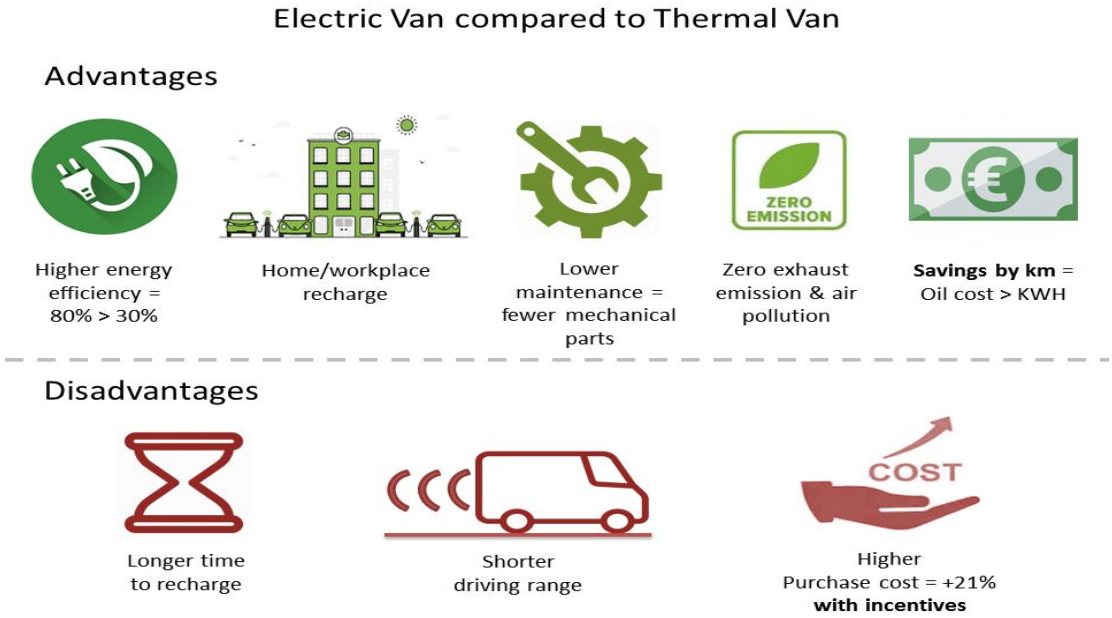
Battery electric vehicles (BEVs) are one of the potential ways in which Europe can move towards a more sustainable transport system.

## AV industry application

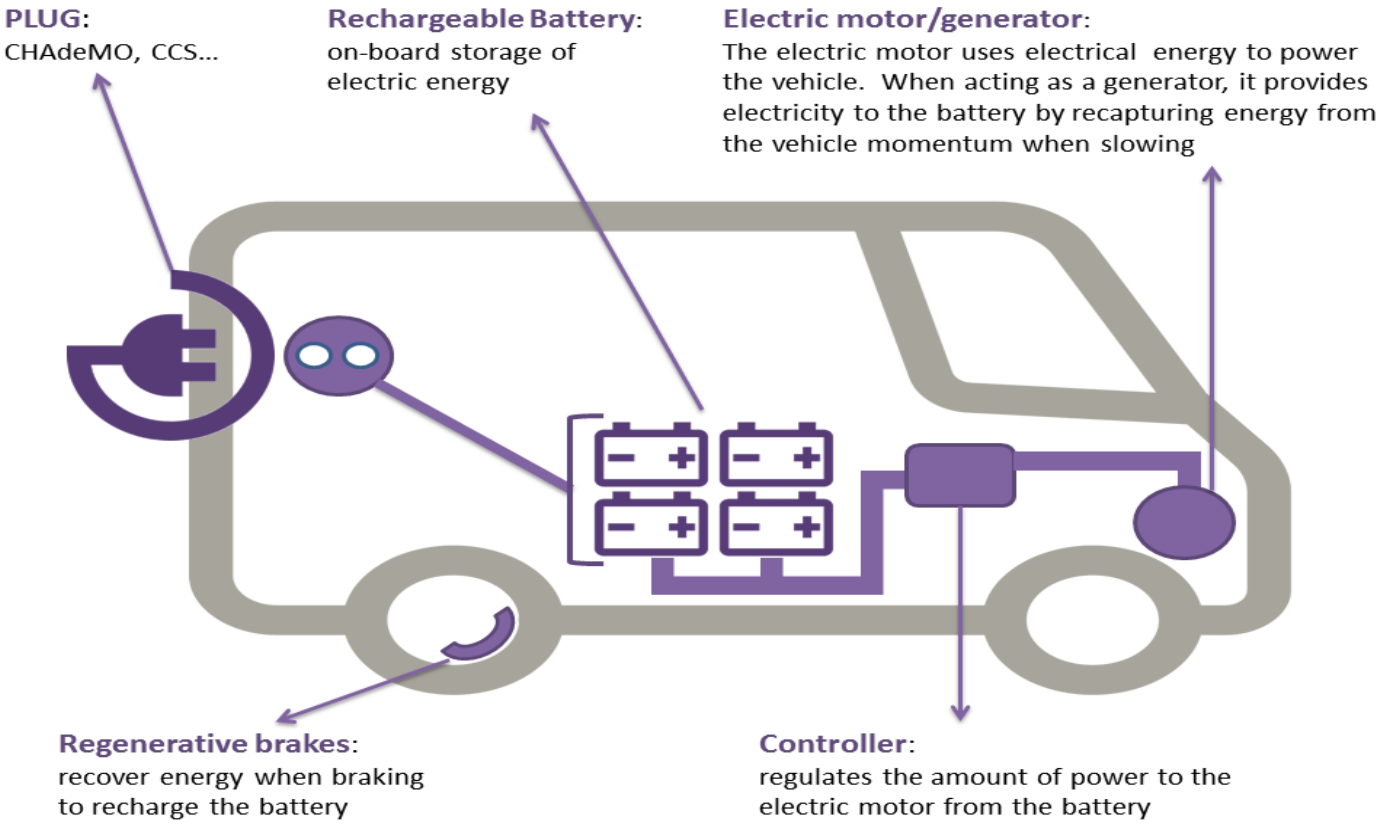
- The most promising EV is the electric van which can be uses in urban area for shooting logistic and deliveries without being affected by low emission zone e.g. The ULEZ in London, and future regulation and for shooting in natural/protected area.
- For AV companies, the generalization of low-emission areas in all major cities in Europe is a major incentive for replacing its thermal fleet with an electric fleet.

## Key features

- **BEVs have the highest energy efficiency of all vehicle propulsion systems**, typically able to convert around 80 % or more of the energy stored in the battery into motion.

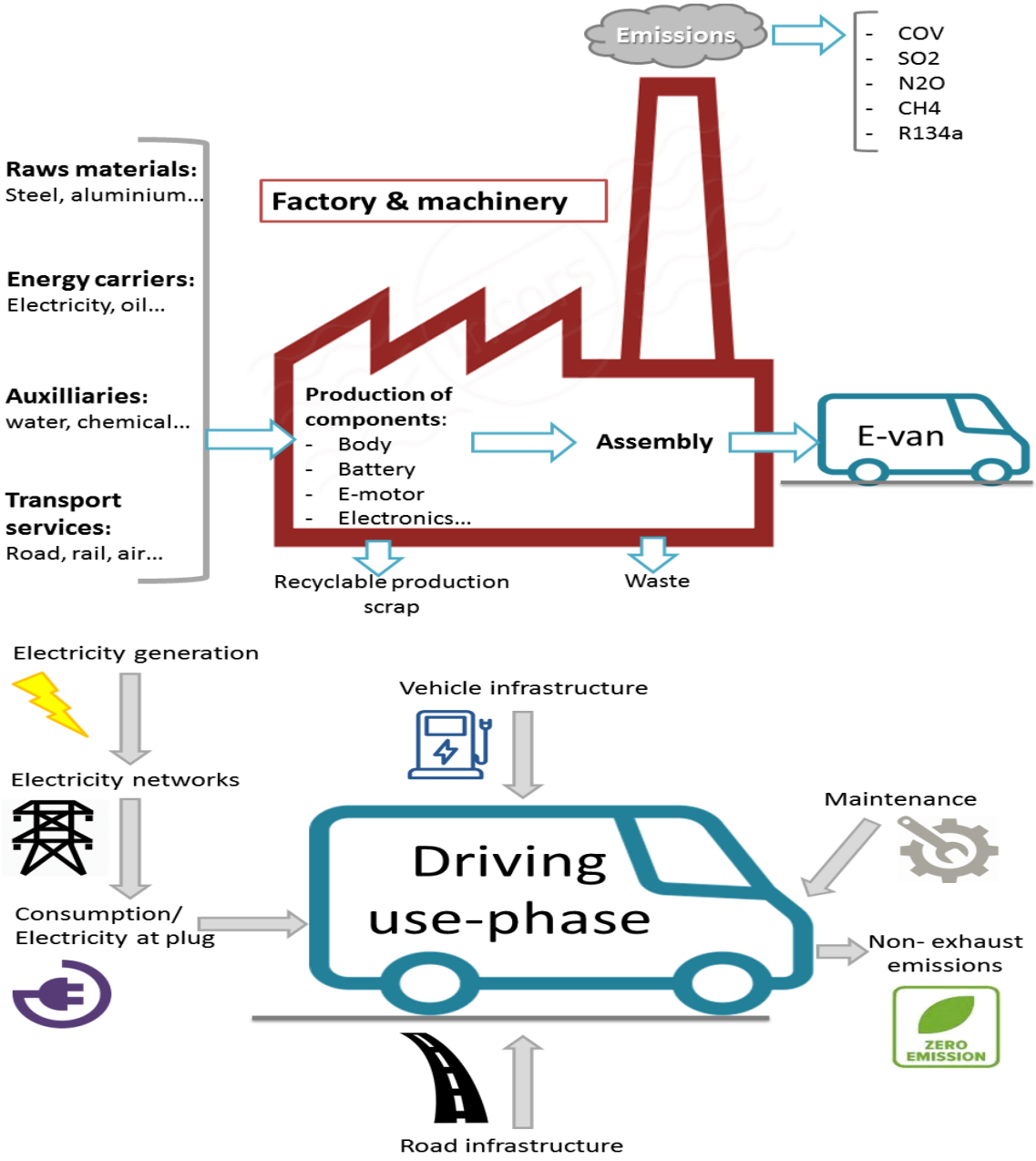


- BEVs, still have somewhat limited driving ranges compared to conventional vehicles and typically need a long time to recharge the on-board batteries, however the number of charging station is increasing rapidly. In 2018, the number of public charging stations in Europe = **152 770 in 2019** (source European Alternative Fuels Observatory)**:**
  - Netherlands, 37,000 chargers
  - Germany 26,200
  - France 24,770 and
  - UK 18,200




- Better suited for services companies and for urban & natural areas shooting
- The power level of charging points ranges widely, **from 3.3 kW to 120 kW**
- **Slow charging** (AC current) = time of charge for the electric van **= 5h with an household socket**
- **Fast charging** (DC current): time of charge for the electric van = **45 minutes with DC Connectors**: CCS & CHadEMO (fast charging stations)
- **Autonomy**:
  - 173 km max with eco + driving profile and empty cargo
  - 100 km loaded + driving in town
- **Electricity consumption** (from batteries): **0,358 kW/km** in average whereas thermal van consumes 0,160 l (diesel)/km
- **Useful load**:
  - Total permissible weight of 4.25 t = 1,700 kg
  - Total authorized weight of 3.5 t (city) = 975 kg
- **Cycle life** at 100% depth of discharge (DOD): ≈ 1 000
  - The batteries are usually replaced at 80% depth of discharge (DOD)
  - local energy storage will be a re-used channel for batteries of electric vehicles that are not longer at 100% of their efficiency

