CLEANHORIZON

Detect, analyze, monetize

# Integrating distributed generation in urban areas: IDEpolis

## The future of energy: leading the change
## Foundation TUCK

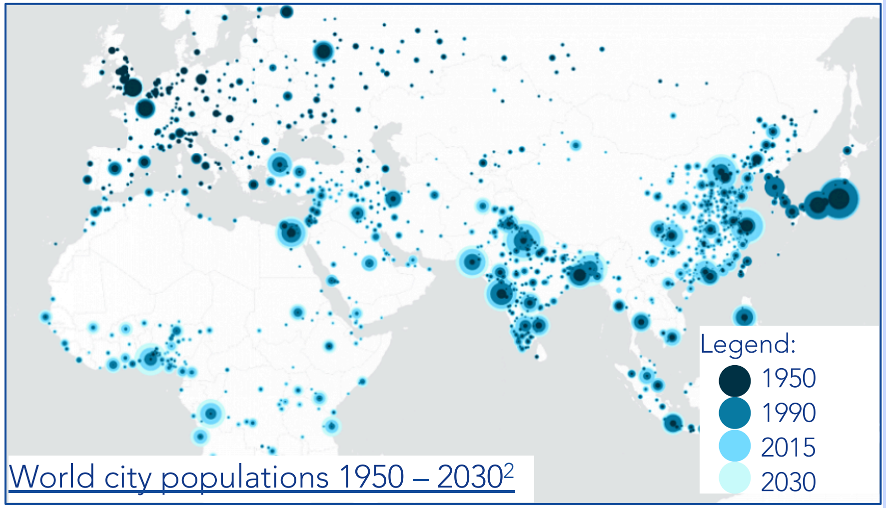
17th January 2017

# Introduction (1/3)
# Urbanisation rates increase globally, as well as electricity consumption per capita, which leads to energy demand increase in urban areas

## Urbanisation is a global trend

According to the UN[1]:

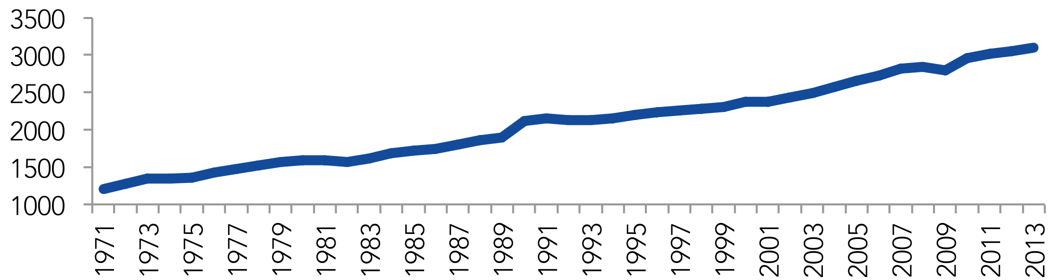
- Cities occupy 4% of the Earth's land area
- Cities were home to more than half of the world's population in 2016
- Cities will absorb most of the world's population increase between now and 2050




World city populations 1950 – 2030[2]

## Globally, electricity consumption per capita increases

World Electricity consumption[3]
(kWh/capita)




- Cities tend to absorb more and more population
- In average, people tend to consume more electricity and gather in cities
- Overall, energy in urban areas is a raising concern

1. Source: United Nations, http://www.un.org/en/development/desa/usg/statements/mr-wu/2013/12/hls-on-scsu.html
2. Source: www.citymetric.com
3. Source: the Worldbank http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?end=2013&start=1971&view=chart

# Introduction (2/3)
# There is a disruption in electricity generation, which requires reconsidering the way energy is transformed

## Transition from traditional heat and electricity generation model to a distributed model

- Historically:
  - Electricity generation was banned from cities because coal fired power plants caused smog
  - Heat generation in cities has always been a problem whose solution has most of the time been left to the end-user
- Today, there are clean and affordable ways  to generate both heat and electricity in cities. Working as a community on energy issues makes sense! But on what basis should decisions be made?

## Advantages of distributed generation

- Increased energy security, such that cities would less rely on neighbouring regions for electricity
- Increased system resiliency, to blackouts, adverse weather or criminal/terrorist actions
- Increased over system reliability, as energy storage can provide ancillary services to support the grid
- Lower T&D losses as electricity is consumed closer to the place it is transformed
- Reduced primary energy consumption because heat can be valued locally
- Possibility to produce low carbon energy
- Potential competitiveness with centralised generation

- The model of electricity generation is changing radically
- Heat and electricity production can be better optimised in cities to achieve cheaper and cleaner energy

# Introduction (3/3)
## The goal of this study is to design and implement IDEpolis, a comprehensive tool to help decision makers include distributed generation in their local policy design

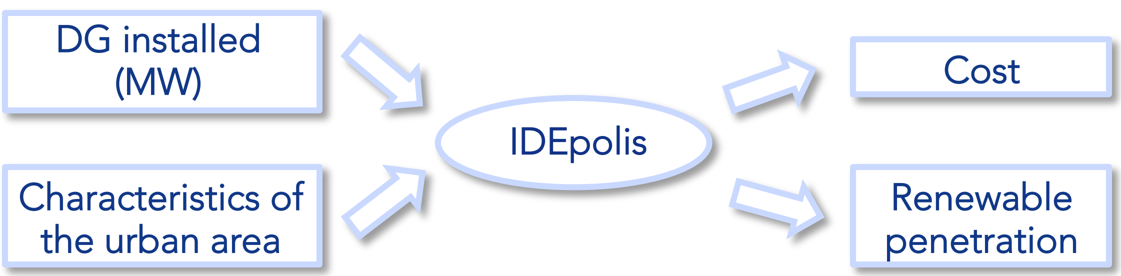
**Issue**

How to help local governments make decisions for the energy transition of their urban areas?

**Constraints**

- Easily accessible data input
- Easily tunable model
- Accessible to energy neophytes

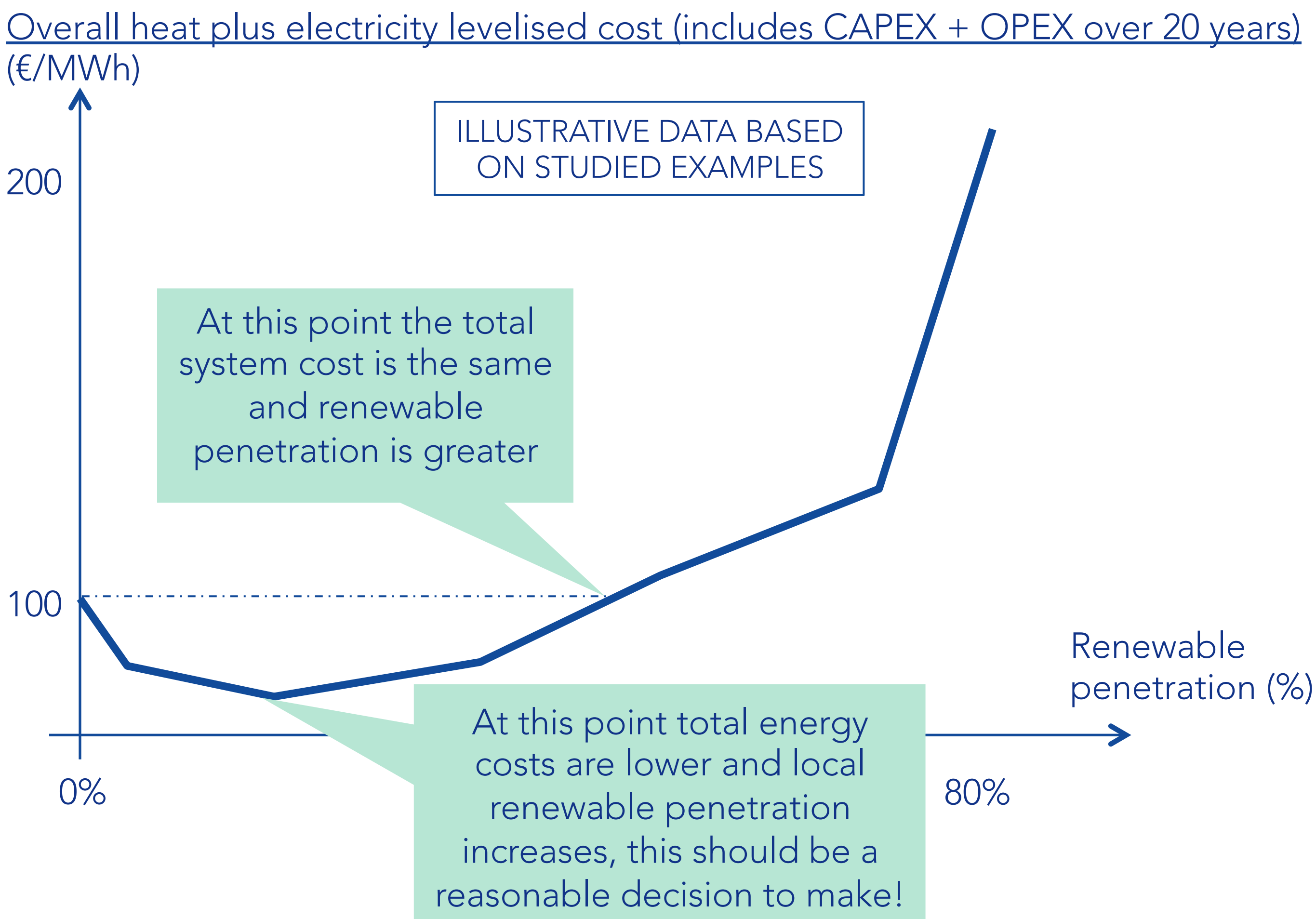
**Proposed solution**




IDEpolis should help decision makers engage with the energy industry and provide a first, high-level understanding of the environmental and economic impact of their local distributed generation policy ideas

# Let's start with a preview of the conclusion: IDEpolis shows that it is often possible to **simultaneously decrease overall energy costs and increase renewable penetration in urban areas thanks to distributed generation**

Assuming distributed generation is the privileged way to generate electricity, how should it be done?




- It is often possible to increase renewable **penetration without increasing the levelised cost of energy**: achieving such a goal should be the target of a rational local energy policy!
- **IDEpolis helps energy neophytes assess this effect and scope their local energy policy**

# Structure of the study

1. State of the art

2. IDEpolis: Technico-economic model of the urban area

3. Regulatory analysis

4. Using IDEpolis and identifying its limits

# Structure of the study

1. State of the art
   i. Existing distributed technologies
   ii. Existing urban areas with distributed generation

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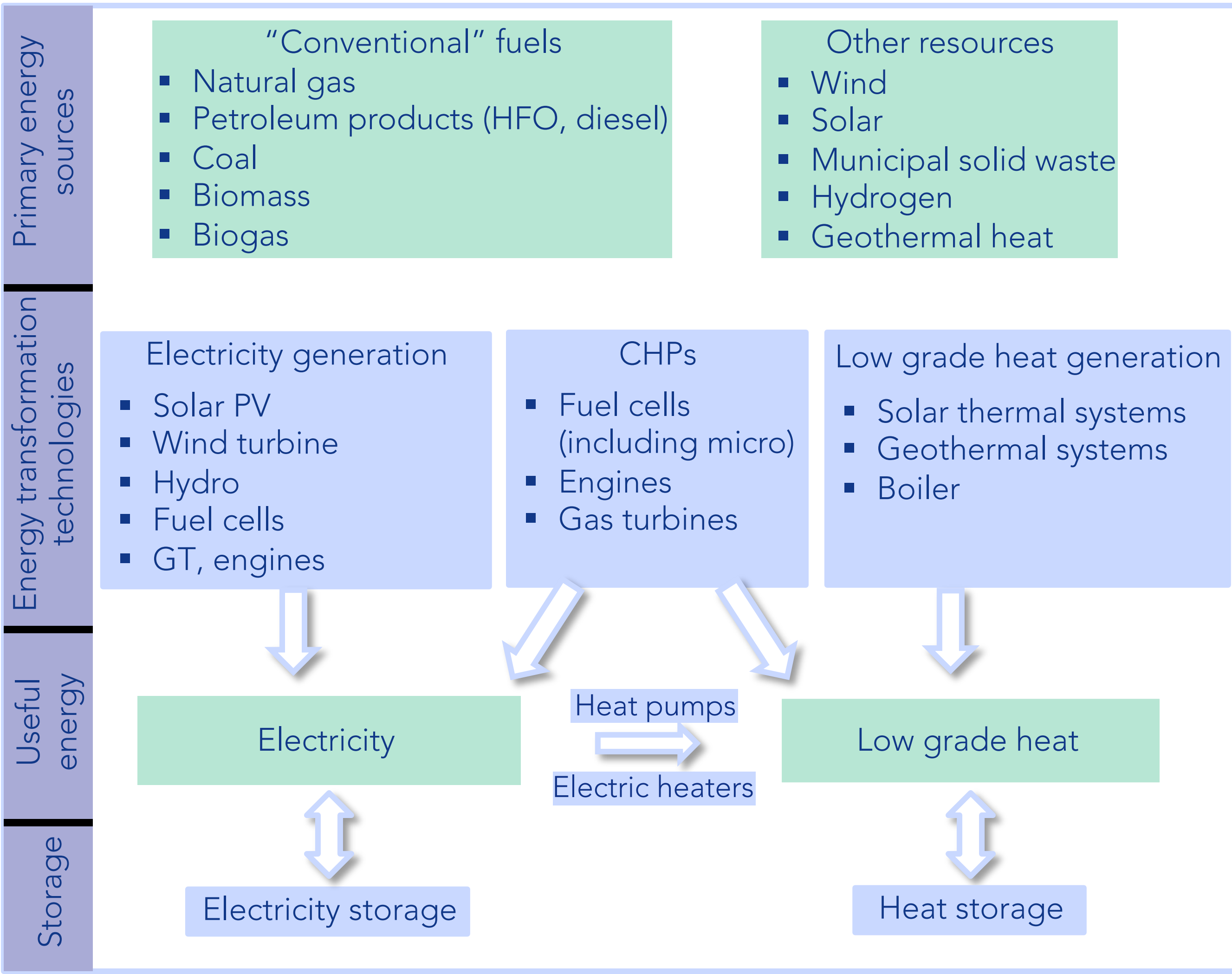
# What resources and established technologies are available to meet urban energy needs?