## Impact mitigation




- Avoided impacts with an electric van per 100 km = 16, 37 $kgCO_2$ i.e. **- 69, 37%** compared to a thermal van.
- An electric van with a battery system of 35, 4 kWh from
  - European manufacturing, would begin to have a lower carbon footprint than a petrol-driven vehicle **at 32 803 km**.
  - Asian manufacturing, would begin to have a lower carbon footprint than a petrol-driven vehicle **at 51 611 km**.
- Sources:
  - Electric car: 697,612 km to become green! True or false? – PHD Damien Ernst, University of Liège
  - Manufacturing energy analysis of lithium ion battery pack for electric vehicles 2017 - Yuan, Chris; Deng, Yelin; Li, Tonghui; Yang, Fan
  - "The Life Cycle Energy Consumption and Greenhouse Gas Emissions from Lithium-Ion Batteries". Technical Report C 243, IVL Swedish Environmental Research Institute, May 2017

## Profitability

- Incentives to go electric:
  - In UK: the grant will pay for 20% of the purchase price for an electric Van, up to a maximum of £8,000.
  - In France: the grant will pay for the purchase to an electric van, up to a maximum of €10 00 (national ecologic bonus €4 000 +Paris Region grant €6000)

- Cost by km (with external infrastructure for fast-charging) = time to value the investment in km
  - Electric van =≈ 0,358 kW/km
  - Thermal van =≈ 0,16 l/km

  - Life span of an electric van 150 000 km / 250 000 km = 200 000 km in average

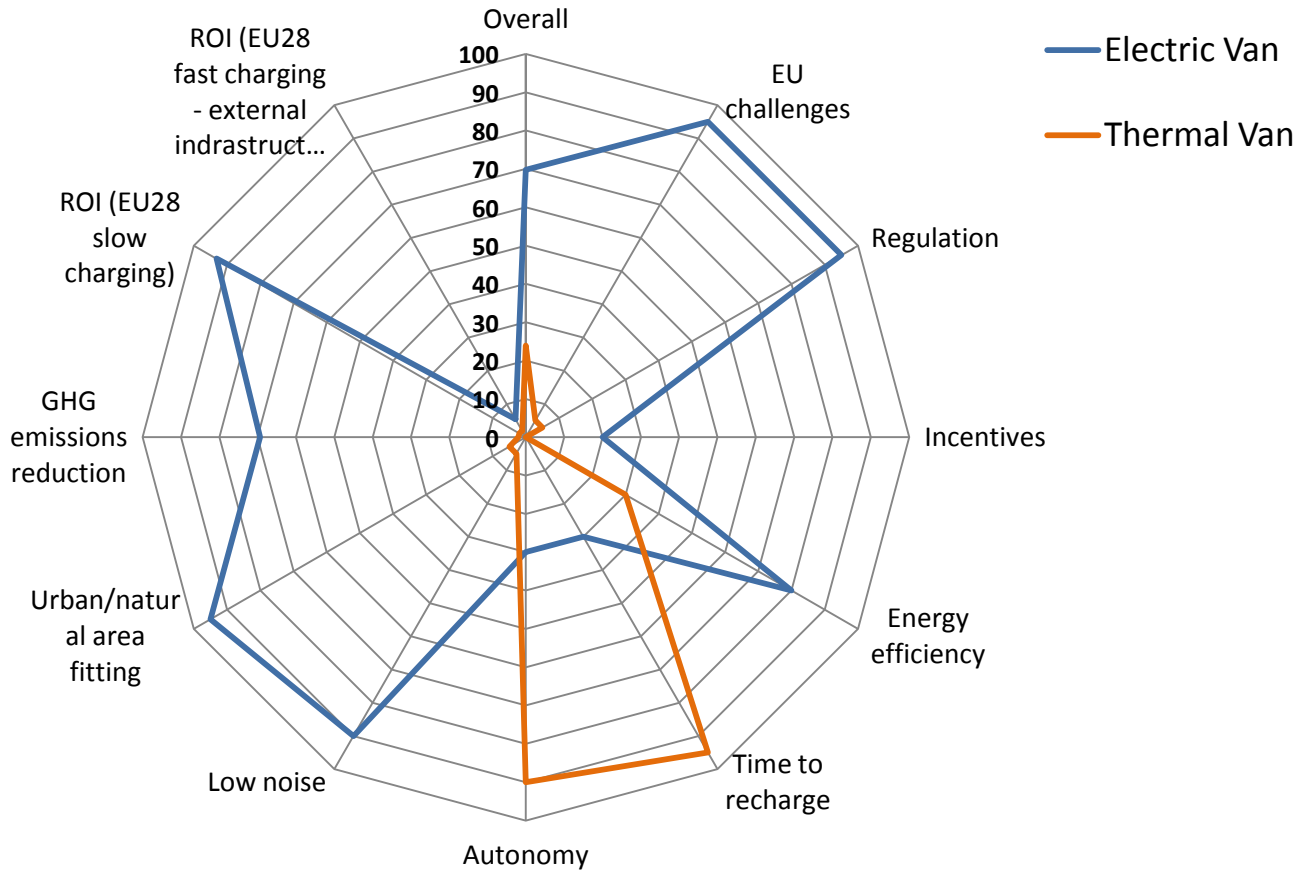
- The cost-efficiency of the electric van depends on the
  - Amount of incentive
  - Cost of gasoline
  - Charging mode: slow or fast = Due to higher price (3x), external charging infrastructure decreases significantly the economic viability = **investment in proper fast charging infrastructure is a smart move.**

- ROI with incentive for an electric van (Europe) compared to a thermal van
  - Slow charging- AC= **+ 93, 16%**
  - Fast charging- DC – external infrastructure **=+ 5, 47%**
- ROI with incentive for an electric van (France) compared to a thermal van
  - Slow charging- AC = **+ 139, 42%**
  - Fast charging- DC – external infrastructure **=+50, 2%**

- ROI with incentive for an electric van (UK) compared to a thermal van
  - Slow charging- AC = **+ 112, 22 %**
  - Fast charging- DC – external infrastructure **=+ 2, 93 %**

- Electric van is strongly cost-efficient in any case (EU28, France, and UK) with slow charging.

## Comparison to thermal van




## Conclusion

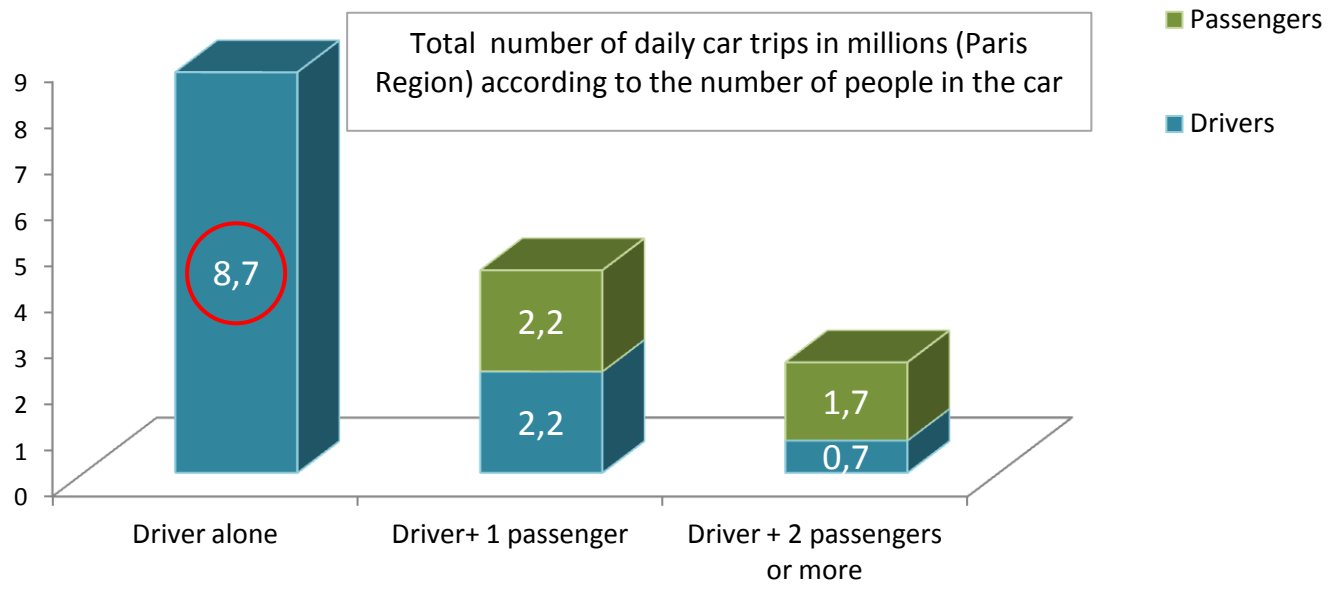
→ *Despite some drawbacks: lower autonomy, long time to charge & the environmental footprint of batteries, Electric van is a cost efficient solution for low emissions mobility and shooting logistic.*

# 24. Transport - Data driven carpooling for work commutes

## Context

The development of the sharing economy has expanded considerably long-distance car pooling: millions of users Europe-wide in 2016, but this not the case for intra-city commutes= 70 % of Europe's commuters drive to work, almost always in the vehicle by themselves.

**Less than one in ten work-related trips is carpooled**. The average filling rate of cars that circulate in **Paris region** on a weekday is **only 1.3 people**. Thus, it remains in general, three or four or places available per vehicle = **40M seats unused**.



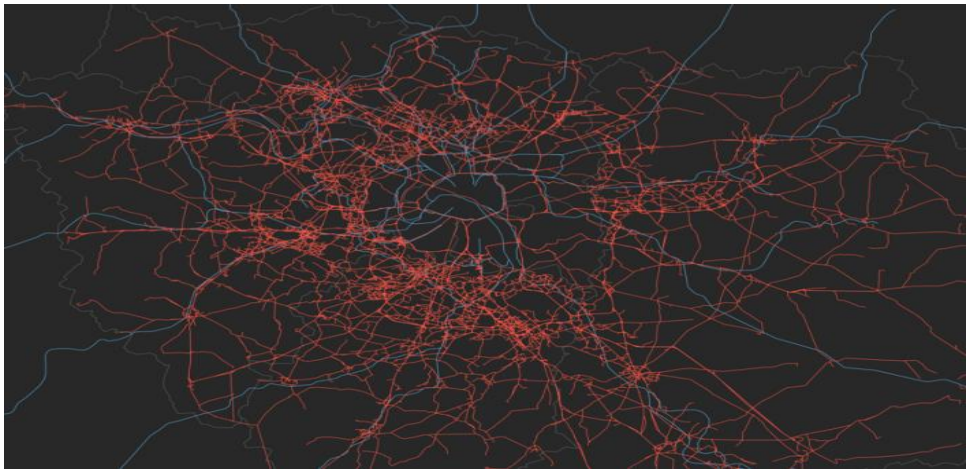

→ Initiatives are multiplying to encourage drivers to carpool for work commuting but they have little efficiency due to:

- Organizational constraints = pick-up location, planning, invoicing & fixed crew.
- Short distance carpooling financial gain is low= average journey of 21 km compared to long-distance carpooling = 367 km

Source: Le covoiturage en Île-de-France: une pratique déjà courante, un potentiel de développement soumis aux contraintes d'organisation -une étude de l'Observatoire de la Mobilité en Ile-de-France (Omnil) - 2017

## Solution

New generation of short distance carpooling Smartphone app is emerging; which is leveraging:



→ To solve short-distance car pooling issues, these solutions are leveraging

- Geo-location
- Big data technologies

- AI and algorithms
- Efficient business models.

## AV industry application

- For AVP industry SMEs, encouraging employees to use a short-distance carpool APP is a way to easily reduce their environmental footprint and help their employees to save time and money.

## Key features

- Transforms empty car seats into public transportation networks and connects them with mass transit.
- Permanent recovery of geo-location data from the smartphone.
- Cleaning up this data to understand:
  - What is the starting point of the users?
  - Where are they going?
  - What is their itinerary?
  - What is their travel time?

  To be able to predict the user needs of displacements.
- As it is done on all users = 5-days prediction on supply and demand = **creation of a predictive transport network**.
- Intermodal engine = synchronization with the public transport database to mix carpooling lines and mass transit lines = Gain of time for work commutes= 25 minutes in average
- Matching algorithm: based on past travels and offer/demand, match between carpooler and passengers.

## Impact mitigation

- For a 21 km work commute, impact mitigation for the entire crew (≈3 people) compared to work commute made alone in the car:
  - - 0,09 kg$CO_2$ per carpooled km = -34,62 %
  - - 0, 03 g $NO_x$ per carpooled km = - 35,72 %
  - - 0,002 g PM = - 33,34 %

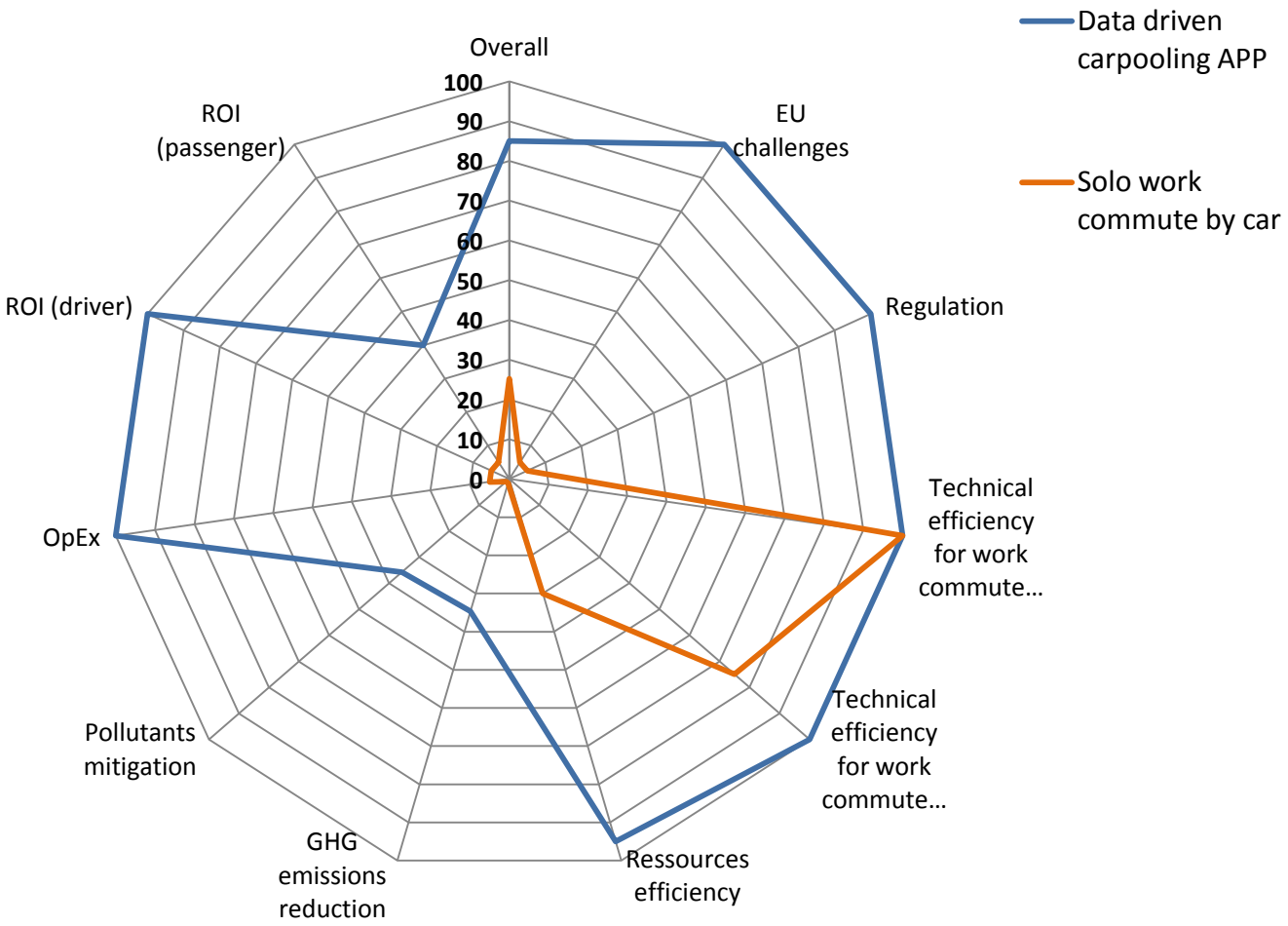
  Sources:
  - Emissions de particules et de NOx par les véhicules routiers Ademe, Juin 2014
  - Etude nationale sur le covoiturage de courte distance – Ademe, Septembre 2015

## Profitability

- Free app
- The journey costs 0.10 € / km to the passenger and earns 0.10 € / km to the driver. Thereby, the app does not take any percentage. The sums are exchanged automatically by transfer to the user account.
- ROI for an average carpooled work commute (21 km) with train interconnection:
  - Driver ROI with 2, 2 passengers = 235%
  - Driver ROI with 1 passenger = 107 %
  - Passenger ROI = 40%

  → The ROI is lower for the passenger because the cost of public transport by train is higher than the fuel consumption

## Comparison to solo work commutes by car




## Conclusion

→ *Low cost and low carbon solution, that is very easy to implement*.

# 25. Transport - Real-time data freight transport

## Context

The logistics sector is underperforming in Europe as many trucks run empty and, although there is no reliable statistical evidence, partially loaded vehicles are also very common.
In Germany alone, empty trucks drive 6 billion kilometers each year, and the number is increasing. If we combine the figures of the European Union and the U.S., that number jumps to **120 billion** kilometers every year. For comparison the distance from earth to the sun is ≈ 149, 6 billion kilometers.

The high rate of running empty can be explained by 2 factors:

- **Relatively low price**: a truck can operate in Germany for about 1.1 euro per vehicle km. This cost is a lot lower in Eastern Europe (72 cents per vehicle km in Poland and 58 cents per vehicle km in Lithuania); the operational cost of a truck is artificially low if we consider the externalities of the vehicle.
- **Information asymmetry**: at the time of arranging shipments, transport planners have no information on what trucks and when will be available near the planned loading location.

→ Technology can play a role in making transport more efficient **by solving the information asymmetry:** The **flow of real time information** regarding cargo space and arrival time is under utilized in road haulage.

## Solution

Internet applications are being developed and increasingly used; enabling road haulage companies to be more aware of goods/equipment 'available' to be transported near their trucks. It is now possible to connect shipments with trucks "in the future" anywhere in Europe.


→ Users can visualize anticipated empty trucks on the map:
This future visibility map provides users with all the relevant information necessary to book the truck which will be closest to their pick-up location at any given time and get the load moving = reduce the number of empty kilometers.

## AV industry application

- This solution can be use to ship equipment to studio or shooting location.

## Key features

- Used a mix of geolocation, machine learning and big data to get & processing real time data.

- Flexible hauling: no constraints of loading and unloading date & time.
- Finding empty trucks on map & requests quotations.
- Book the best truck: cheaper & closer.
- Cut empty run will extend the useful life of trucks (loaded)

## Impact mitigation

- For 1 cargo of 25 tons by a 40 tons truck **without empty return** compared to the same journey with empty return:
  - 2,1 kg $CO_2$/t.km (ton.kilometre) = - 46,25%
  - 2 g $NO_x$ /t.km
  - 0,02 g PM /t.km

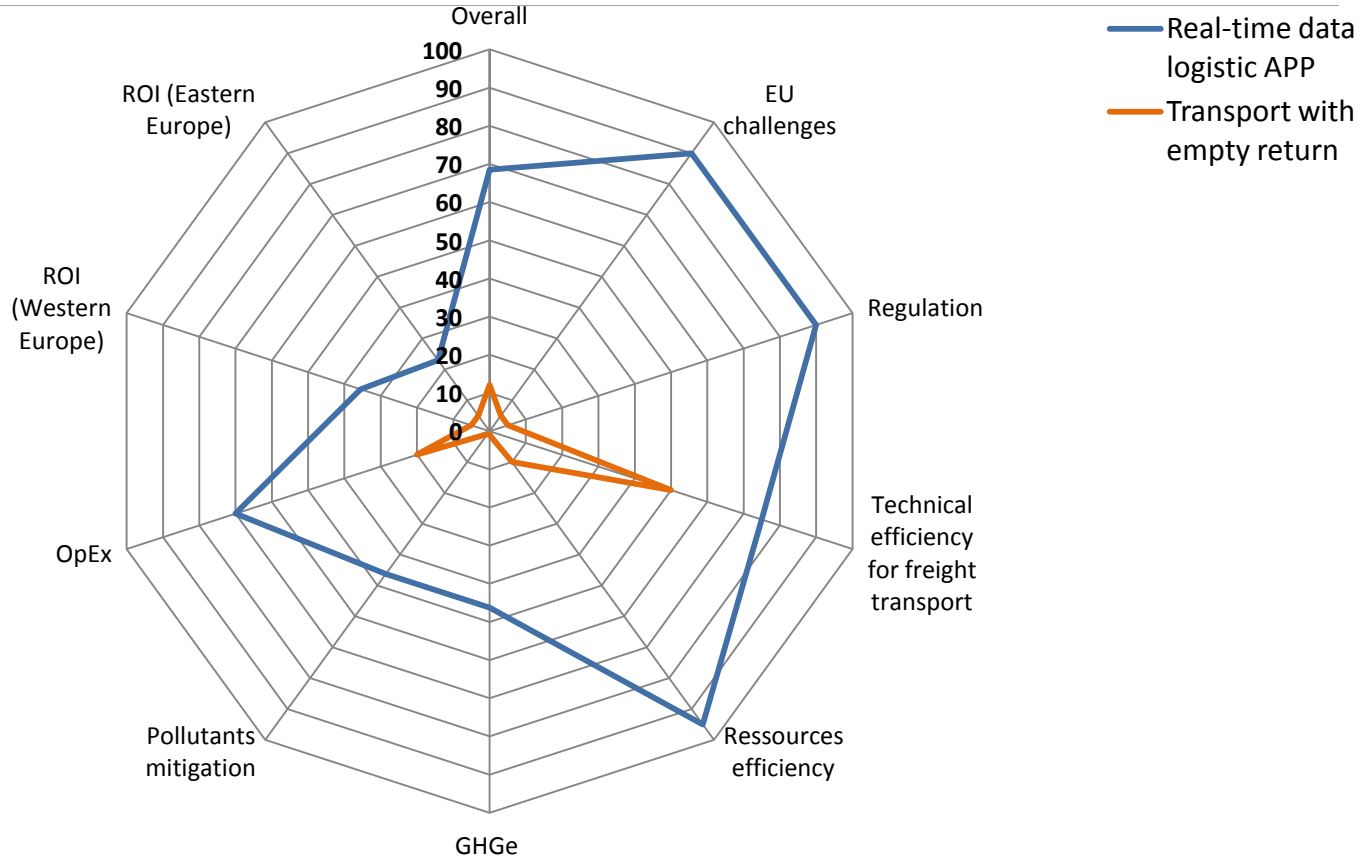
Sources:

- COMPETE - FP7 European project p.15 table 3-15
- Info CO2 Transport methodological guide - ADEME p.77,78

## Profitability

- Without empty return i.e. with a tank load factor of 100% the cost of the carrier per t.km in Western Europe will decrease by - 34.66%, so it will be able to offer more competitive prices while improving its profit margin, it is a win / win agreement for the carrier and the shipper
- Depending on the carrier, the shipper can benefit from a discount price
  - Western Europe: 15 to 30% cheaper = **average of -22.5%**
  - Eastern Europe: 5 to 15% cheaper = **average of -10%**
- ROI, Western Europe= 35, 51% / ROI, Eastern Europe = 23 %

## Comparison to Transport with empty return




## Conclusion

→ *Cost-efficient solution for AVP SMEs to ship theirs machinery/equipment/goods to film shooting location.*