Electricity and heat are intimately bound in urban areas and there are multiple technologies available to meet local energy needs.

Legend: Energy / Technology

# Emerging distributed technologies that are not mature enough are not taken into account in the IDEpolis model

Emerging technologies that could participate in meeting urban energy needs but are not taken into account in IDEpolis:

Piezoelectricity (Pavegen)
Price unavailable

PV + V2G technology (Sono motors)
Price unavailable

Wind tree (New wind)
11.2 €/W


PV road (Colas)
13€/W

Emerging technologies are not taken into account in the model because:

- Not enough capacity installed to have a track record of the electricity production
- Those products are in the developing phase and their future costs are unknown

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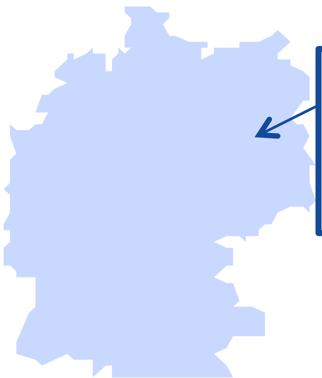
# Reality check on distributed generation in urban areas: Feldheim, the German village making the case for DG

Feldheim: Case of a village surrounded by agricultural fields and exporting 99% of its electricity



Feldheim:
- 80 km SW of Berlin
- 128 persons
- 15.7 $km^2$

Feldheim and its wind turbines

Electricity
- Generation
  - 42 wind turbines: 81.1 MW in total
  - Solar photovoltaic: 2.26 $MW_p$
- Storage:
  10 MW / 10MWh battery system

Heat
- Biogas CHP plant 526$kW_e$ + 500 $kW_{th}$
  - Heat generation: 4.3 million $kWh_{th}$
  - Electricity generation: 4million $kWh_e$
- Backup heat generation: biomass system using waste wood: 399 kWth

- This example proves that it is possible for a village to be energy autonomous
- Moreover, 100% of the electricity produced is renewable

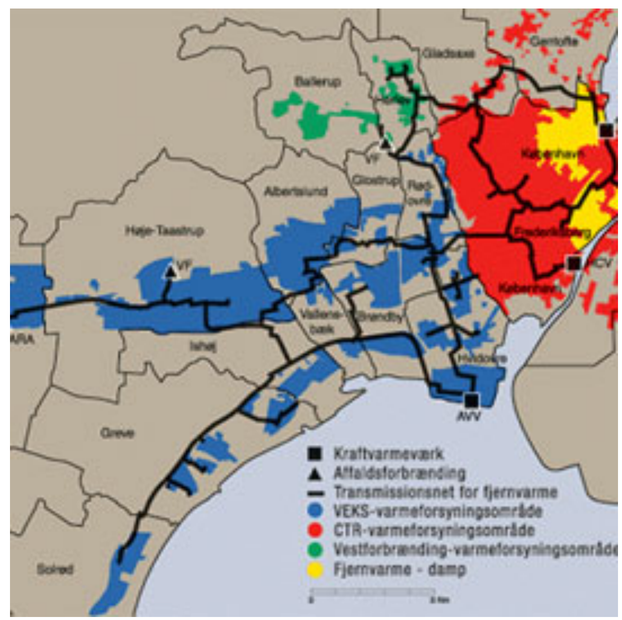
# Copenhagen chose to address heat generation with district heating networks, which increases efficiency

## Copenhagen: case of an ambitious city aiming for 100% renewables by 2025

Characteristics:
- 86 $km^2$ area
- 1.2 million people
- The city targets carbon neutrality in 2025

The Middelgrunden offshore windfarm, 40MW (3km outside Copenhagen)

Distributed energy generation and policies:
- In 1976 Denmark implements a drastic policy in favor of CHPs
- CHPs and energy from waste plants are vastly installed, providing both electricity and heat to the city
- Exemplary district heating, supplying 97% of the city with heat. It represents 1 300km of pipes
- Public transportation as well as bike routes are vastly implemented




Copenhagen district heating networks

- Copenhagen proves that CHPs for district heating bring fuel flexibility
- District heating networks are key to decarbonise efficiently cities

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# There is a rationale to give local decision makers a high level understanding of the potential of DG in urban areas

2

The technologies are proven and resources are well estimated, what prevents cities from planning out their energy transition?

There are two main reasons:

1. **It is difficult to understand and assess the energy (heat and electricity) needs of a city:**
   - As opposed to countries, cities usually do not produce clear import and export data on their energy flows
   - Energy consumption is highly dependent on the climate, city activities and the inhabitants' lifestyle
   - Heat is often generated on the end user side, thus not allowing to optimise the energy system from a collective perspective

2. **As they are very often not versed in the complexities of the energy world,iIt is difficult for decision makers to assess the impact of distributed generation:**
   - On the environment in terms of local pollution as well as carbon emissions
   - On the citizens' energy bills (both gas/oil and electricity)
   - From the perspective of energy independence
   - On the system resilience

As energy is having more and more importance in politics, the energy industry needs to provide local decision makers with some understanding of the impact of distributed generation on their locality.

- Heat and electricity generation are complex to grasp in cities, especially for decision makers that are not energy specialists
- If evaluating this impact of distributed generation is delicate for engineers, how can we expect local political decision makers to make educated choices?

# The IDEpolis model aims at providing decision makers with a quantified view of the economic and environmental impact of DG based on easily accessible local assumptions

2

The IDEpolis model relies on two steps for decision makers to better apprehend energy in their urban area and assess the impact of distributed generation on the environment and on the citizens' bills

| Step 1 | Step 2 | IDEpolis model outputs |
| --- | --- | --- |
| Type in your urban area's characteristics | Try out several energy pathways using DG | The economic and environmental impacts of distributed generation |

What does it take for decision makers to use the model?

- Step 1: Enter high level data on your locality
- Step 2: Choose the distributed generation technologies for the selected urban area as well as the capacity to install

The model has two main outputs for a given urban area energy system:

1. The carbon content of both heat and electricity, also measured with the renewable penetration
2. The levelised cost of "total energy" representing the cost of both heat and electricity from a system perspective

# Once the urban area characteristics are entered, IDEpolis uses a simple dashboard to display the installed capacity and its impact on the energy price

## IDEpolis main dashboard

1/ Select an urban area — Paris — Reset Mix

2 200 000 Inhabitants — 1 315,982 MWth average heat demand — 665,23 MW average electricity demand

2/ Design your distributed energy mix using the buttons or changing the numbers in blue

**HEAT GENERATION**

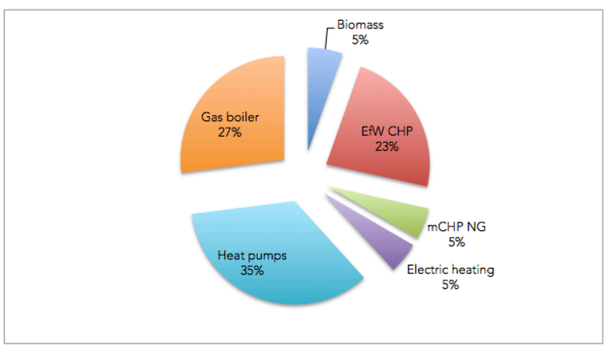
| | Installed | Max | | |
|---|---|---|---|---|
| **Renewable heat generation** | | | | |
| EfW CHP plant (kW_th installed) | 391 598 | | EfW CHP – | EfW CHP + |
| Biomass fired plant (kWth) | 131 598 | | Biomass – | Biomass + |
| **Non renewable Cogeneration** | | | | |
| mCHP FC from NG (kWth installed) | 131 598 | | mCHP – | mCHP + |
| **Shifting heat demand to electricity demand** | | | | |
| Heat pumps (kWth installed) | 931 598 | | HP – | HP + |
| Electric heating (kWth installed) | 131 598 | | elec H – | elec H + |
| **Conventional sources** | | | | |
| Individual gas boilers (kWth installe | 943 927 | | | |

**ELECTRICITY GENERATION**

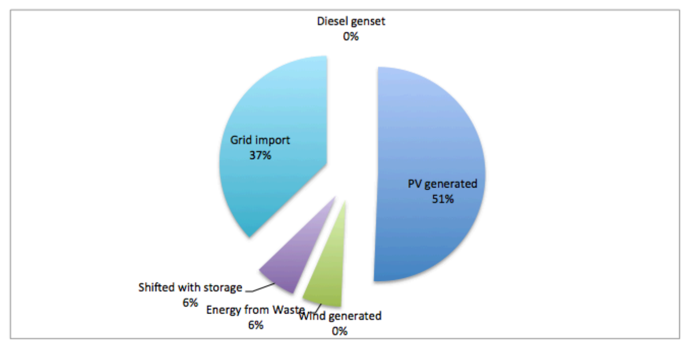
| | Installed | Max | | |
|---|---|---|---|---|
| **Intermittent renewables** | | | | |
| PV installed (kWp) | 4 360 049 | 4 650 000 | PV – | PV + |
| Wind turbine (kW) | - | - | Wind – | Wind + |
| **Energy storage** | | | | |
| Storage capacity (kWh) | 5 199 568 | | Storage – | Storage + |
| Battery power required (kW) | 1 518 651 | | | |
| **Controlable renewable energy sources** | | | | |
| Energy from waste (kWinstalled) | - | | EfW – | EfW + |
| Energy from waste production (kWh/ye | - | 16 578 857 | | |
| **Controlable conventionnal energy sources** | | | | |
| Grid connection import capacity (kW) | 3 000 000 | 3 000 000 | Grid Imp – | Grid Imp + |
| Diesel genset required (kW) | - | | | |

3/ Simulation results

**HEAT PRODUCTION MIX**




**ELECTRICITY PRODUCTION MIX**




| | |
|---|---|
| Heat carbon intensity (gCO2/kWh_th) | 94 |
| LCOTE (€/MWh_th&elec) | 169,25 |
| Electricity curtailed (% demand) | 19,58% |
| Renewables percentage | 52,6% |
| Grid carbon intensity (gCO2/kWh_el) | 46 |

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# The model is based on simple parameters to estimate the energy needs of an urban area as well as its resources

**The model uses 18 key parameters to both characterise the needs of the urban area and estimate the available resources such as municipal solid waste and solar irradiance**

| | # | Characteristic | Unit |
|---|---|---|---|
| General characteristics | 1 | Total urban area | $km^2$ |
| | 2 | Population | # |
| | 3 | People per household | # |
| | 4 | Heating degree days with a reference temp of 18°C | Degree days |
| | 5 | Ground surface available | $m^2$ |
| | 6 | Rooftop surface available | $km^2$ |
| Characterising demand | 7 | Number of commercial & industrial (C&I) customers | # |
| | 8 | Household average yearly electricity demand | kWh/ year |
| | 9 | C&I average yearly electricity demand | kWh/year |
| | 10 | Other constant load (street lighting, public buildings) | kWh/year |
| | 11 | Share of hot water within heat demand | % |
| Resources / Import | 12 | Municipal solid waste production | kg/pers/day |
| | 13 | Average summer irradiation | $W/m^2$ |
| | 14 | Average winter irradiation | $W/m^2$ |
| | 15 | Grid electricity carbon content | kg $CO_2$/kWh |
| | 16 | Grid electricity price | €/kWh |
| | 17 | Natural gas price | €/kWh |
| | 18 | Diesel price | €/kWh |