# 26. Waste management - IoT based waste management (smart bin)

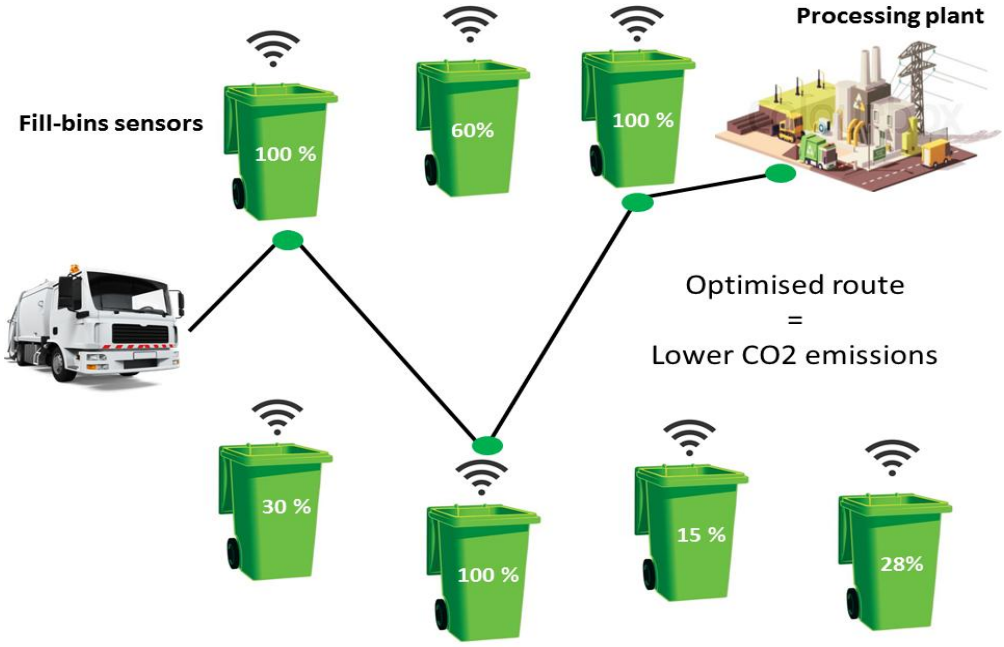
## Context

Picking up trash and recyclables from trash receptacles on street corners, in parks, or on campuses is pretty resource-intensive because workers have to drive hauling vehicles to every collection point… whether they're full or not. A trash can that could tell collection crews when to pick it up could save a lot of fuel, work hours and GHG emissions.
In offices, the problem is similar, employees sort badly or not waste; and garbage bins are collected whether they're full or not.

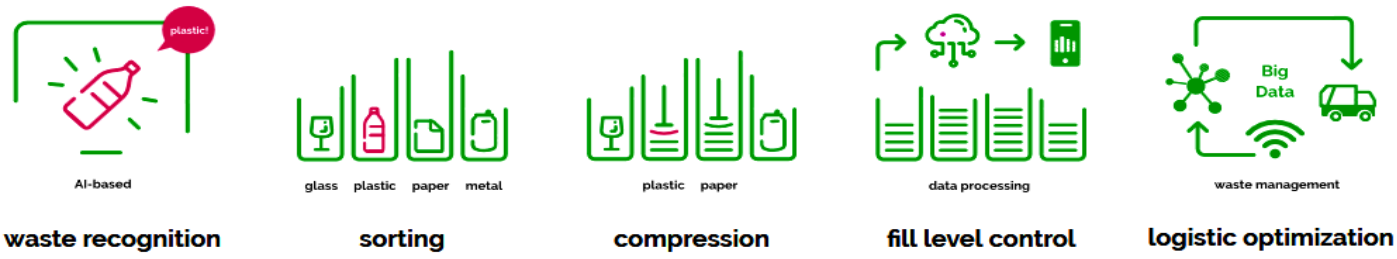
→ This inefficiency is largely due to outdated manual collection methods and logistical processes which lack efficient data-driven solutions.

## Solution

The waste management industry is beginning to develop and implement IoT (internet of things)-related solutions to solve these issues, e.g. trash cans with fill-sensors embedded.




→ IoT solutions are also available for office i.e. a smart bin that identifies categorizes sorts and stores the trash.




## AV industry application

- This solution is suited for AVP industry offices and studios.

## Key features

- Recognizes the object then compresses and sends it to the relevant container.
- At the same time, collects the data and sends it to the external database.
- The database collects data from multiple devices to improve the recognition process.

- If one of the containers needs to be emptied, the device informs the maintenance service.
- The signal also goes to the waste management company, so the logistical process of collection is optimized = based on received data (fill level), the company decides or not to collect the waste.
- Thanks to the previous segregation and compression of waste, the collection process is simple, economic and clean.

## Impact mitigation

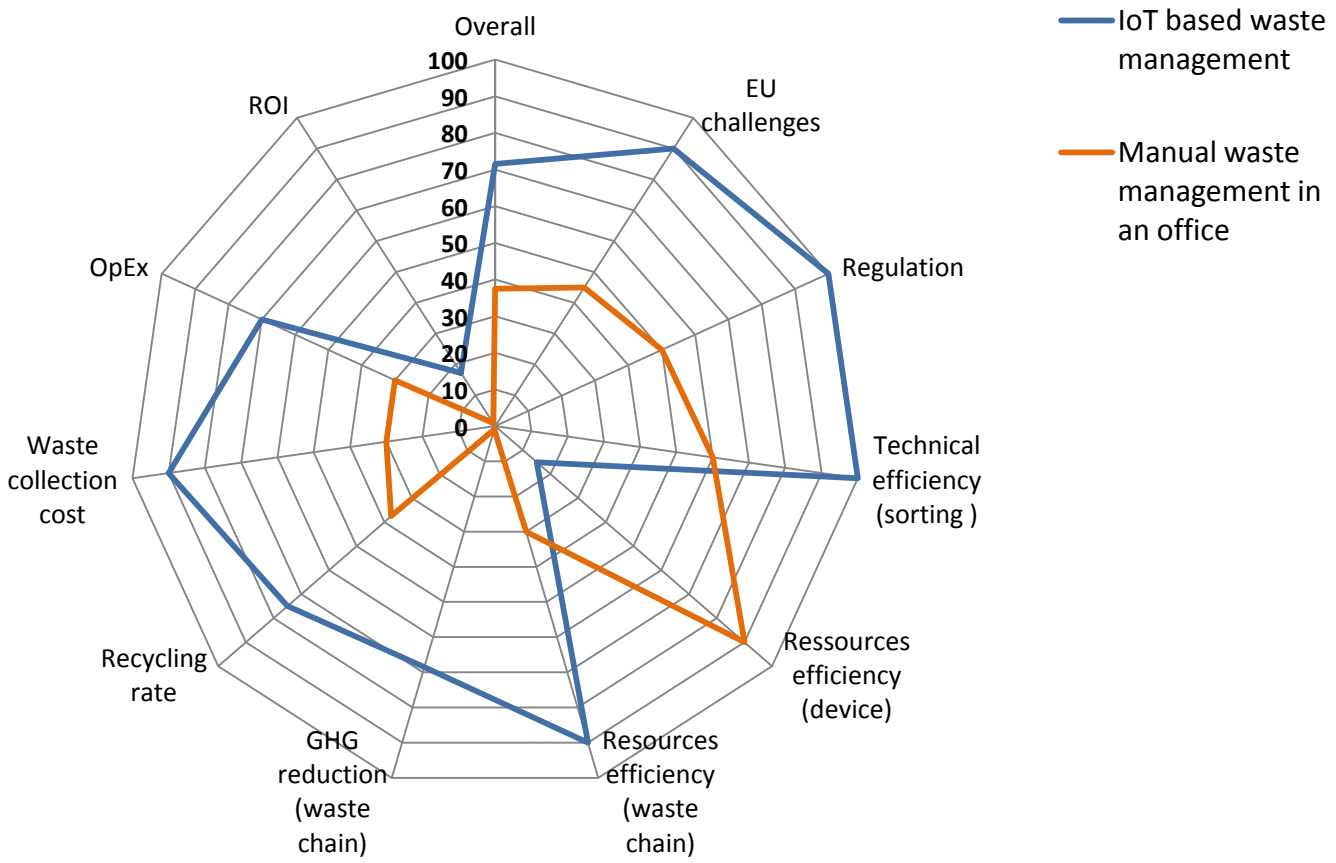
- For waste collection of 1 ton of recyclable waste: paper, metal, glass, plastic compared to non IoT based waste management:
  - Improves recycling rate
  - - 13,542 kg $CO_2$ eq = - 68,53%

## Profitability

- When SMEs pay their waste management per m3 rather than ton like in France, it's a cost-efficient solution.
- For an office of:
  - 25 people , ROI per year = 17, 23 %
  - 50 people, ROI per year =34,4%
  - 100 people, ROI per year = 68,94%

  The ROI is proportional to the number of employees and therefore to the volume of waste generated.

## Comparison to manual waste management in an office




## Conclusion

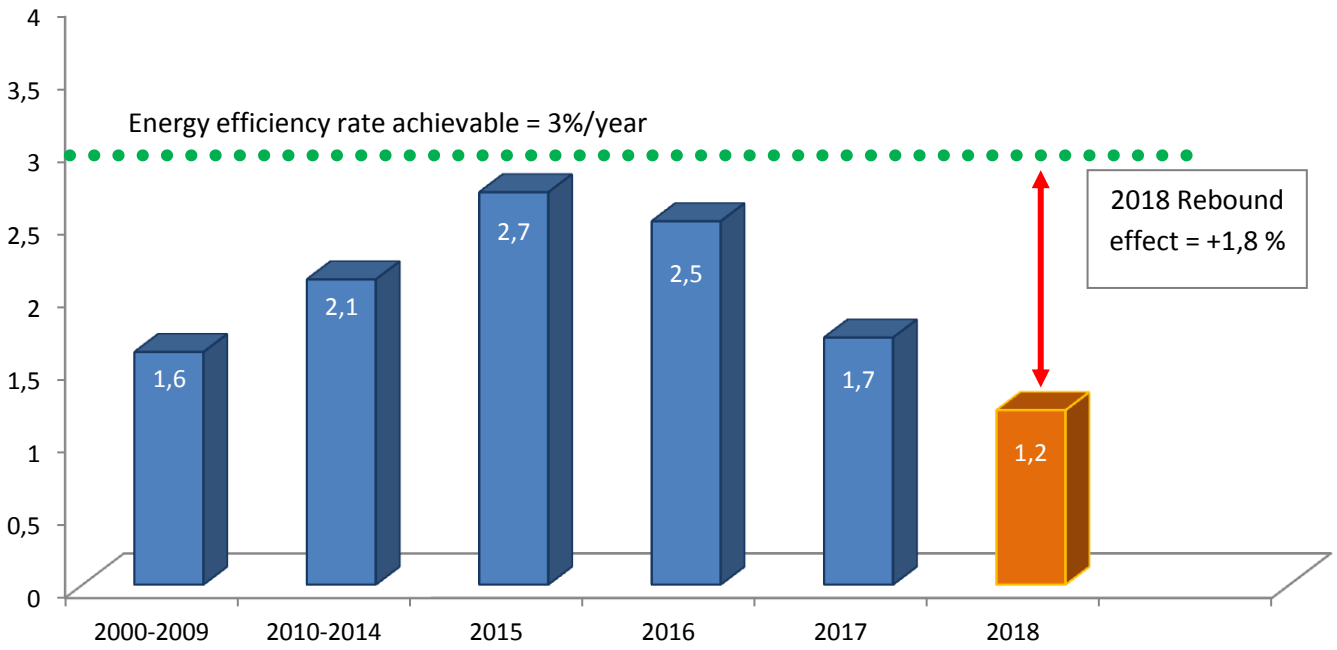
→ *This solution provides environmental and economic benefits for the SMe but also for the entire waste management chain.*

# 27. Workflows pipeline & physical infrastructure - Bipolar LVCD for datacentres, render farm, studio stage

## Context

- The demand for undisturbed electricity is growing while society relies more and more on electricity and higher energy demand due especially to digital. The occurring outages have more effects to the customers and outage costs increases attempts at **putting a price** on such non-delivery of electricity indicate values of EUR 3,000 and over per megawatt-hour, at least 500 times the current market price.
- Electricity may be the one industry in which suppliers actively encourage customers to use less of their product, and that is partly due to demand-side management (DSM) policies. DSM policies such as energy efficiency laws encourage or force utilities to sell less electricity, particularly during peak hours when electricity use and electricity prices are highest.
  DSM policies fail to accomplish their stated goals—energy efficiency mandates can have a “rebound effect.” That is, people increase their use of energy-consuming technologies as they become more efficient, which undermines the initial goal of using less energy.

Primary energy intensity ( EE improvement in %)




- Many today applications run on DC power: electronic devices, batteries, renewable, HVAC… Our electricity system thus contains a substantial number of blocks with the sole purpose of turning alternating current into direct current and vice versa.
- With the looming energy crisis = shortage of oil by 2025 and ever-increasing consumption, it is essential to improve the grid’ efficiency, otherwise the energy security of Europe will be jeopardized. We will increasingly rely on electricity as our main energy source.

These challenges: **undisturbed electricity supply + more energy efficient distribution to mitigate rebound effect and oil supply crisis + compatibility with the sources we used nowadays** has raised demand for more reliable network solutions compared to traditional 3-phase AC distribution systems.

Sources:

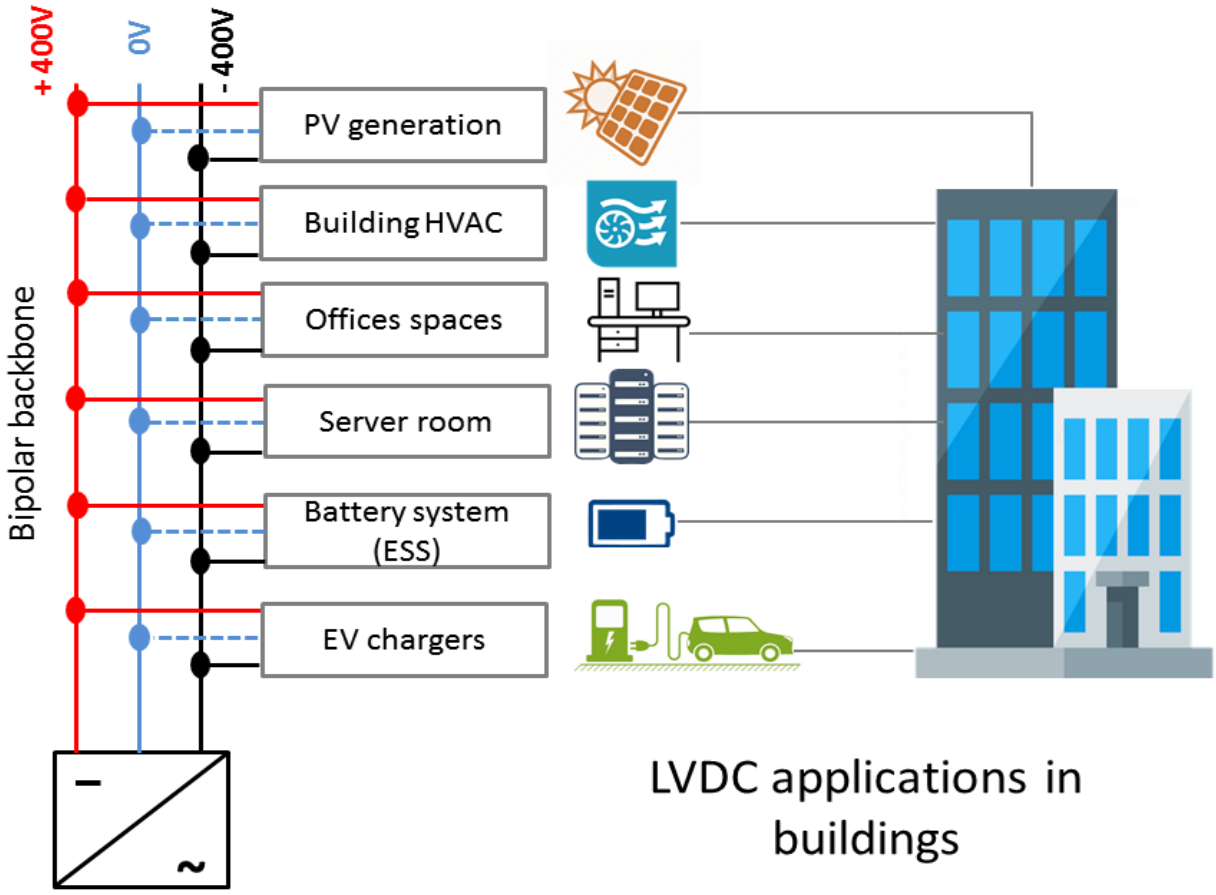
- Energy Efficiency 2019 - IEA
- Capturing the Multiple Benefits of Energy Efficiency - IEA
- An LVDC Distribution System Concept Pasi Salonen, Tero Kaipia, Pasi Nuutinen, Pasi Peltoniemi and Jarmo Partanen
- Electricity distribution - IER institute for energy research

## Solution

To improve electricity distribution efficiency we can build low voltage direct current electricity distribution system (LVDC), i.e. micro grid in buildings/site.

## AV industry application

This solution can be adapted in a studio which has local production (solar panels), charging infrastructure for electric vehicles in the parking lot, LED lights, a server room, elevators, ventilation, cooling and heating systems based on heat pumps = lower GHG emissions and reduced costs.




## Key features

- Cut energy losses = - 20% (measured in lab)
- A reduction of energy losses also indicates the cooling system can be down-scaled in Data-center, server room, nodal render farm = ≈- 40%
- Improves QoS, climate change resiliency (reduced vulnerability to power outages), Increased energy efficiency and lower costs.
- Versatility = Retrofit solution for buildings / Design for new buildings
- With the conversion (AC/DC) simplification = less components =less consumption of CRM & rare earth element.
- More power can be transported with the same cables, i.e. more power with less (expensive) conductor materials (copper).

## Impact mitigation

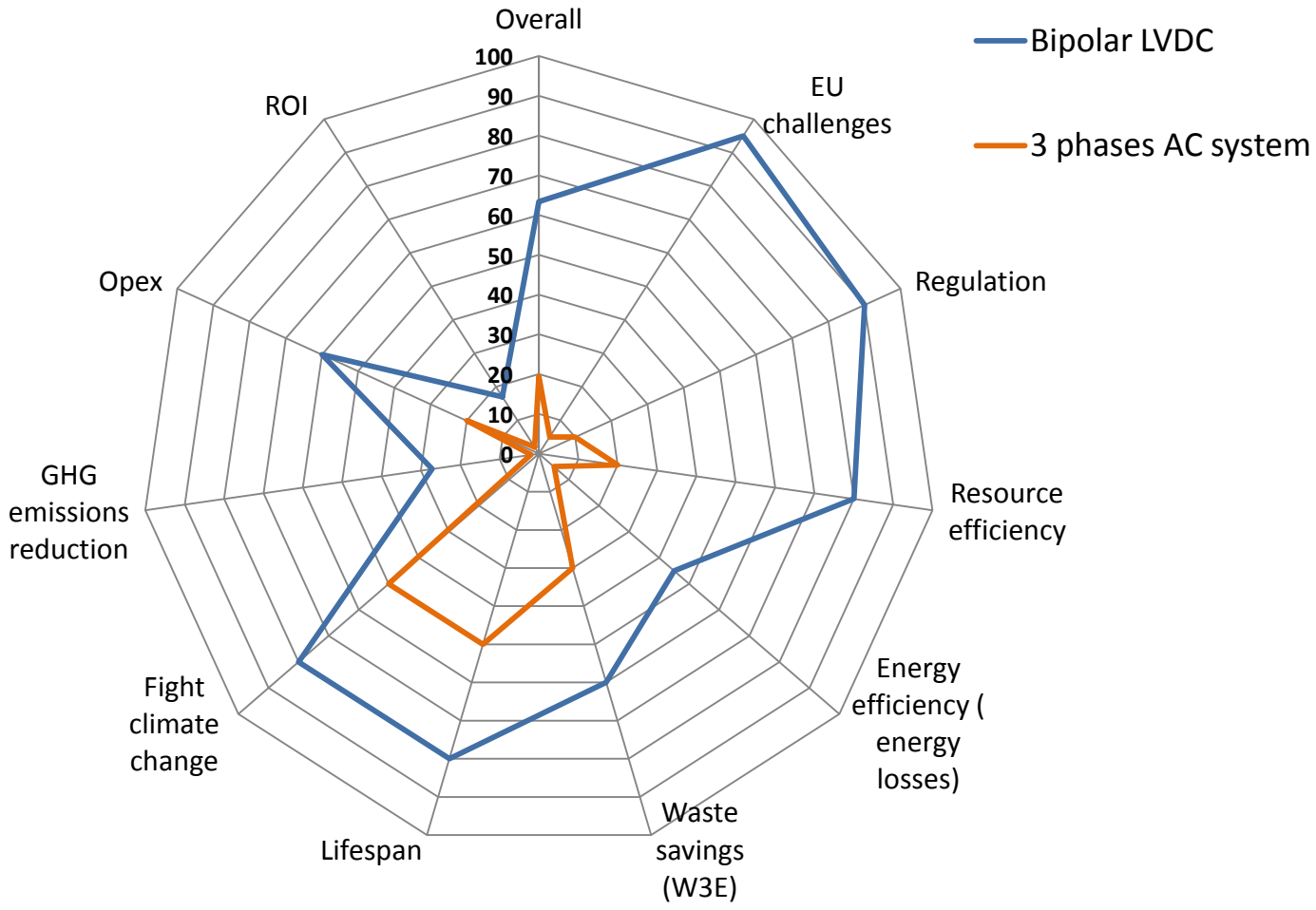
- Infrastructure and energy losses from transmission and distribution.

- Avoided impacts B LVCD vs. 0.4 kV 3 phases AC system for the delivery of 1 kWh of electricity in Europe (transmission + distribution) = **- 7,6 g CO2eq i.e. -27,14%**
- **Source:**
  - Turconi, R. (2014). Life Cycle Assessment of Electricity Systems. Kgs. Lyngby: DTU Environment – PHD thesis

## Profitability

- +/-500 V 100 kW Bipolar LVDC facility cost over Unipolar LVDC and 0, 4 kV 3 phases AC
- Bipolar LVDC is the cheapest electricity distribution system = less components, cable + lower energy losses
- Furthermore it's more reliable against power outages (higher breakdown voltage) = continuity of service + downsized back-up system.
- ROI Bipolar LVDC over 3 phases AC facility investment + energy losses (15 years) = **+ 17%**
- A 17 % ROI can seems low, however the electricity distribution is usually considered as a cost center and not a profit center.