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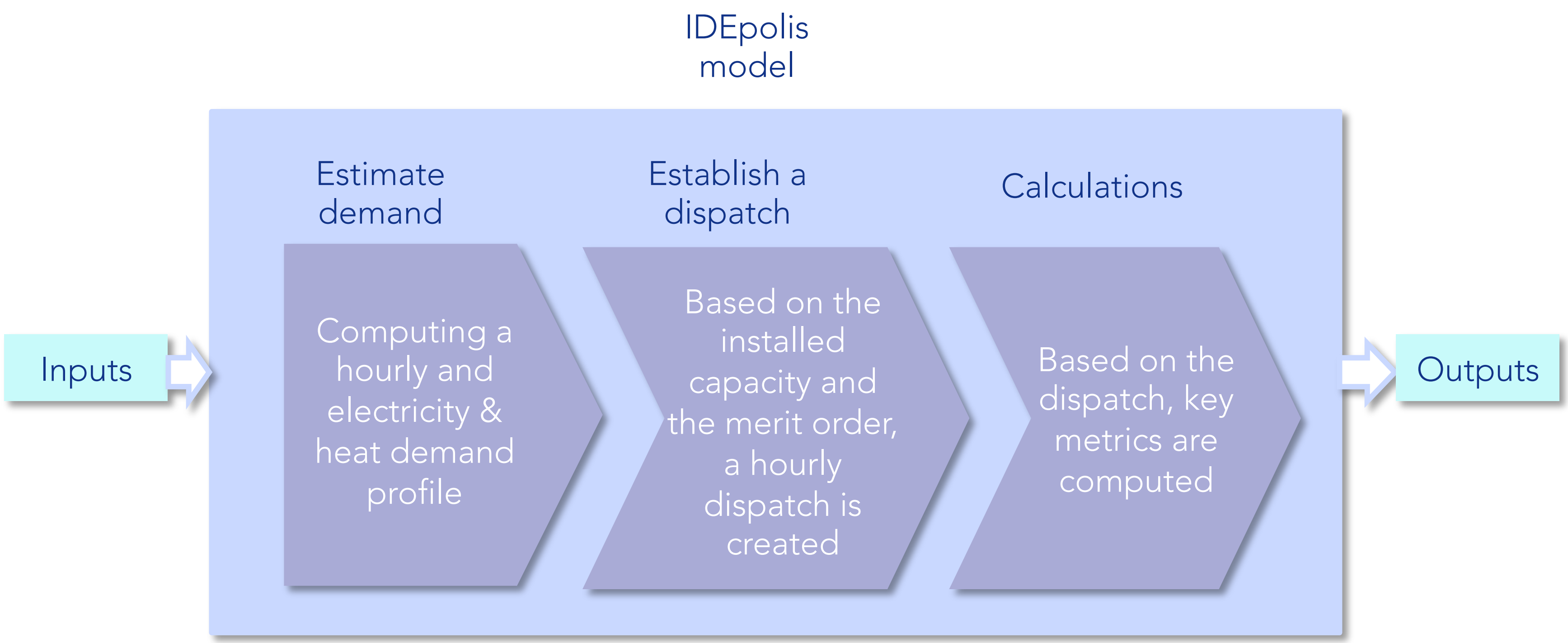
# There are three key steps in the model to get from the input data to the key outputs



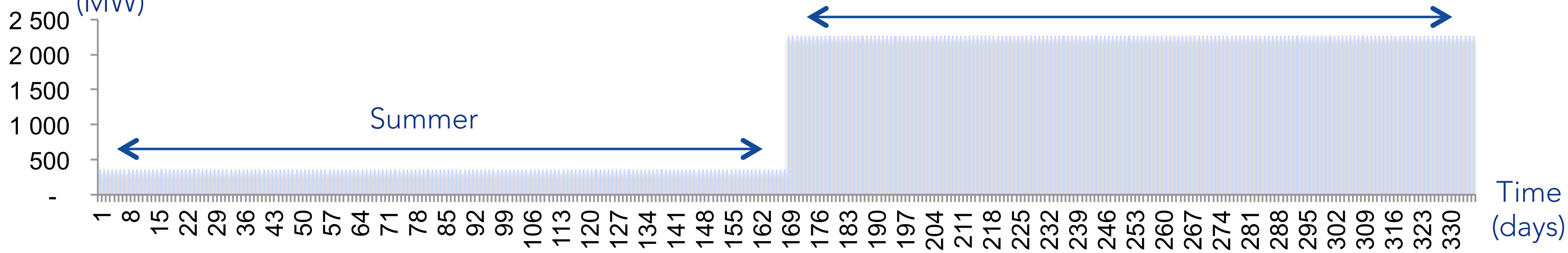
# Based on the previous characteristics, the model establishes a hourly consumption profile for both heat and power during two representative weeks: summer and winter

## Estimating the need for heat and electricity based on the previous parameters

Assessing the needs of the urban area with a 1h time step and 2 seasonal weeks:

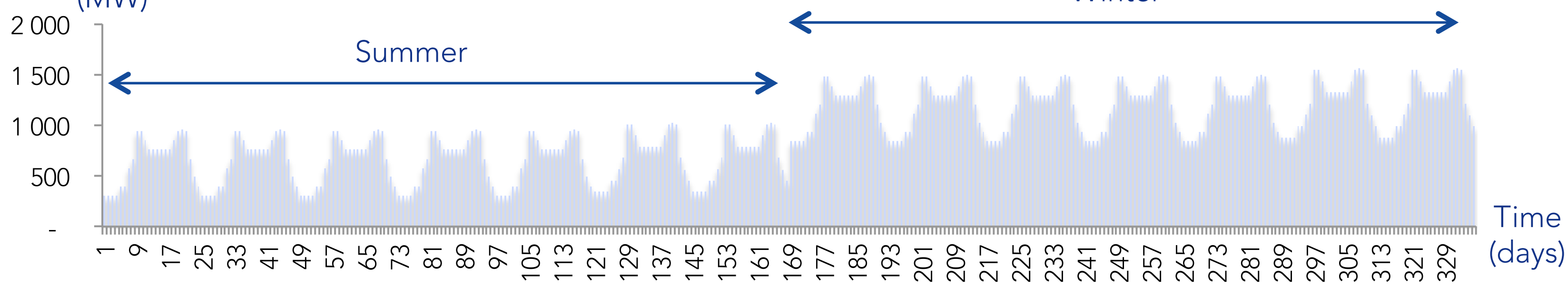
- Heat demand
  In the base case, no hourly variation is considered, but it can easily be modified if more accurate data is available

Paris heat demand (MW)




- Electricity demand

Paris current final electricity demand (MW)

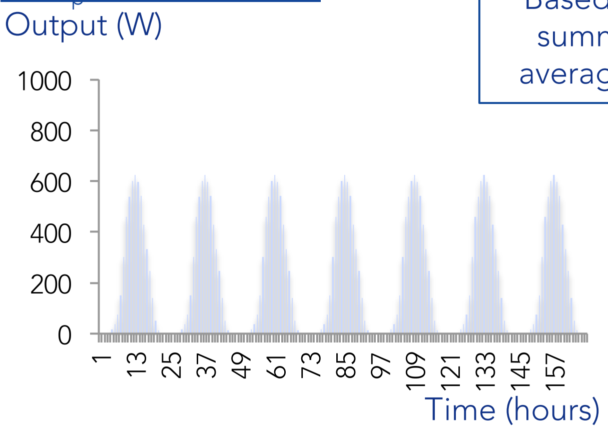


# The model integrates PV and wind profiles, that can be edited if the end user has more accurate representative data

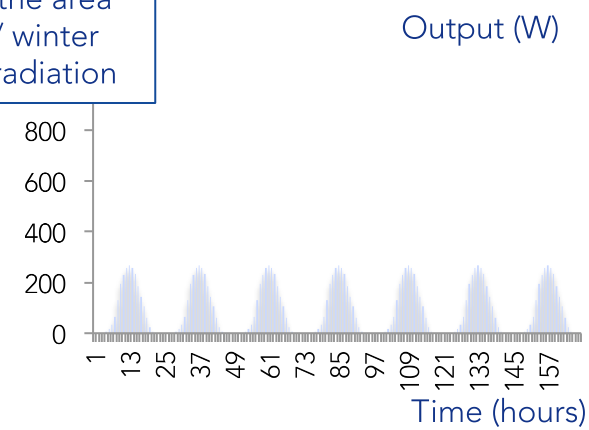
## Summer – typical week

## Winter –typical week

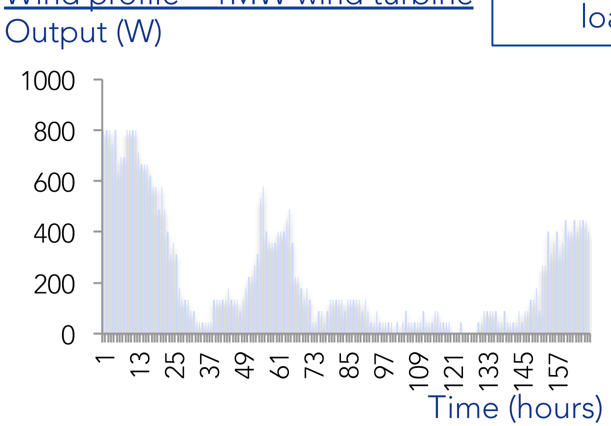
1 kW$_p$ PV Profile (Paris)



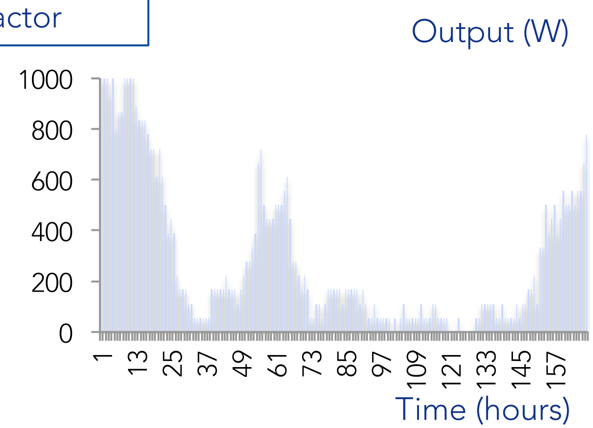

Based on the area summer / winter average irradiation




Wind profile – 1MW wind turbine




Based on a 22% load factor




- A typical PV profile is integrated in the model and is adapted based on local irradiance
- A wind profile is integrated in the model and can be adapted depending on the site resource

# The model uses a simple merit order to dispatch both heat and power generation: it uses in priority renewable energy

2

**Renewable heat and electricity are used in the first place and are curtailed if they exceed the demand**

The general rule used in the model to build the heat and electricity merit order is that the energy inevitably produced (such as wind, PV) comes first, then controllable renewables kick in, and finally conventional sources are used.

At each time step, the energy needs as well as the resources are assessed

- Merit order for heat generation:

1. Energy from waste combined heat and power
2. Biomass boiler
3. Micro CHP Natural gas fired
4. Heat pumps
5. Electric heating
6. Individual gas boilers

- Merit order for electricity generation:

1. Solar PV
2. Wind turbine
3. Energy from waste power plant
4. Energy storage
5. Grid import
6. Distributed diesel engines

Storage use and curtailment:
If in a single one hour time step, the energy produced is greater than the energy consumed:

- The excess is stored if there is a storage system,
- The energy surplus is curtailed if the storage is full (or non existent)

The merit orders built for heat and electricity generation:

- Ensure that sustainable energies have priority on the network
- Minimise the fuel costs

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# Based on the installed capacity, the load and the dispatch, the model computes the penetration of renewable energy produced locally with distributed generation

2

## What is defined as renewable energy in the model?

Renewable energy technologies ($RE_{techno}$ ) are defined in the model as heat or electricity generation units that do not rely on fossil fuels, namely:

- Solar plants
- Energy from waste power plants
- Wind turbines
- Biomass combustion for both heat and power generation
- Energy storage (corresponding to renewable energy prevented from being curtailed)

Heat pumps are included in the model but not considered as a renewable technology, however heat pumps can help decarbonise heat if electricity has a RE share.

## Computation of the renewable distributed energy penetration (in %)

The renewable penetration is computed based on the total renewable energy produced minus the energy curtailed ($E_{curtailed}$) and the energy losses in the storage systems ($E_{losses\_storage}$):

$$RE_{penetration} = \frac{\left(\sum_{j=RE_{techno}} TE_{produced\_j}\right) - E_{curtailed} - E_{losses\_storage}}{E_{th\_demand} + E_{elec\_demand}}$$

## Heat and electricity carbon intensity[1]

Based on plants efficiencies, the carbon content of the different fuels and the carbon content of imported electricity, the model computes two carbon intensities in $g_{CO2}$/ kWh:

$$Heat_{carbon} = \frac{Mass_{CO_2\_produced\_for\_heat}}{E_{th\_demand}} \qquad Elec_{carbon} = \frac{Mass_{CO_2\_produced\_for\_elec}}{E_{elec\_demand}}$$

- The renewable distributed energy penetration measures the local renewable heat and electricity produced
- Heat and electricity carbon intensity encompass the effects of the installed capacity on the carbon content of heat and electricity separately

1. Regarding CHPs, they are considered here to generate electricity as a by-product, hence CHP's fuel consumption is only taken into account to compute the heat carbon content. As a consequence, CHPs are considered to be reducing the electricity demand. In the carbon intensity formula

# The model computes the total levelised cost of energy, a rationale metric to estimate the economic consequences of energy policies on the local community as a whole

## The model reflects the cost of both heat and electricity generation from a system perspective

We define the "total energy" (written TE) production of a specific plant as the sum of heat and electricity produced over a year:

TE [MWh/yr] =$\text{Heat}_{\text{production}}$ [MWh/yr] + $\text{Electricity}_{\text{production}}$ [MWh/yr]

## The model computes the total discounted costs associated with heat and electricity generation over 20 years

- Capital expenditure in year 0:
  - Payment for all commissioning of plants as well as individual heating systems
- Operational yearly costs:
  - Electricity import costs
  - Variable costs such as fuel costs (gas, diesel, biomass)
  - Fixed operation and maintenance costs
  - Other costs such as heat network costs, battery replacement after 10 years

## Computing the levelised cost of total energy (LCOTE)

The levelised cost of total energy (LCOTE) reflects the cost associated with both heat and electricity production in the urban area over 20 years, and is computed as:

$$LCOTE = \frac{\sum_{j=techno}\left[CAPEX_j + \sum_{i=1}^{20}\frac{OPEX_j}{(1+d)^i}\right]}{\sum_{i=1}^{20}\frac{\sum_{j=techno} TE_j}{(1+d)^i}}$$

Where:

- d is the discount rate (8% set as default)
- TE is the total energy defined above

- The levelised cost of total energy reflects the end users' energy bills and includes both heat and power costs.
- The levelised cost of total energy encompasses the overall system costs.
- The LCOTE enables decision makers to make rational economic decisions

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3. Regulatory analysis
   i. France
   ii. The United Kingdom

4. Using IDEpolis and identifying its limits

# Regulatory analysis in France: distributed generation is encouraged but PV installations require building permission

3

## Policies supporting renewable distributed generation

- Commercial and industrial level:
  - Article 142 of French law of August 6th 2015, referred to as "overamortisation Macron" allows companies investing in heat or electricity production to benefit from a tax reduction of 40% of the value invested.
  - For PV installations smaller than 100 kWp the feed in tariff is 5.6 cts € /kWh.
- Residential level:
  - The national agency for the improvement of housing (ANAH) can provide subsidies depending on the end users revenues
  - Reduced VAT (5.5% instead of 20%) for renovation of existing buildings heating system. Moreover, installation costs of systems such as heat pumps, insulation, condensing boilers, or renewable source heat can benefit from a tax credit (CIDD).
  - 30% income tax credit, with the "tax credit for the energy transition" (CITE)[1] .This mechanism concerns insulation works, heat pumps, micro CHP, renewable energy, electric vehicle chargers, connections to heating or cooling networks
  - The feed-in tariffs in 2016 for installations smaller than 9 $kW_p$ were 24.2 cts /kWh in case PV is building integrated, and 12.7cts /kWh for roof-mounted installations[2].