## Comparison to manual waste management in an office




## Conclusion

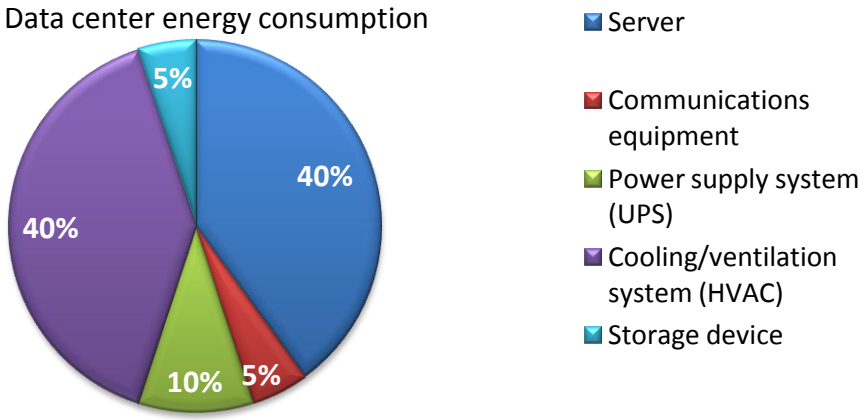
→ *Electricity distribution system of the future.*

# 28. Workflows pipeline - Multi site hierarchical green workload management

## Context

Data centers already consume roughly 3% of all globally generated power and account for approximately 2% of greenhouse gas emissions – a carbon footprint equivalent to the airline industry.
The energy efficiency of a data center is measured with its:

- Power usage effectiveness (PUE) = *Total Facility Power / IT Equipment Power* = $\frac{Cooling+Power+lighting+IT}{Energy\ IT}$



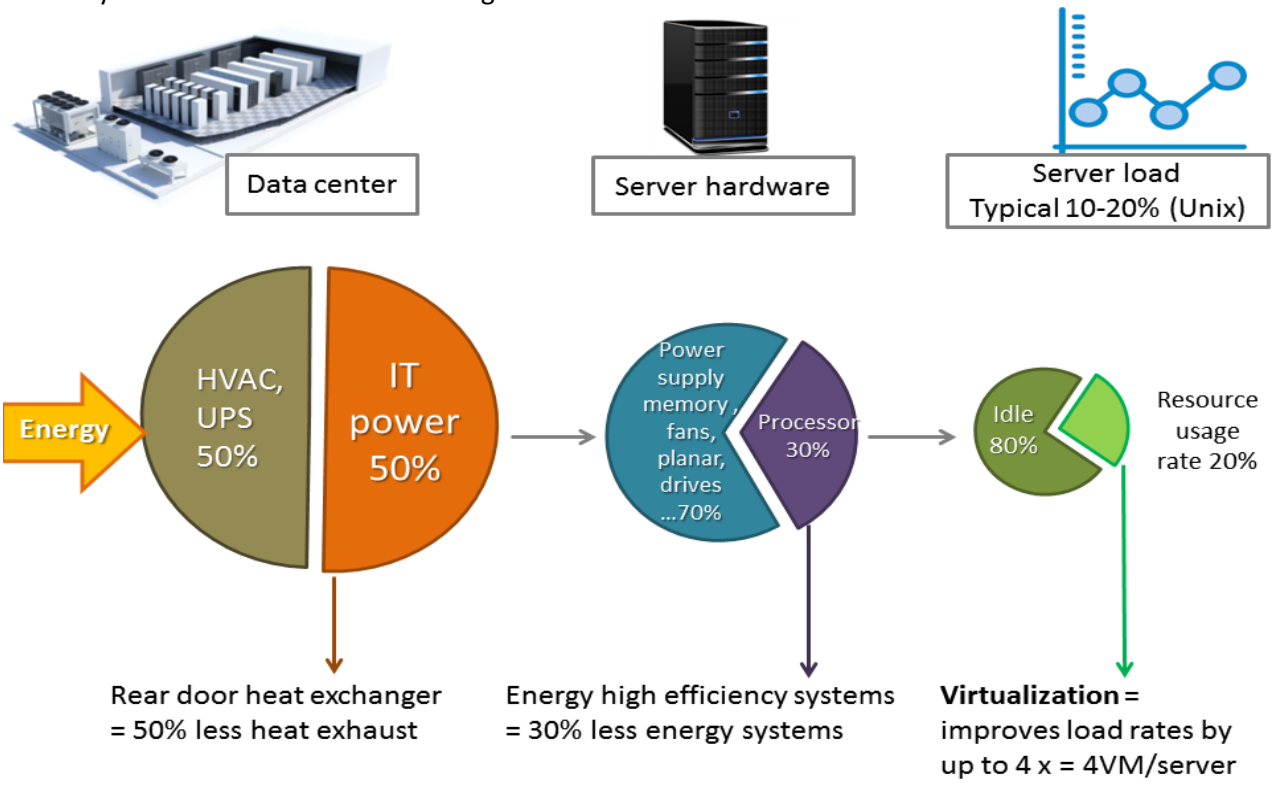

Data centers report average PUE of 1.6, it's probably underestimated, and the truth is probably close to 1.8/1.9. It means that nearly half of their energy consumption is not related to IT power.

→ There is a lot of room for improvement in energy efficiency,

Source: [Dates centres code of conduct](#) - Joint research centre - European Energy Efficiency Platform (E3P)

## Solution

In the recent years some solutions have emerged:




Typical energy savers options for Data center

Virtualization refers to the creation of a virtual resource such as a server, desktop, operating system, file, storage or network. The main goal of virtualization is to manage workloads by radically transforming traditional computing to make it more scalable.
Server virtualization allows creating multiple virtual machines (VM) on a server, which increase the load of the physical server and thus its energy efficiency.

→ In virtualization frame, there is a private Cloud solution that is developing a hierarchical architecture for the efficient distribution of the workload on a multi-site scenario.

## AV industry application

- This solution is suited for high performance computing (HPC) in interconnected render farms/servers rooms (multi-sites).
- Using this solution in the private cloud enables companies to achieve their SLAs (service level agreement) at the lowest cost, mainly through workload migration and applications stacking.

## Key features

- Power consumption reduced between 30 and 60%.
- Automated workload redistribution among sites = reduce cost on hardware, cooling, energy and labor.
- Preemptive VM migrations in order to prevent overload of hardware resources.
- Real-Time adaptation = ability to react quickly to dynamic workloads, performing multiple parallels and asynchronous migrations.
- Combination of multiple goals: the goals such as energy saving, $CO_2$ emission reduction and load balancing may be combined with different priority.
- Resiliency to natural disasters, heat waves = multi site dispatching

## Impact mitigation

- For 3 render-farms with a workload of 25 200 000 GHz. Hour calculation per year in interconnected managed with this solution, in comparison with semi-automated workload management:
  - - 345 000 kWh = -16 380 kg CO2 eq = - 30%

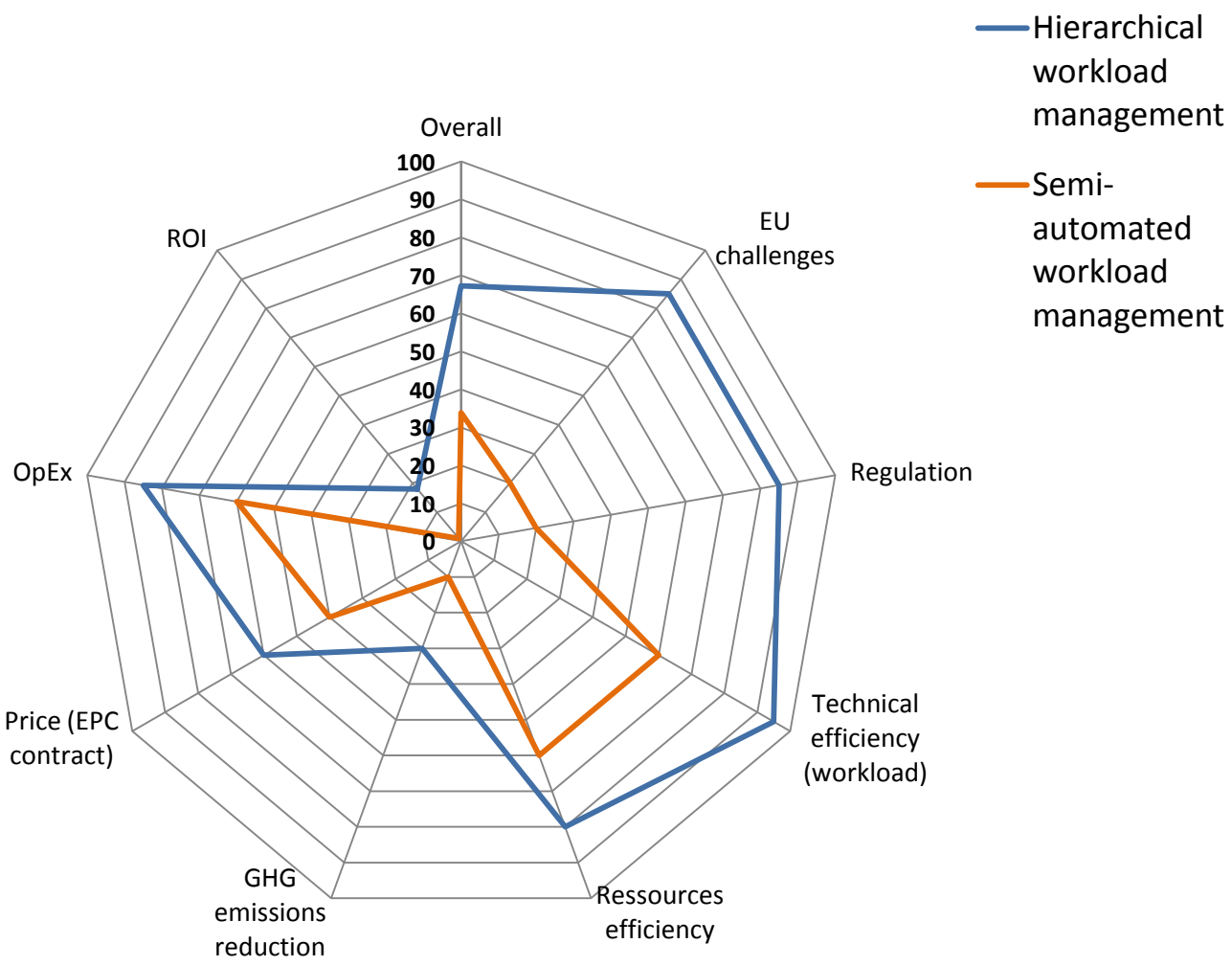
  → The greater the number of DCs and their power, the greater the mitigation will be.

  Source: EcoMultiCloud - SME instrument phase 2 - H2020 project

## Profitability

- The cost of this solution is based on an energy performance contract (EPC) = fraction of verified energy savings, usually 30/40%.
- This EPC is reserved for SMEs who operate at least 1000 servers = 2000/3000 VMs.
- ROI per year for an SME with 3 interconnected render-farms/servers-rooms = 18 % with the EPC

## Comparison to semi-automated workload management




## Conclusion

→ *Thanks to its EPC contract this solution is cost efficient.*

# 29. Workflows pipeline - Machine learning render with an Edge data-center

## Context

**Global IP traffic will increase threefold over the next 5 years**. Overall, IP traffic will grow at a Compound Annual Growth Rate (CAGR) of 26 percent from 2017 to 2022. Monthly IP traffic will reach 50 GB per capita by 2022, up from 16 GB per capita in 2017.

Sources: Cisco Visual Networking Index: Forecast and Methodology, 2016–2021 / Cisco Visual Networking Index Complete Traffic Forecast (2017–2022)

In parallel with this data volume exponential growth, the microprocessor processing capacity reaches a **technological dead end** with the **obsolescence of the Moore's law,** which postulated since 1965, an extension of the chips transistors every 24 months.
Nowadays the goals of Moore's Law come up against physical limits: the circuits' miniaturization = 14 nanometers (nm) today, waiting for the 10 nm soon, will drive the microprocessors of the traditional physical principles to those of **quantum physics**.
As quantum computing will only become operational within a decade, today's **3D processors are limited by heat dissipation**.