## Permitting

- In case the building is shared, an agreement needs to be found with all co-owners
- Regarding permitting, the French urban code specifies in its article R.421-14 to 17 that installing solar panels on one's roof needs to be approved by the local government and is subject to building permission or a preliminary notice depending on the local urban master plan.
- For instance, in sight of historical monuments, a specific permitting needs to be reviewed by an architect from the "Bâtiments de France".

- In France, distributed generation is incentivised and supported by several policies
- However, permitting for installations are very dependent on the local rules and the environment

1. Source: https://www.legifrance.gouv.fr/affichTexte.do;jsessionid=E1D8DAC78B26774D8FB194D89817F47C.tpdila10v_2?cidTexte=JORFTEXT000030978561&categorieLien=id
2. Source: http://www.developpement-durable.gouv.fr/Le-credit-d-impot-transition.html
3. Source: http://www.photovoltaique.info/Aujourd-hui-arrete-du-4-mars-2011.html

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# Distributed heat and electricity generation is incentivised in the UK

## Policies supporting renewable distributed generation

- The renewable heat incentive supports the following four technologies[1]: the scheme offers a tariff ranging from 5 to 20 p/kWh renewable heat over 7 years:
  1. Air source heat pumps
  2. Ground source heat pumps
  3. Solar thermal panels providing hot water
  4. Biomass boilers and pellet stoves with integrated boilers providing space heating

- Distributed generation benefits from a generation tariff:
  - Solar photovoltaic panels, FiT from 4.2 p/kWh for installations smaller than 10 kWp to 1.83 p/kWh for installations in the range of 50 to 250 kWp
  - Micro CHP (smaller than 2kW) with a generation tariff of 13p/kWh

## Permitting

- The installation of solar panels may be 'permitted development' or subject to planning permission depending on the Local Planning Authority of each area. The planning permission requirements for installing solar panels have been simplified and relaxed for most residential as well as C&I installations[3].

- The UK has targeted heat to contribute to its 2020 ambition of 12% heating from renewable sources

- Permitting rules are local but tend to be simplified

1. Source: http://www.energysavingtrust.org.uk/scotland/grants-loans/renewables/renewable-heat-incentive
2. Source: http://www.fitariffs.co.uk/eligible/levels/
3. Source: http://www.inbalance-energy.co.uk/articles/planning_permission_for_solar_photovoltaic_systems.html

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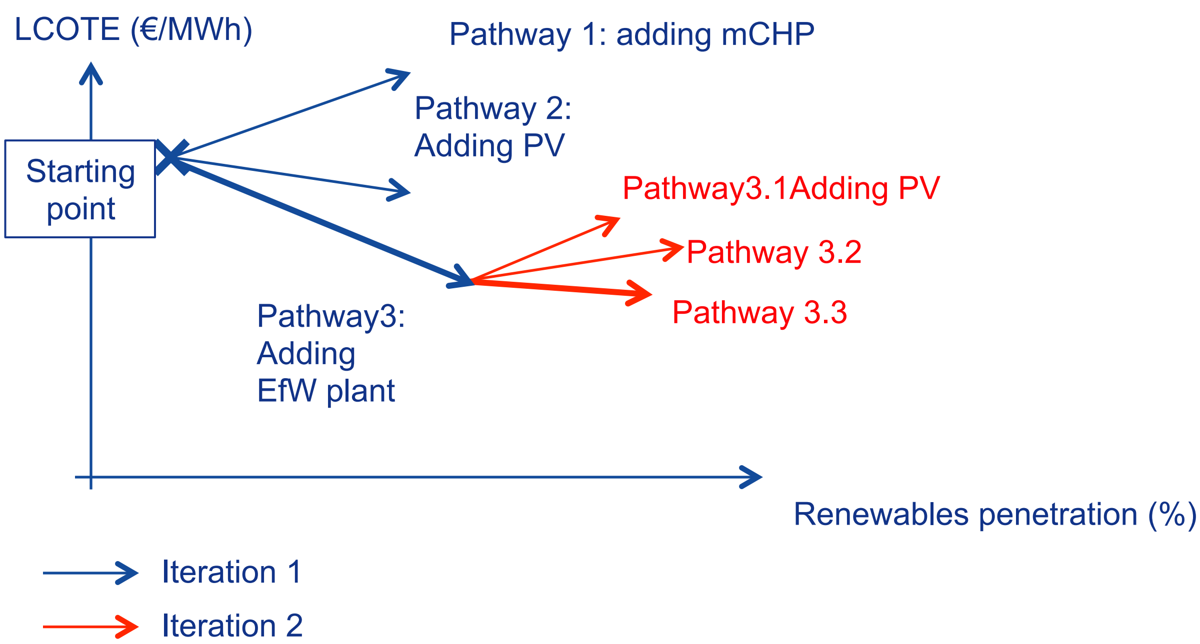
   i. Villages
   ii. Dense urban areas
   iii. Metropolitan areas
   iv. Limits of the model

# The LCOTE vs local renewable penetration curves shown in this presentation were built based on the model but do not result of an optimisation, they only suggest a potential route

IDEpolis can be used to estimate the impact of an energy route

- The curves shown below are not raw output from the model, rather results from hands on simulations
- Looking at the effect of different renewables installations on the LCOTE, renewables penetration and carbon contents of both heat and electricity, a suggested route is proposed

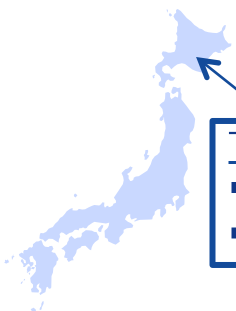



It is possible to have an idea of an efficient pathway to both decarbonise and decrease the electricity and heat cost with IDEpolis but it requires to iterate

# Tsurui Mura, a Japanese village looking at renewable energy generation



## Distributed energy generation currently installed in the village



**Tsurui, an agricultural village:**
- 571 km$^2$ area
- 2 500 people

Tsurui village hall

**Electricity:**
- 6 MW PV in construction
- 6 MWh of energy storage in construction

**Heat:**
- High gas price, twice as much as in Europe
- No district heating network
- 500kW biogasification of manure scheduled for 2017, the production will be injected in the natural gas network, hence contributing to decarbonise indirectly heat

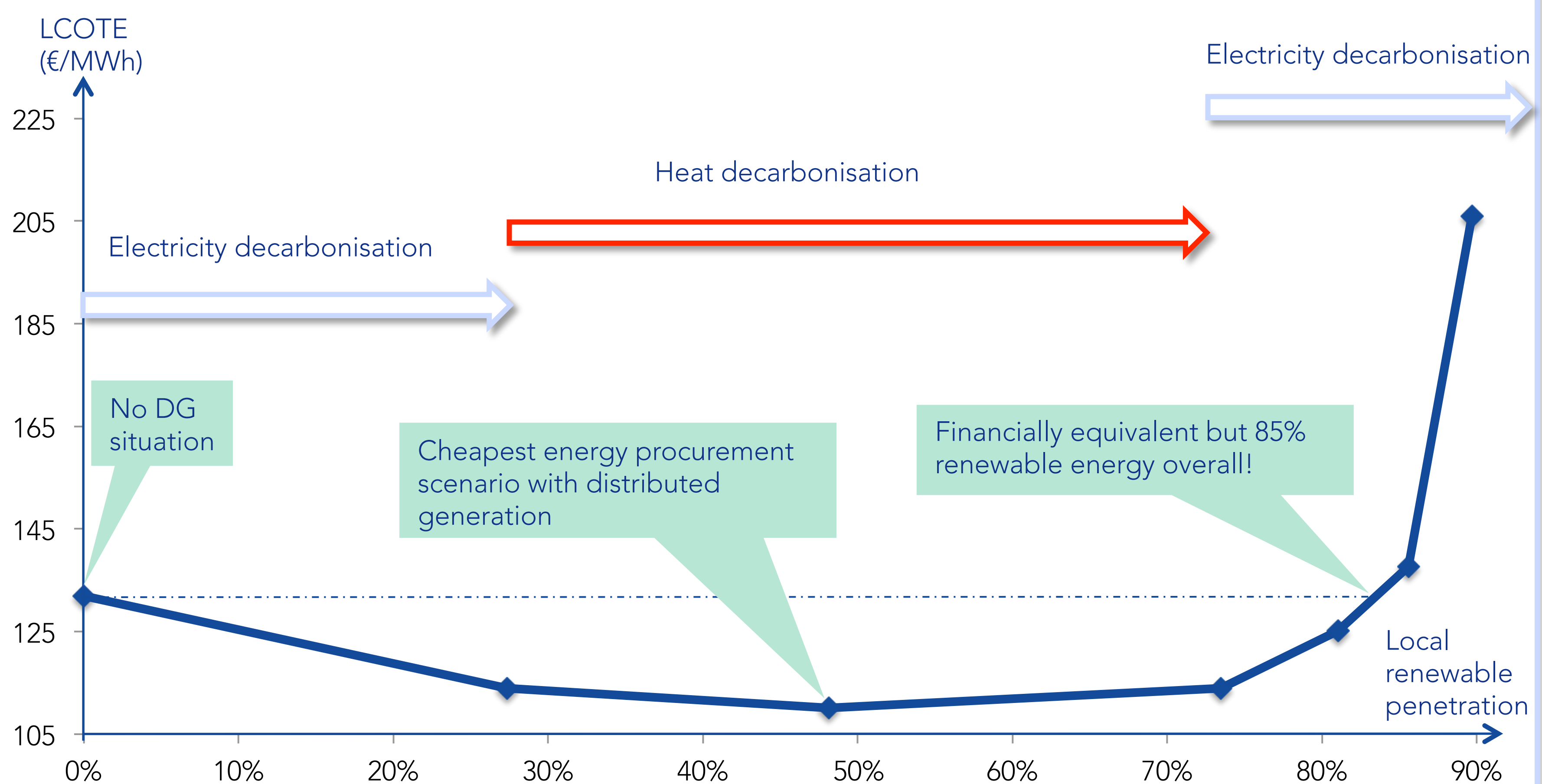

Map: the village of Tsurui

- Tsurui Mura is investigating pathways to decarbonise its energy
- The village is dense enough to have a heat network

# Tsurui Mura – one energy pathway with IDEpolis
# What can be achieved with distributed generation, and at what cost?



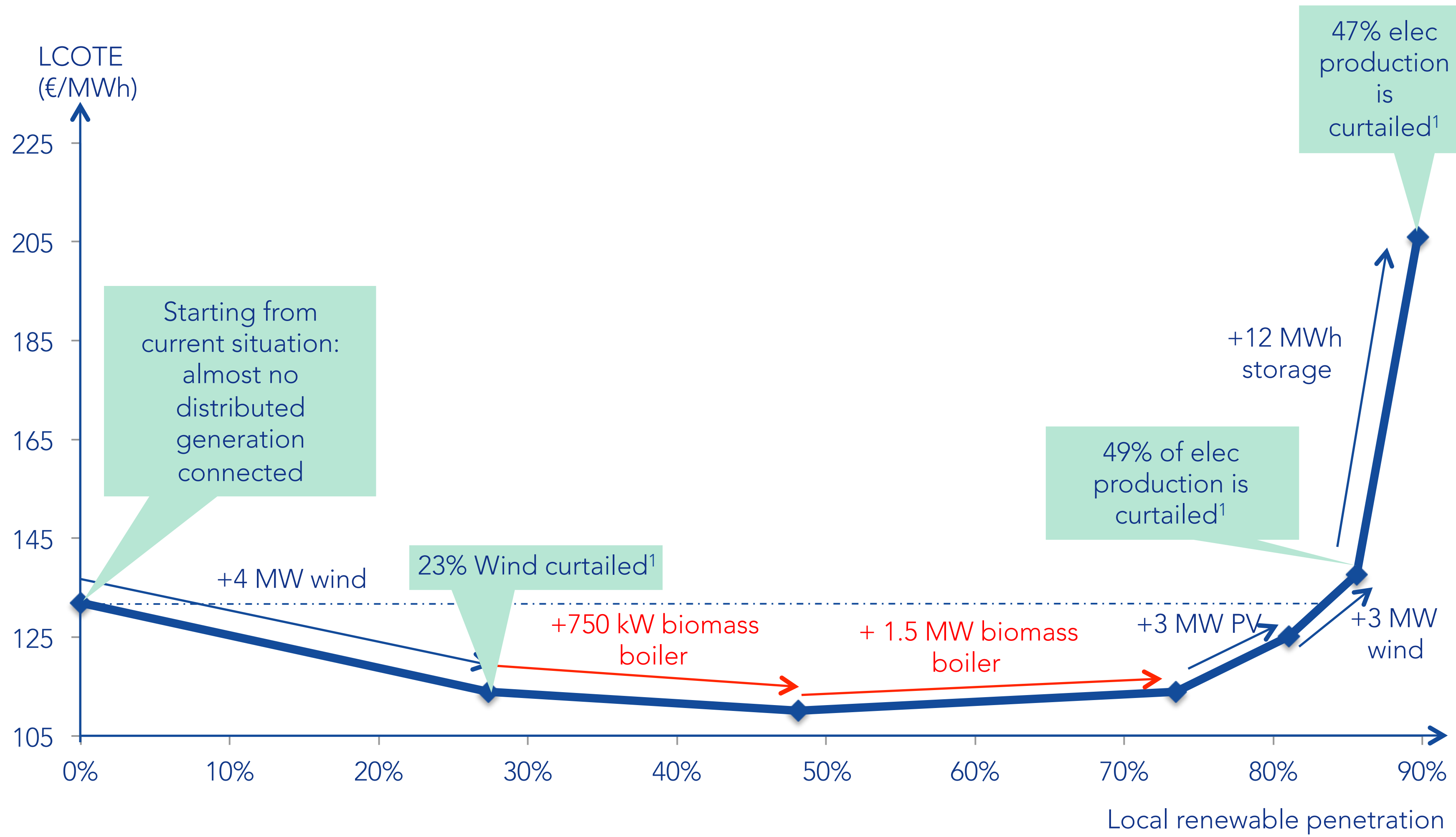
Levelised Cost Of Total Energy (LCOTE) in Tsurui for a specific decarbonisation scenario



# Tsurui Mura – one energy pathway with IDEpolis
# What the proposed decarbonisation route implies in terms of capacity installed

4

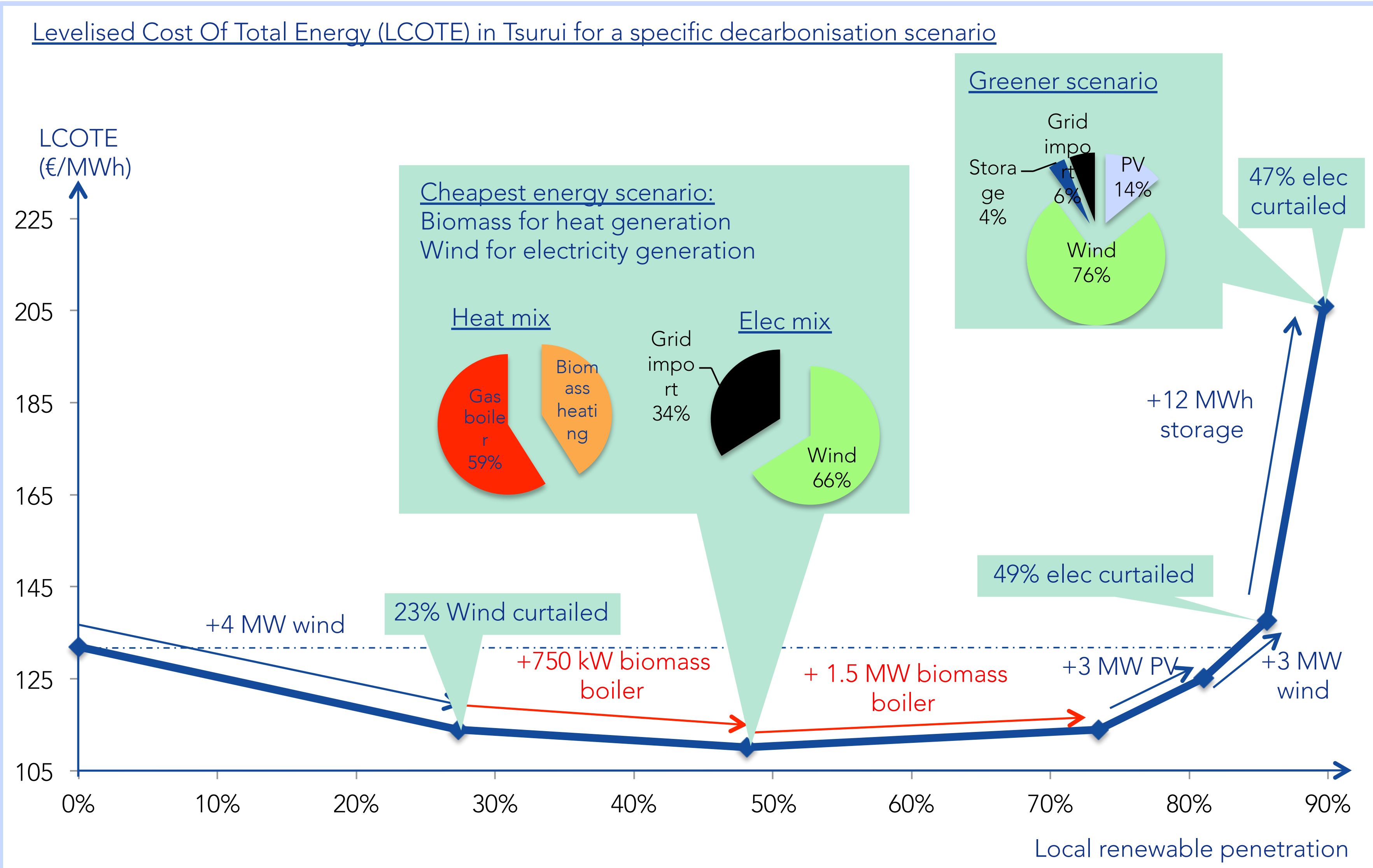
Levelised Cost Of Total Energy (LCOTE) in Tsurui for a specific decarbonisation scenario




1. Curtailment here refers to the fact that the power output of renewables needs to be reduced because it is in excess

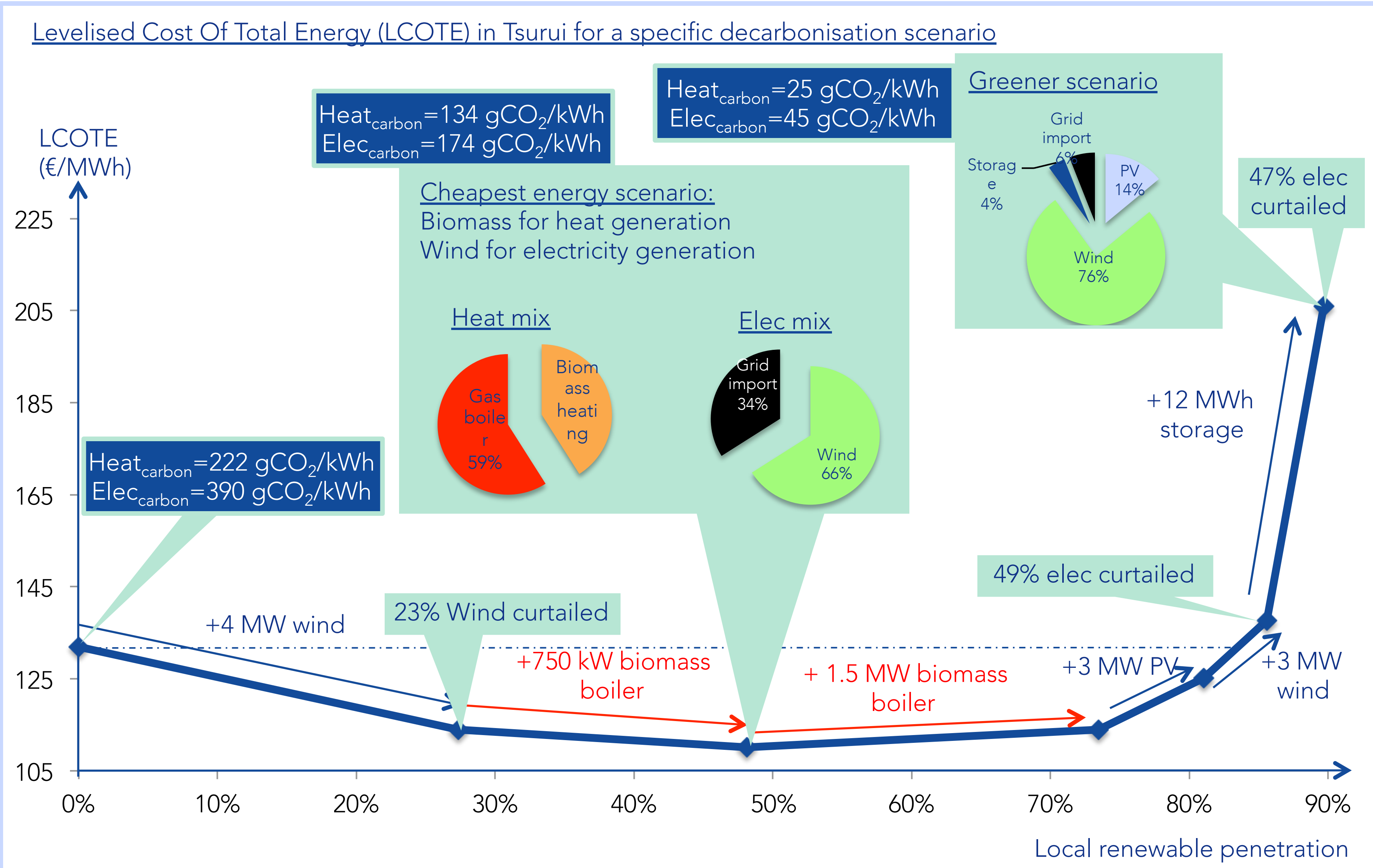
# Tsurui Mura – one energy pathway with IDEpolis
# Snapshots of the heat and electricity mix on the proposed route to decarbonisation





# Tsurui Mura – one energy pathway with IDEpolis
# Evolution of the heat and electricity carbon contents along the proposed route





# Structure of the study

1. State of the art

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3. Regulatory analysis

4. Using IDEpolis and identifying its limits
    i. Villages
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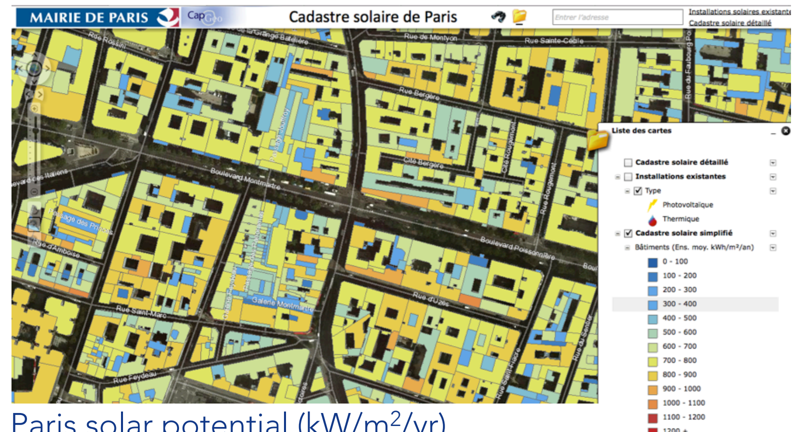
# Paris has a good potential for cleaner heat due to a well developed heat network, and has not exploited its rooftop potential for solar energy collection

4

Paris: a compact city aiming at providing 25% of its primary energy consumption from renewables in 2020

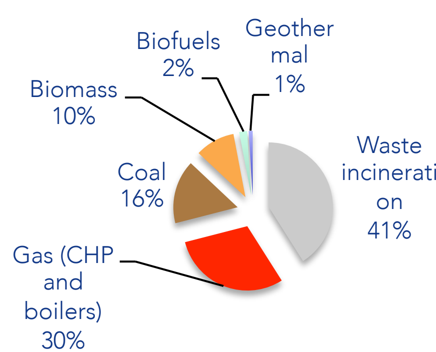
**Paris intra muros**
- 105 km² area
- 2.2 million people




Paris solar potential (kW/m²/yr)

Electricity:
- The "Ile de France", to which Paris belongs, produces less than 10% of the electricity it consumes.
- 50% of this local electricity production comes from gas CHP generation.
- Currently, 27 000 m² of roofs (out of the existing 31 million m², so less than 1% ) are used for solar panels, equivalent to 3.3 $MW_p$ of capacity installed.