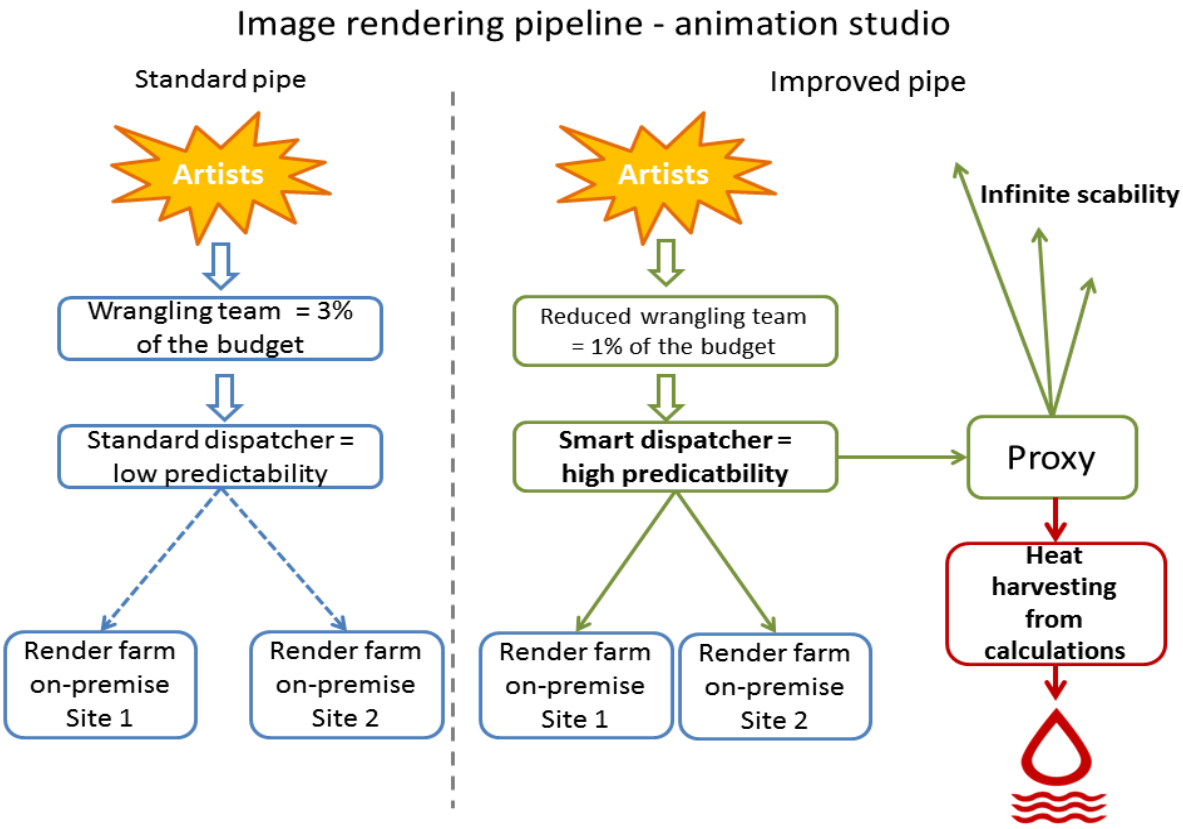
→ The increase in the volume of data + the chips physical limits + global warming compels datacenters/render-farms to **an equipment race**; they must multiply the number of servers and the cooling systems sizing, for ever greater energy consumption.

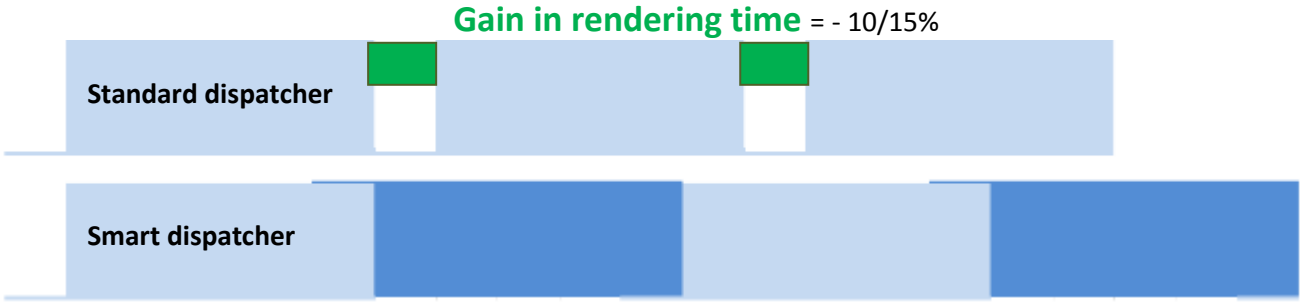
## Solution

In the recent years, innovations have emerged:

- **Decentralized edge datacenter** = smaller units interconnected which shape a decentralized datacenter.
- **Thermo-digital micro cogeneration** = harvesting of the fatal energy emits by servers for ambient heating/hot water = no cooling system
- **Optimization of computing resources** thanks to machine learning = precise management of the computation resources: CPU +RAM +Hard Disk + Bandwidth = smart dispatcher

→ One solution combines these 3 innovations, in order to manage + reuse the fatal heat and improves the render pipeline efficiency e.g. for an animation studio.






Standard dispatcher vs. Smart dispatcher. Source: TeamTo

## AV industry application

- HPC mainly for 3D animation, CGI & VFX in 4k/5k.

## Key features

- Power usage effectiveness (PUE)= 1,09 , whereas the" best in class" conventional data centers have a real PUE (measured by Neutreo) = 1,4 (Google- Datacenter in Saint-Ghislain, Belgium)
- 50 GHz calculation = 50 billion computing operation per second.
- No cooling system thanks to heat harvesting.
- High availability & predictability.
- No risk of overload = decentralization + smart dispatcher.
- Reduce workforce for wrangling.
- Smart dispatcher in open-source.
- No lag (located in downtown).
- Immune to electrical consumption peaks.
- Cyber security : encryption / decryption service.
- Integration of licensed and open source rendering software's:
  - MAYA
  - 3DSMAX
  - Blender…

## Impact mitigation

- Energy reuse factor (ERF) = The ERF of a data center reflects how much energy is exported for reuse outside of data center operations = > 90% of input primary energy are recovered for hot water.
- Second hand servers = better efficiency of resources.
- Saves water = no cooling system.
- For a 50 GHz. Hour calculation with this solution, in comparison with an highly-efficient Datacenter (PUE = 1,4):
  - - 1,54E-03 $kgCO_2$ eq/50 GHz. Hour calculation = - 28%

  Source: Life cycle assessment of is solution made by- Neutreo /Green IT - Caroline Vateau, Frédéric Bordage, Damien Prunel.

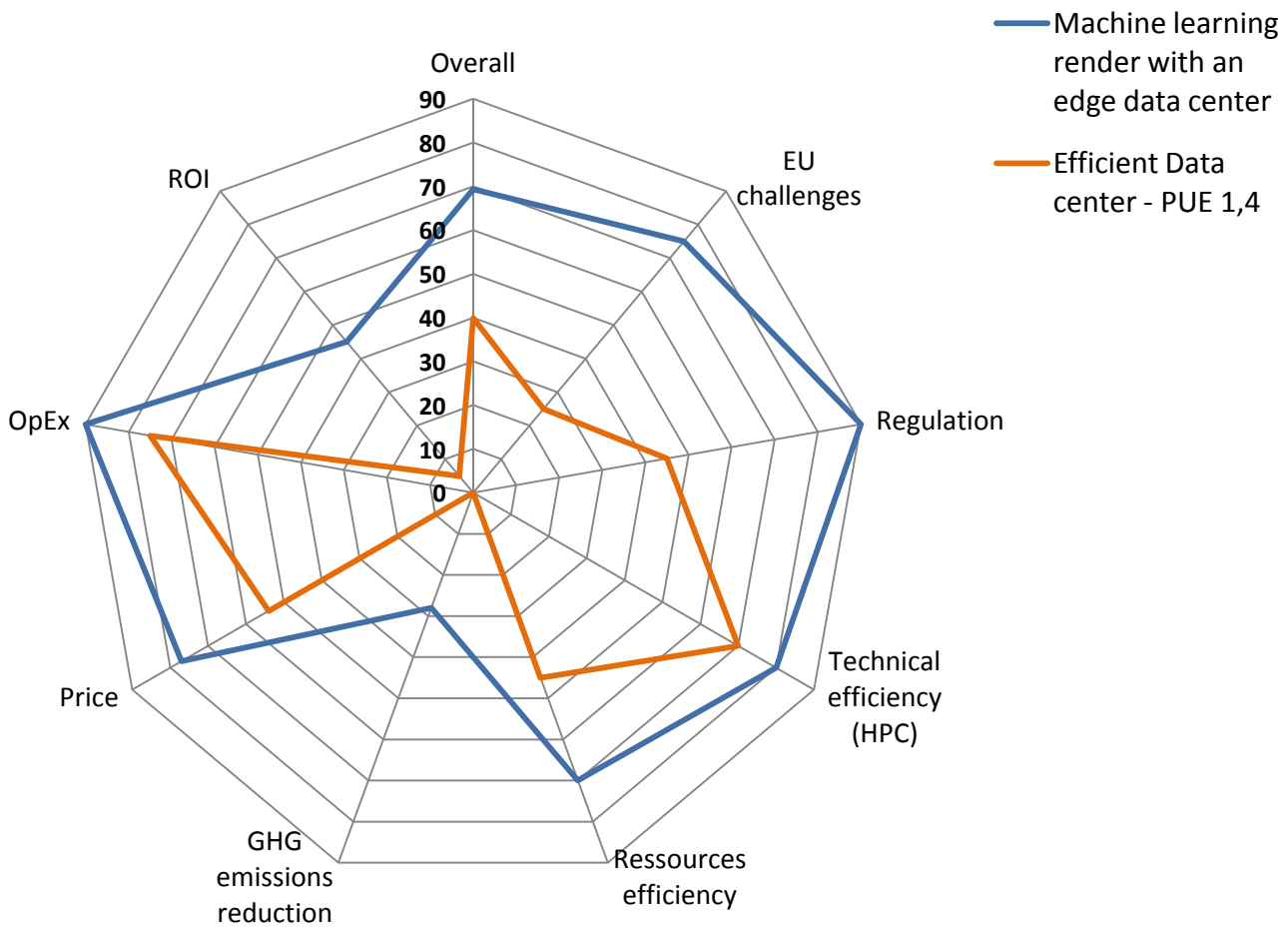
  → Compared to a render farm on-premise, or a medium efficiency datacenter, the mitigation is even higher.

## Profitability

- Compared to equivalent HPC service (rendering) with a conventional infrastructure, this solution' cost is 23 % lower from the most competitive one, on the market.
- It's a structural cost gap, as 50% of the energy costs of a datacenter are related to servers 'cooling.

- ROI for a 50 GHz. Hour = 0,009(price gap from 2nd most competitive tariff) +0, 0045 (15 % render time gain) /0, 03 (total cost) = 45%.

## Comparison to highly efficient & cost effective datacenter



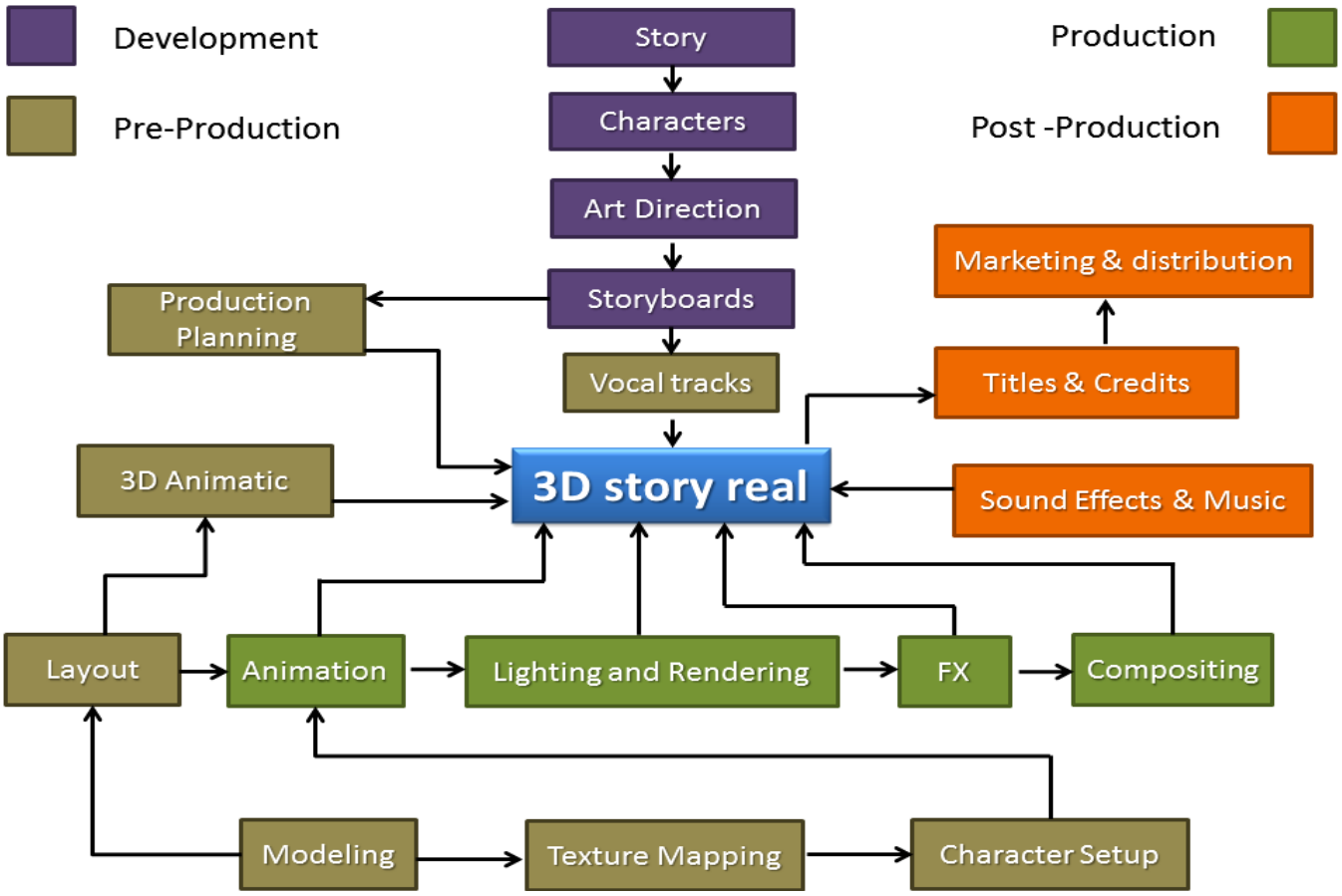

## Conclusion

→ *This solution which combines technical, economic and environmental advantages is far better than HPC service provided by "best in class" conventional data centers.*