Heating:
The district heating network is managed by CPCU
- Covers 1/4th of the heating needs of the town[1]
- Gathers 4.3 GW of heat generation
- 480 km of heat distribution network
- 50% renewable heat production




Paris DHN current mix

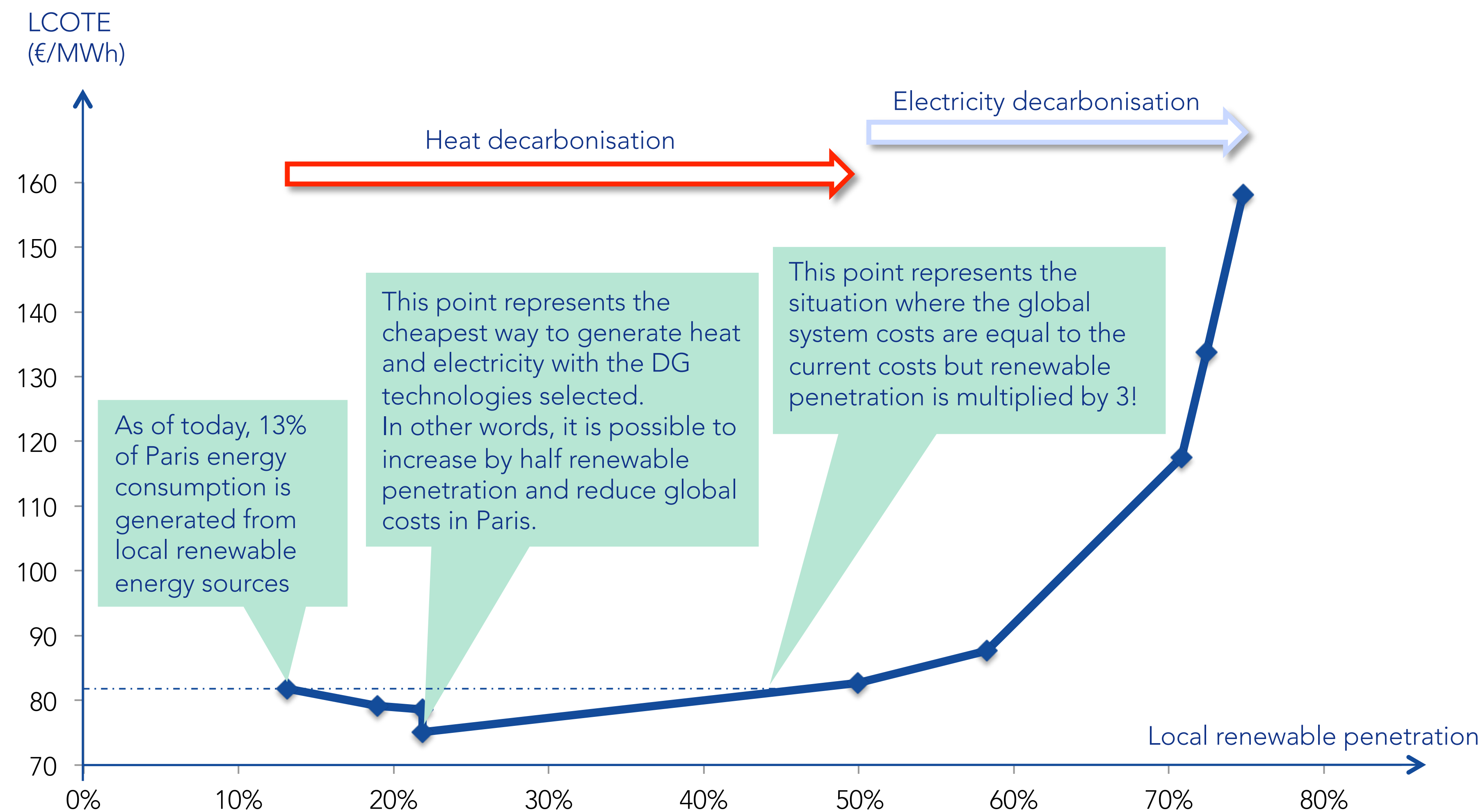

Paris district heating network

1. Source: CPCU-Marc Barrier / "Au 1er janvier 2016, le réseau de chaleur de Paris sera majoritairement d'origine renouvelable" - DHCNews

# Paris – one energy pathway with IDEpolis
# Trends and key points on the proposed pathway



Levelised Cost Of Total Energy (LCOTE) in Paris for a specific decarbonisation scenario



# Paris – one energy pathway with IDEpolis
# Retrofitting existing heat generation plants seems an efficient choice as well as using the rooftops for solar panels

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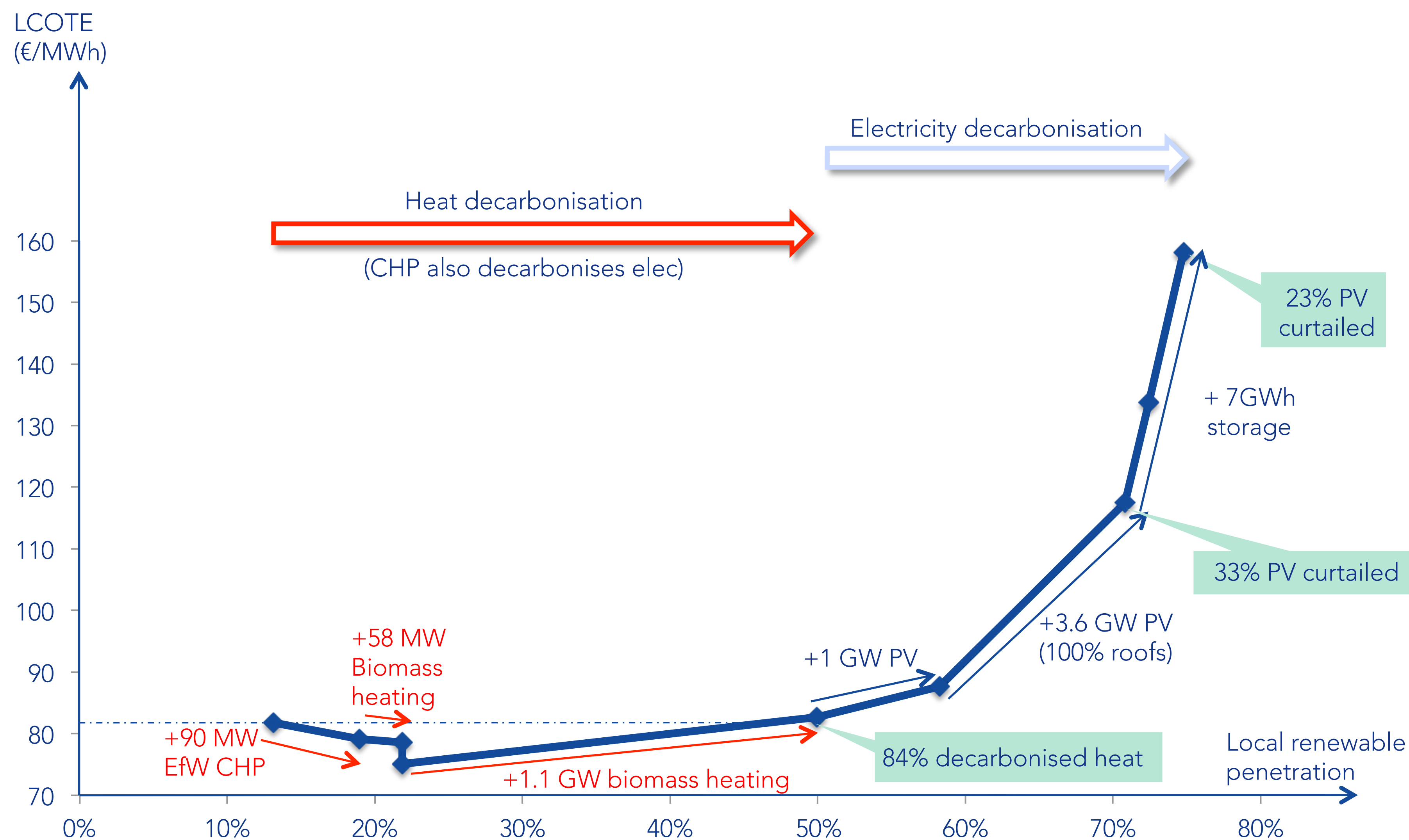
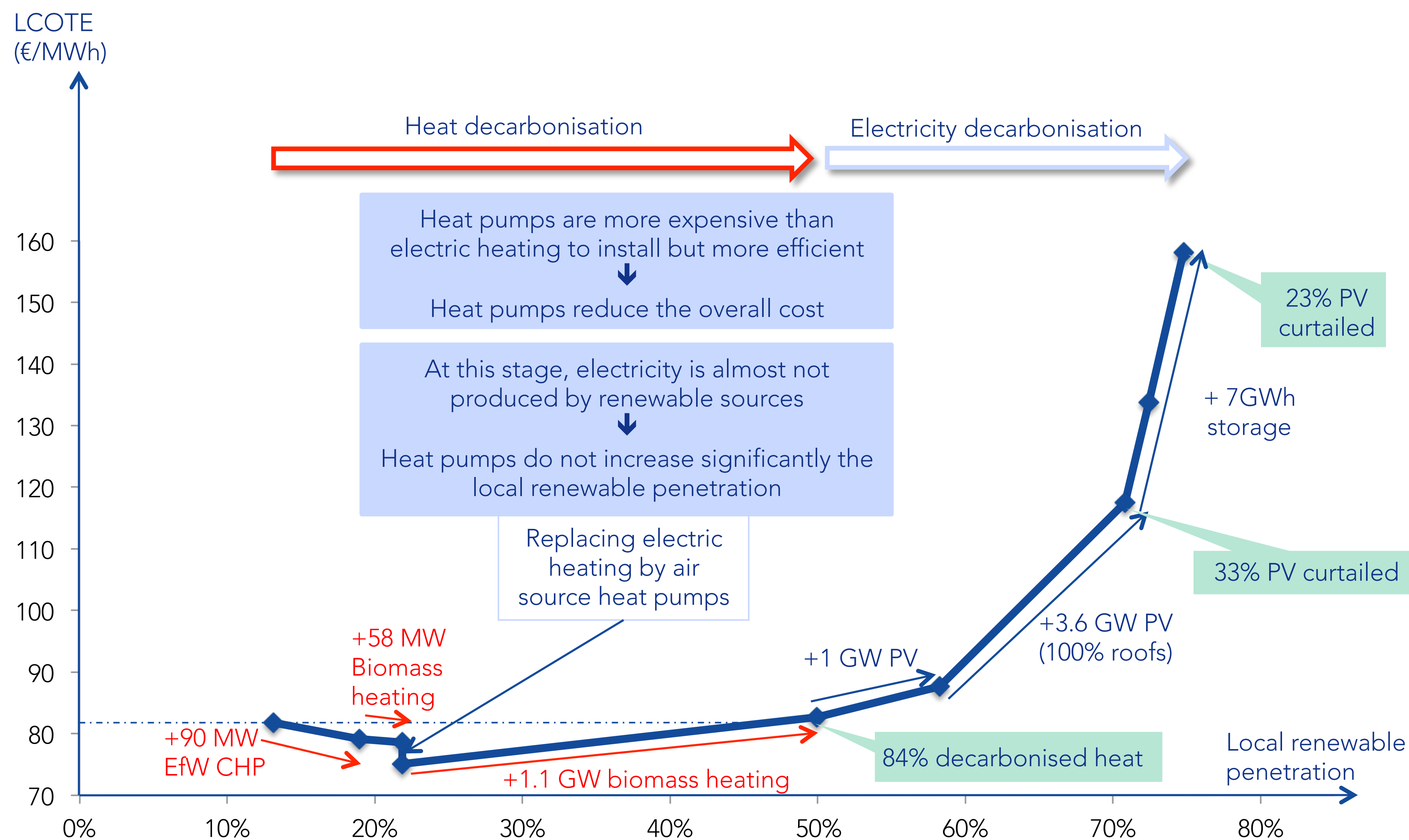
Levelised Cost Of Total Energy (LCOTE) in Paris for a specific decarbonisation scenario



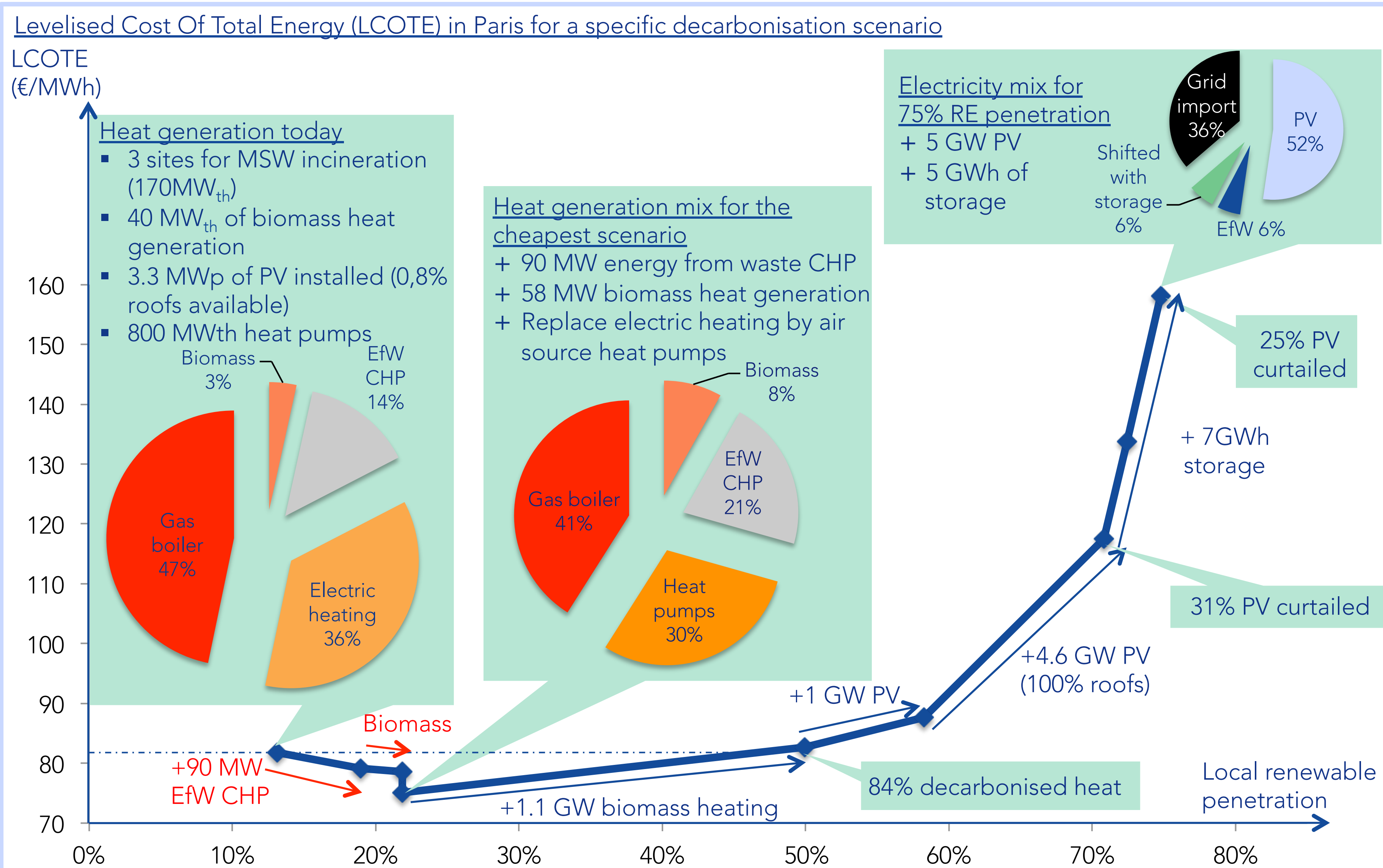
# Paris – one energy pathway with IDEpolis
# The effect of heat pumps on the levelised cost of total energy

4

Levelised Cost Of Total Energy (LCOTE) in Paris for a specific decarbonisation scenario



# Paris – one energy pathway with IDEpolis
# Snapshots of the heat and electricity mix in the proposed pathway: PV can cover half of the city electricity demand



# Paris – one energy pathway with IDEpolis
# Heat and electricity carbon contents can be reduced further with distributed renewables

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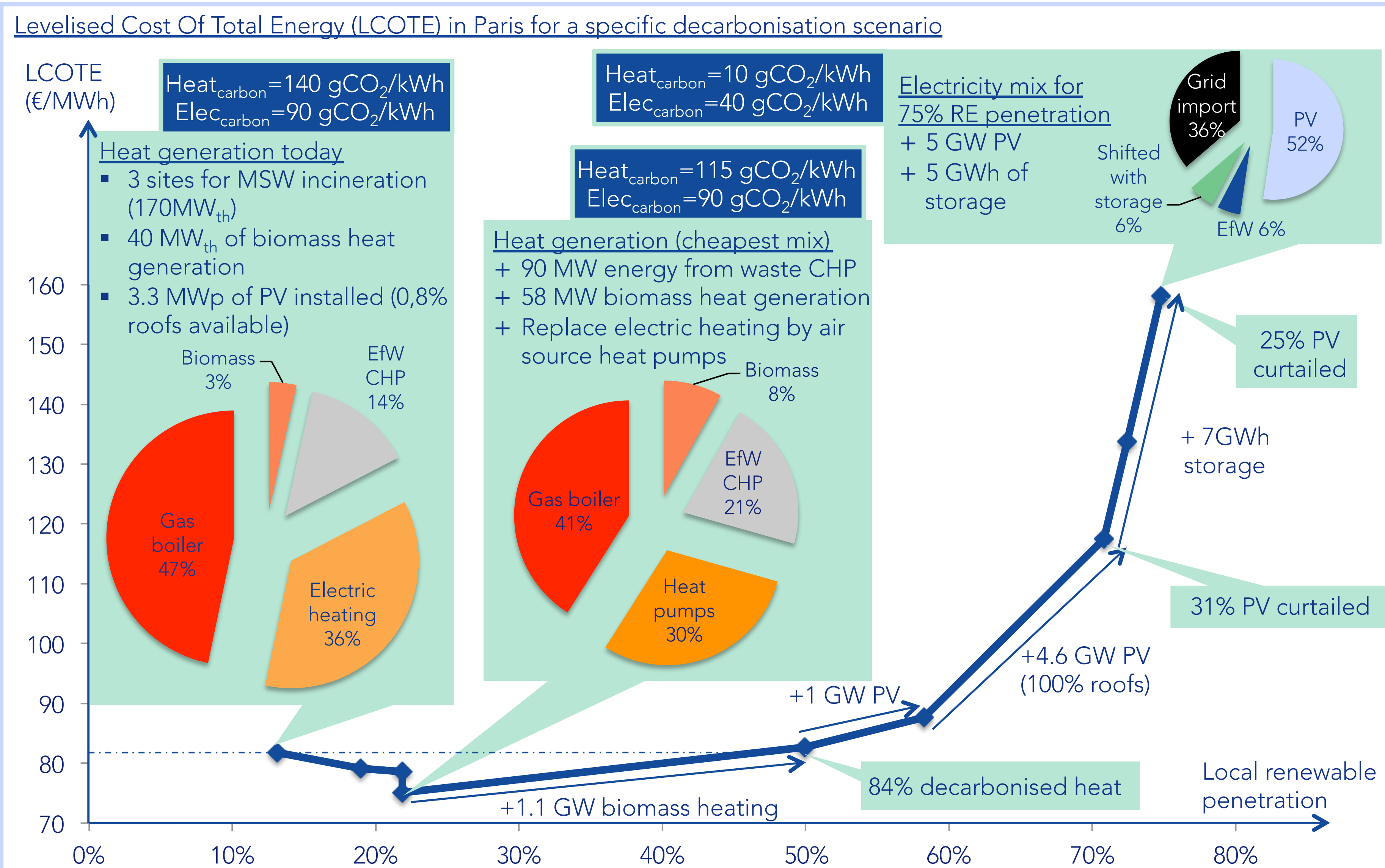

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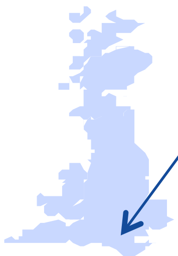
# The Greater London does currently not have much heat networks, and little distributed renewable electricity generation



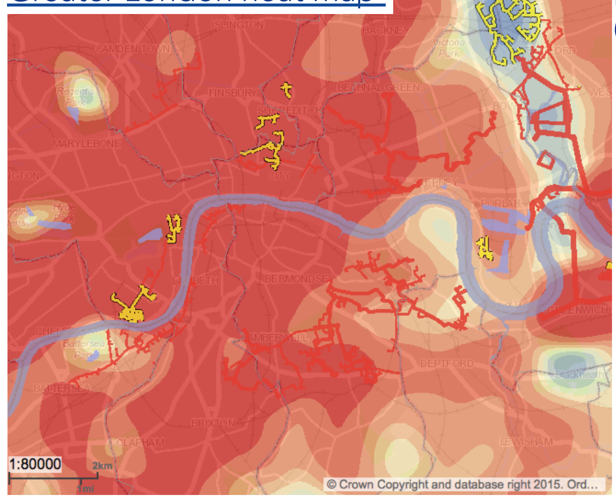
The Greater London region:
- 1 600 km$^2$ area
- 8.5 million people


Belvedere riverside EfW

Electricity:
- PV installed: 57.8 MW$_p$ registered under the FiT scheme
- Electricity price (without taxes): 0.18 cts €/kWh[2]

Heat:
- Only few and small district networks (Wesminster, Stratford)
- Energy from wastes sites total 166MW$_e$

Greater London heat map[1]

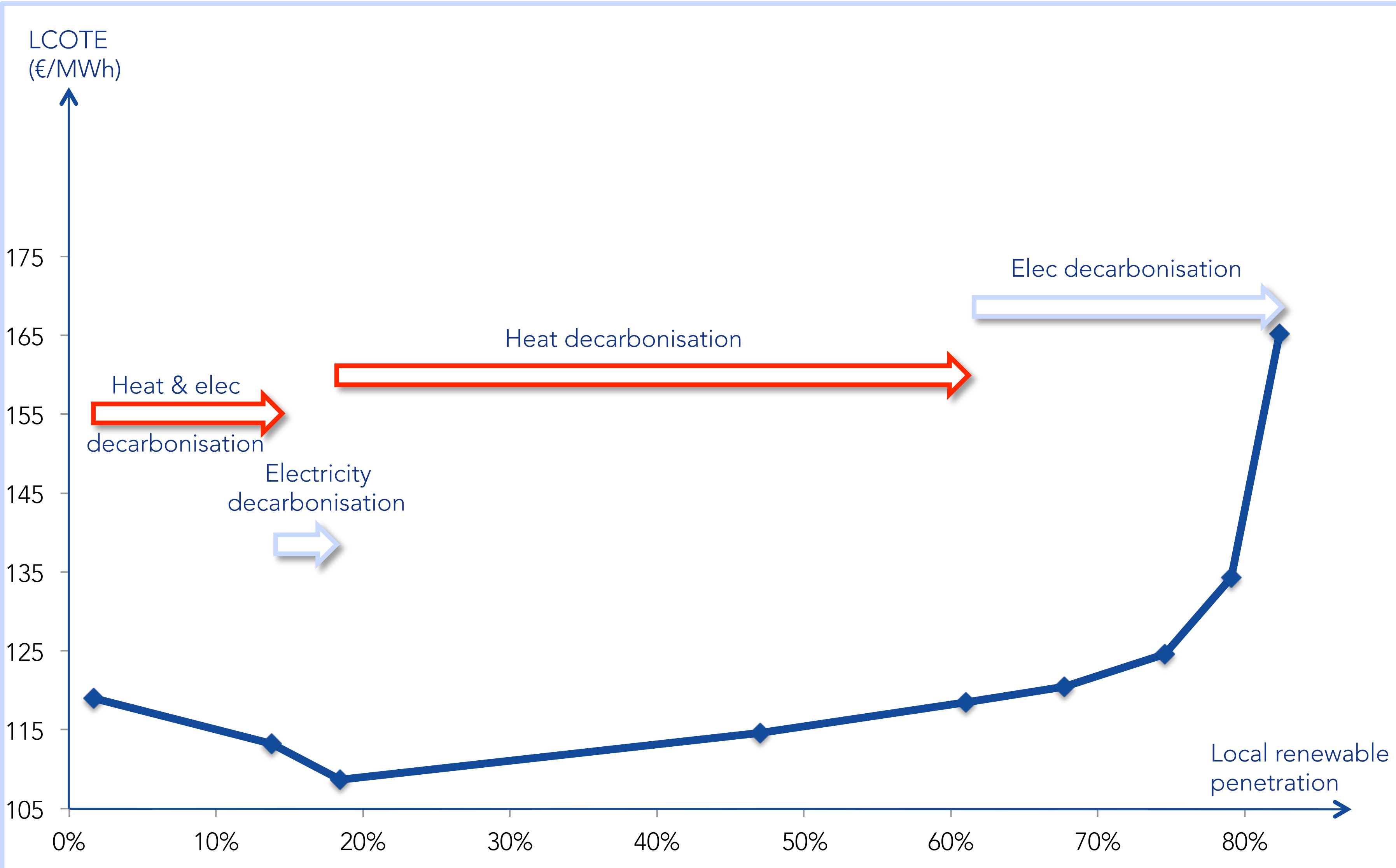



- London has a vast potential for district heating
- PV on rooftops and winds in peri-urban zones are potential development routes

1. Source:Mayor of London, https://www.london.gov.uk/what-we-do/environment/energy/london-heat-map/view-london-heat-map
2. Source: Eurostat
3. Sites: Belvedere 65MWe, Lakeside 37MWe, SELCHP 32MWe, Edmonton 32MWe