## 30. Workflows processing - AI based painting software for scan-based workflows

### Context

By 2022, the 3D Graphics market will represent €282 billion, a 2.5x increase from current levels. 3D computer animation is a costlier and time-consuming process compared to 2D animation as it involves many more steps. See below, simplified 3D animation production chain:




→ Studios creating 3D content are already at the limits of human capacity and are challenged to meet the current market demands as the 3D animation is much more complex than 2D animation.

### Solution

The main solution to improve productivity in the 3D workflow is automation of the mundane work: smart asset search, **scan and texturing**, painting, seam removal, remove defects, i.e. will provide time and energy consumption savings.
In 3D content creation Scanning has always existed, but historically there have been three significant barriers to widespread adoption:

- Availability of high-quality real-world scans
- Affordable tools for capturing raw scans
- Economic means of grooming raw scans into render-ready assets

What would previously have from hours to days to complete in the case of a highly complex texture with multiple maps, can now be completed in a matter of seconds through a new software solution based on an AI engine.

→ As a result scan based workflows can become a new paradigm for the 3D industry.

### AV industry application

- For now this solution is mostly used in VR and video games studios, but it can be used successfully in animation and VFX giving studios productivity gains especially for scan based workflows.

## Key features

- Automating the tedious & the mundane aspects of 3D content creation.
- Transform studio' scan-based textures into production-ready assets.
- Convert a single texture map into a **full PBR material** (Physically-Based Rendering) from a single image.
- Clean up photogrammetric scans by filling holes and making the texture tile able.
- Automation powered by AI and artificial neural networks (ANNs).
- Software architecture: Interface / Library panel / 2D & 3D viewports / Node Graph for Custom Workflows / Node panel
- Cloud-based Software-as-a-Service (SaaS).

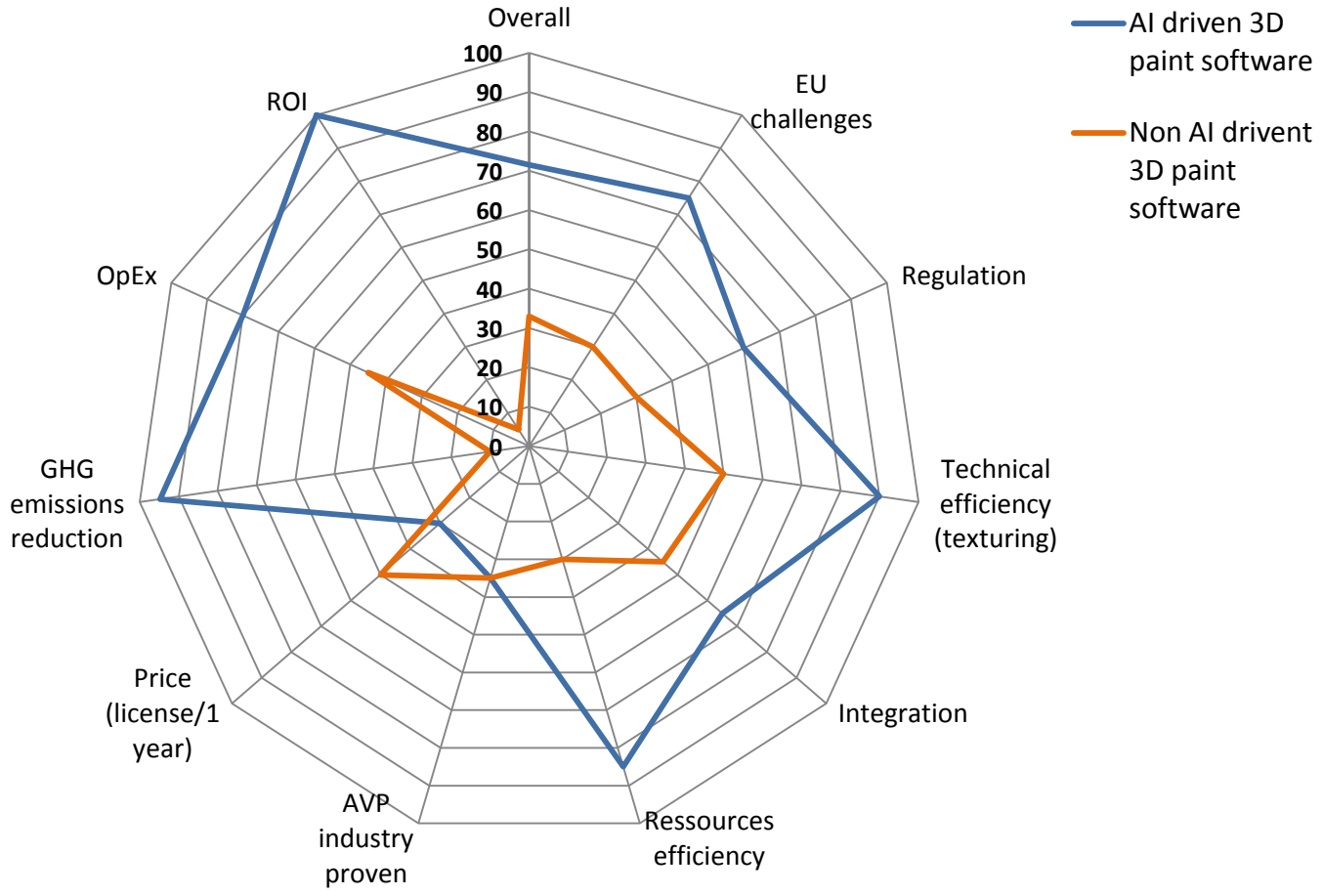
## Impact mitigation

- Automation can provide from 50 to 90 % time savings = energy consumption saving.
- For the automated groom of 1 000 scans with this solution compared to manual groom:
  - - 18,44 kg $CO_2$ = **- 94,79%**
- Source : Lean ICT – towards digital sobriety 2018, Electricity usage (kWh / year) for a laptop p32 – The Shift project

## Profitability

- A texture artist salary in France= 2k€-4k€ /month =in average 3k€ /month
- ROI per year:
  - Small studio (3 texturing artists) = **112,13**%
  - Medium studio (5 texturing artists) = 204,13%
  - Major studio (10 texturing studios) = 408,26%

## Comparison to non AI driven 3D paint software for scan-based workflows



# Conclusion

→ *In a context of declining resources of animation production: time & budger, it's a cost efficient solution.*

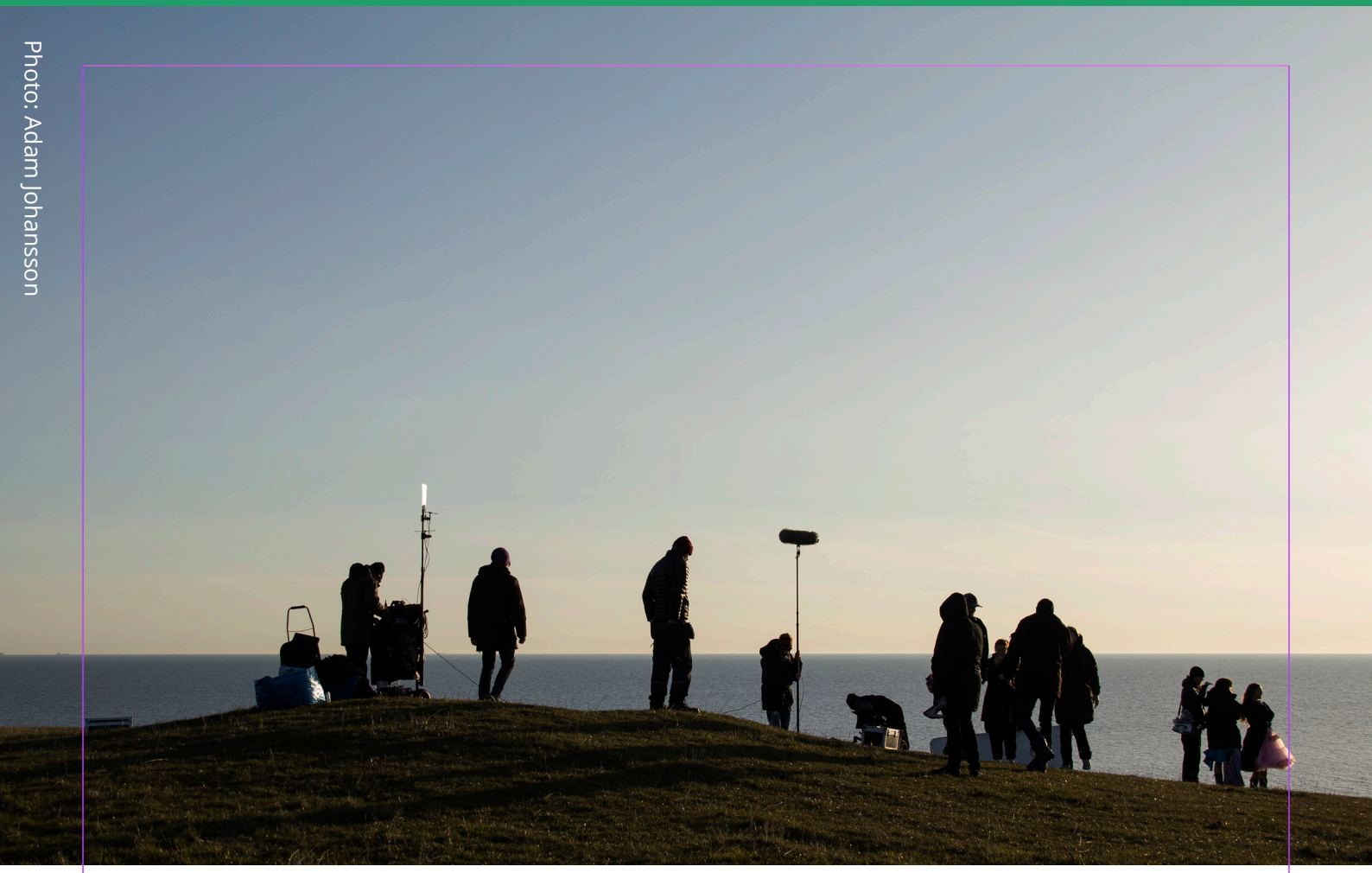


Photo: Adam Johansson

Green Screen
Interreg Europe

European Union
European Regional
Development Fund

FILM PARIS REGION

VAF

LONDON

ADR

Ystads kommun

SLOVAK FILM COMMISSION

RARR
RZESZOWSKA AGENCJA ROZWOJU REGIONALNEGO

PROMÁLAGA

Ayuntamiento de Málaga