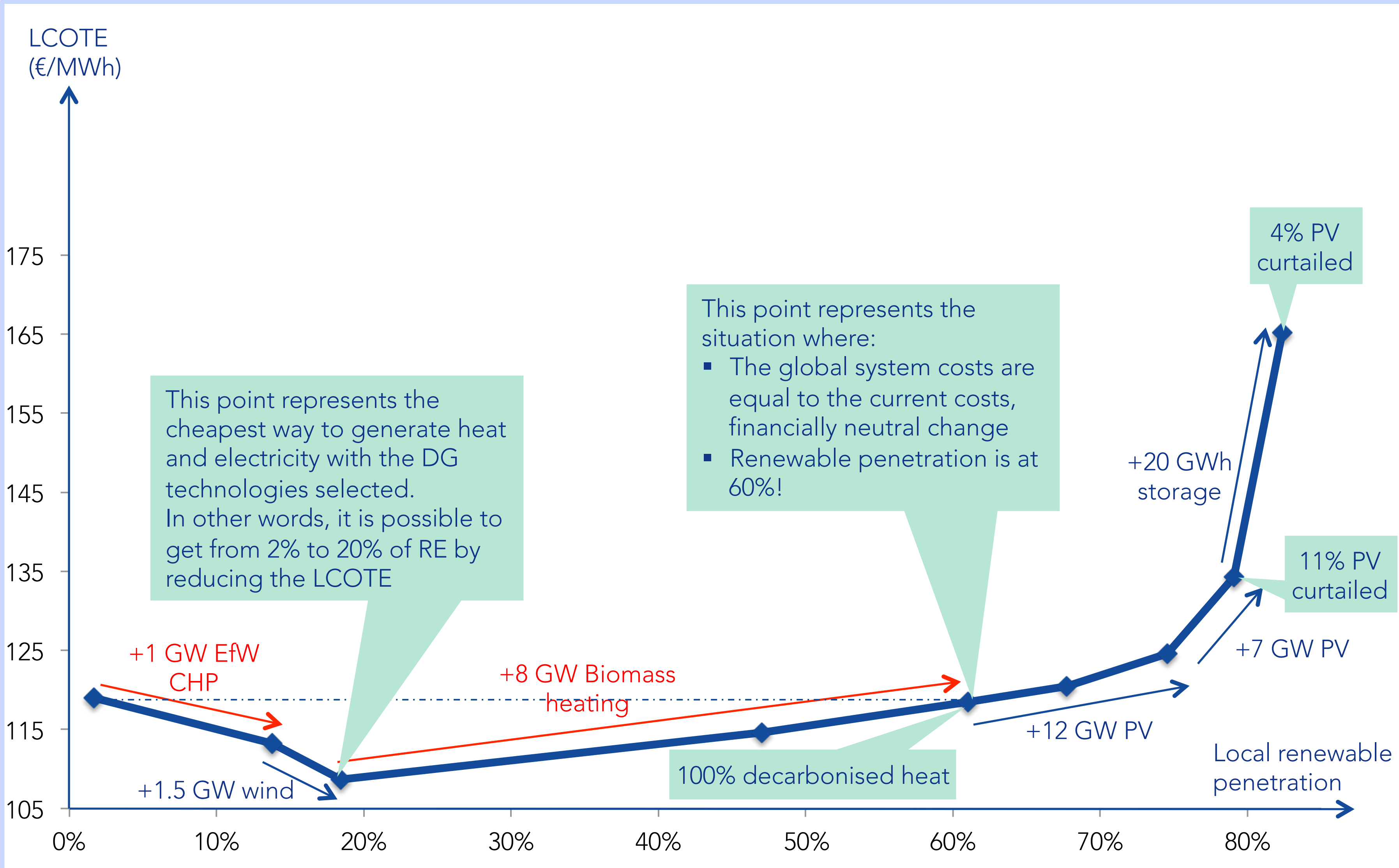
# Greater London – one energy pathway with IDEpolis 60% local renewable penetration can be achieved without any additional cost for the community

4

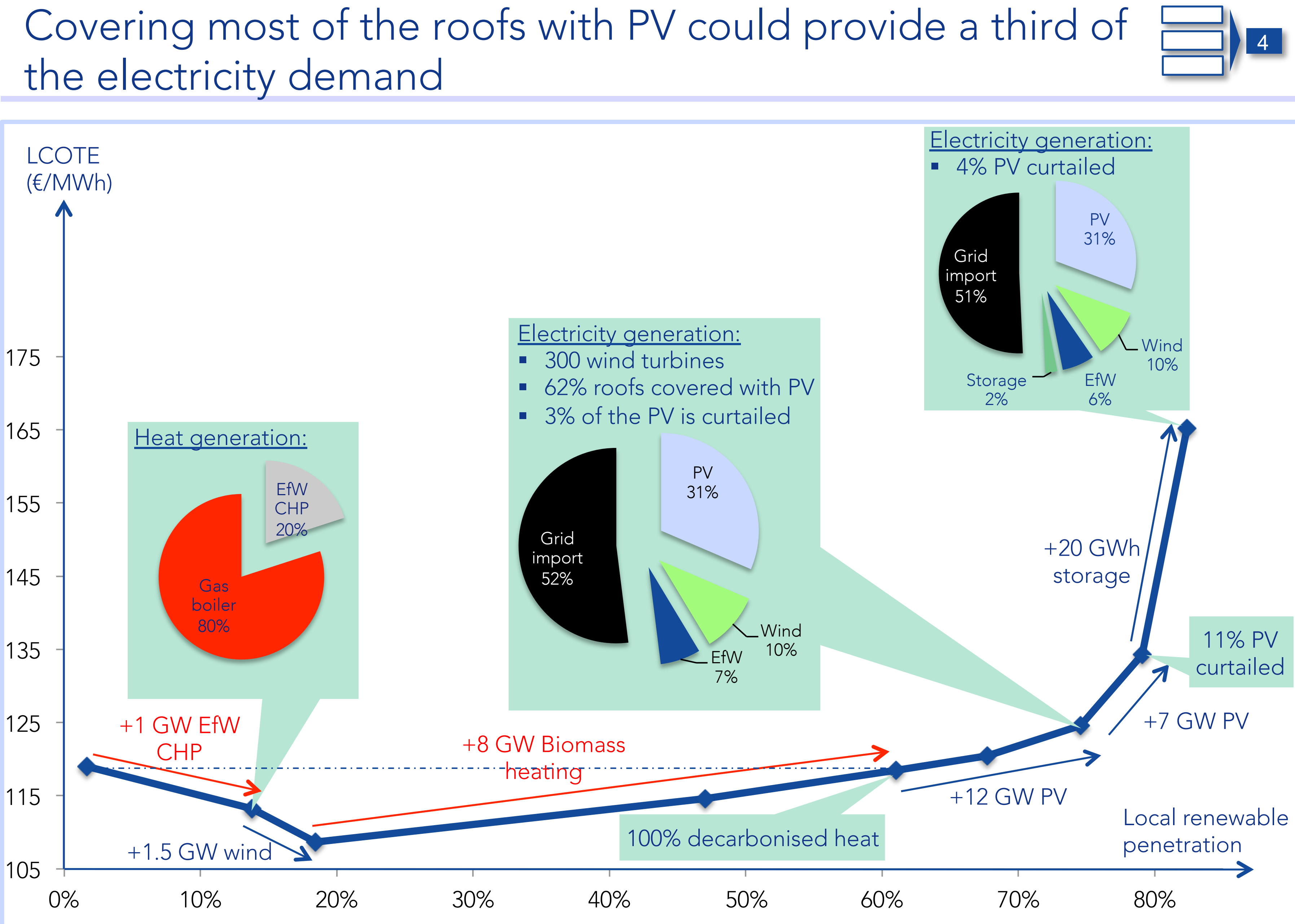


# Greater London – one energy pathway with IDEpolis
# Heat networks and PV rooftops seem to be an efficient way forward to increase local renewable penetration

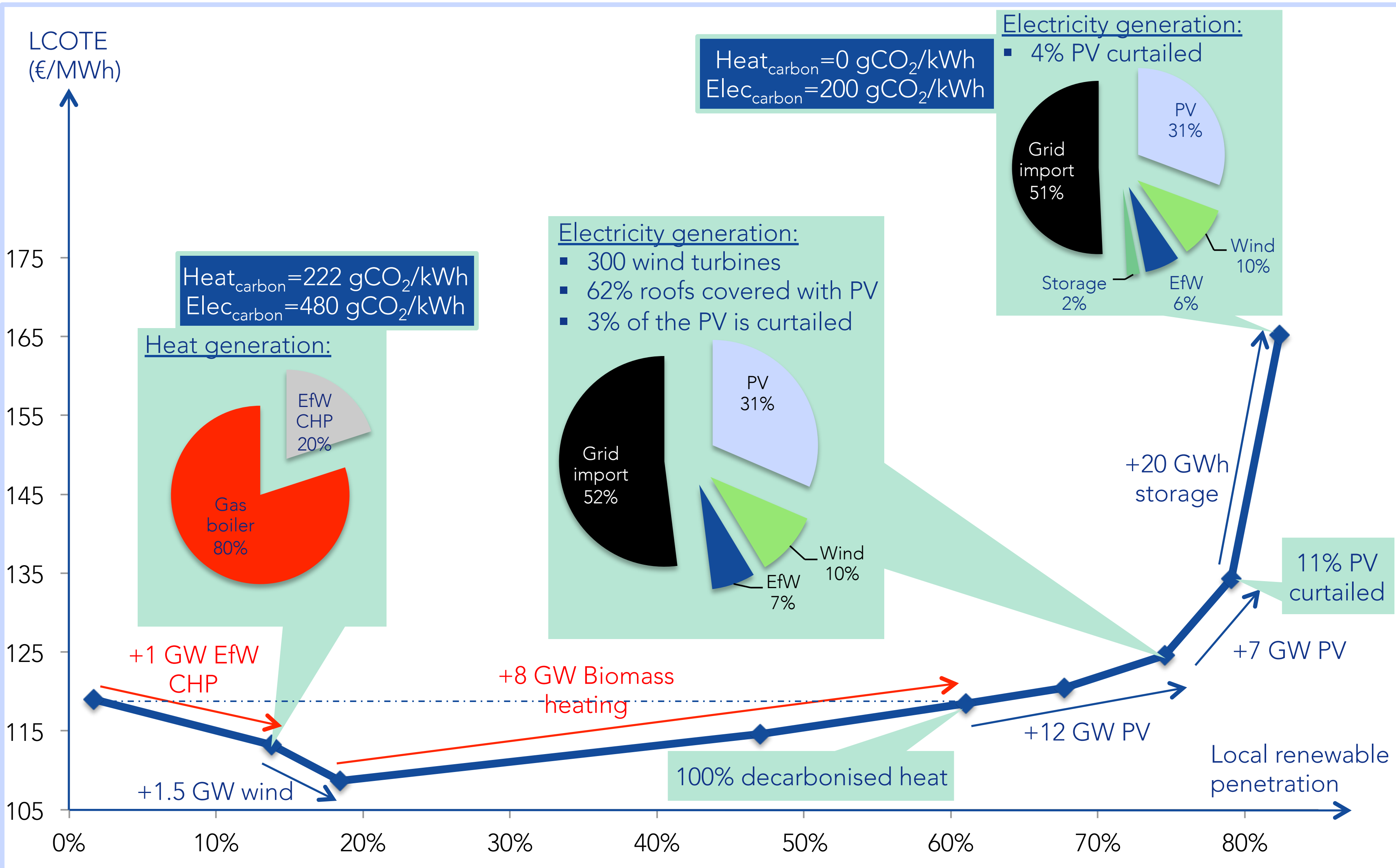
4



# Greater London – one energy pathway with IDEpolis Covering most of the roofs with PV could provide a third of the electricity demand



# Greater London – one energy pathway with IDEpolis
# The carbon content of electricity can be more than halved, heat can be carbon neutral with waste and biomass



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# The model has inherent limits, which need to be kept in mind while using it

4

**The model uses rough assumptions and should only be a starting point**

- The model assumes that each urban area is independent in terms of energy policy, purchase and production

➔ This energy "autonomy" is not representative of how the heat and electricity generation costs are dispatched today.

**The model uses rough assumptions and should only be a starting point**

The model uses by default standard technologies and generic generation profiles:

- Wind and solar resources as well as potential are based on estimations
- Costs vary depending on the location, specially for district heating networks

➔ Further studies should be led depending on the location

**The results might not match local constraints**

In Tsurui Mura, it appears that the wind turbines technology used by default in the model cannot match with local constraints such as typhoons and earthquakes

➔ The 'default technologies' are the most common and the user should make sure they are adapted to the local specific constraints

**Intermittent renewable put grid stability at risk, this stability is not assessed here**

Reaching a certain level of intermittent renewable generation, the grid stability is jeopardised, a dynamic stability study would be required to better understand the impact of renewables on reserve requirements and frequency

➔ The model is only a static, high-level and first order analysis

- The model assumes that each urban area is responsible for its electricity
- Local constraints are not represented in the model
- The results should only be referred to as a high level analysis that could lead to further analysis and initiate discussions with energy professionals

# Conclusion
# Decision makers can now engage discussions with the energy industry by assessing the impact of DG with IDEpolis

## Heat generation in cities can represent a large share of energy use

- In the case studies that are considered in this document, which are all in relatively similar climate conditions, heat decarbonisation is often a cost effective solution.
- Heat and electricity needs intertwine, CHPs represent an interesting solution to produce both heat and electricity locally

## IDEpolis, a tool to help urban areas in their energy transition

- Local empowerment: IDEpolis gives results that allow decision-makers to draw regulatory directions based on economic factors and available resources.
- IDEpolis highlights the trade off between levelised cost of total energy and renewable penetration

## The model can be adapted to deal with cities future challenges

- EVs deployment in cities is about to grow rapidly in urban areas:
  - Fast charging stations deployment will increase the stress on the networks
  - Vehicle to grid technology will be key to provide flexibility
- The energy demand profiles and average consumption can be changed in the model to account for Evs consumption

- Heat has a significant importance in cities and should not be overlooked
- IDEpolis is a hands-on and holistic model to help decision makers engage with the energy industry to integrate distributed generation in their localities

Thanks for your attention!

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