PhD Brainstorming Day
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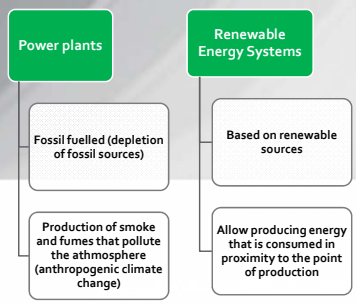
Catania, 30 ottobre 2017

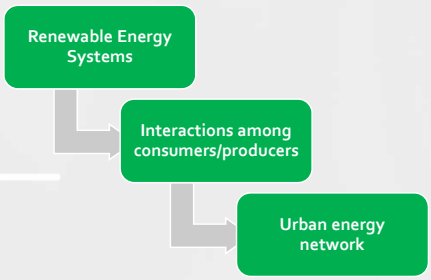
A methodology for the design of an urban energy distribution network of prosumers

ENERGY CONSUMPTION IN CITIES AND ENERGY DISTRIBUTION NETWORK

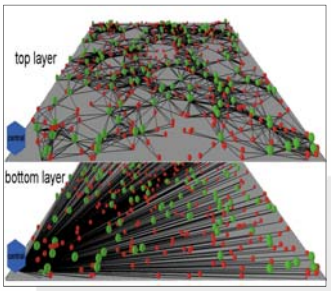


AIM: elaboration of a methodology for the definition of energy planning strategies focused on the insertion of distributed energy systems on urban territories for both encouraging the energy exchanges among consumers and achieving energy efficiency targets in cities

Two different modelling approaches have been applied: the complex network theory and agent-based models, dealing the former with static applications and the latter with dynamical simulations.



THE MATHEMATICAL MODEL



Models parameters:

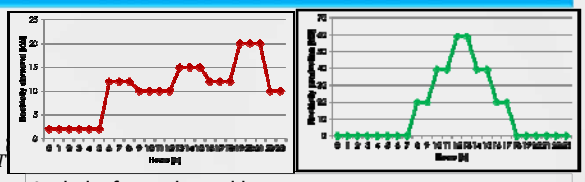
- $i = 1, \dots, N$ → nodes
- $central$ → central node
- $D_i(t)$ → energy demand of node i at time t, with $t = 0, \dots, T$
- $P_i(t)$ → energy production of node i at time t, with $t = 0, \dots, T$
- $S_i(t) = P_i(t) - D_i(t)$ → energy surplus of node i at time t, with $t = 0, \dots, T$
- $connection\_radius$ → metrical distance between two nodes

$$\boldsymbol{links\_percentage} = \frac{active\_links}{active\_links + inactive\_links}$$

$$\boldsymbol{energy\_loss\_percentage} = \frac{\sum_{t=0}^{T}\sum_{i=1}^{N}(production_{it} - demand_{it} - exchange_{it})}{\sum_{t=0}^{T}\sum_{i=1}^{N} production_{it}}$$

$$\boldsymbol{supply\_percentage} = \frac{\sum_{t=0}^{T} central\_supply_t}{\sum_{t=0}^{T}\sum_{i=1}^{N} demand_{it}}$$

$$\boldsymbol{index_{mix}} = links\_percentage * (1 - energy\_loss\_percentage) * (1 - supply\_percentage)$$

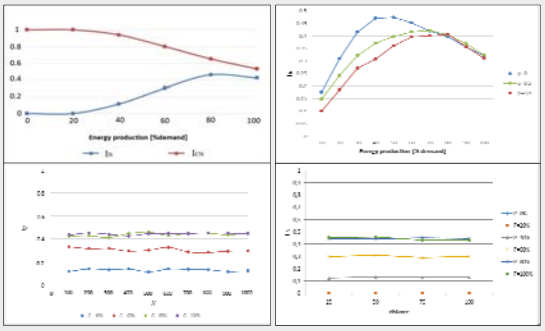


Analysis of scenario considers:

- the number of nodes of the network
- random assignment and geographical assignment of the energy demand and energy production
- percentages of producers within the territory
- distance of connection among nodes
- links activation threshold

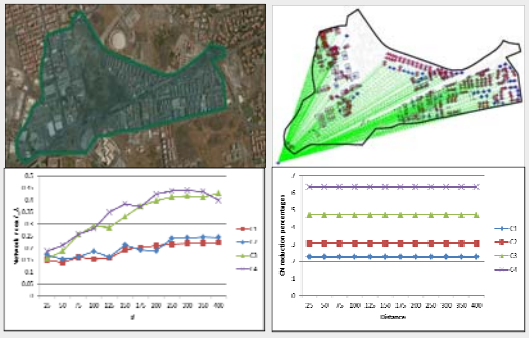
RESULTS

Static simulations – test area



Static simulations – Nesima

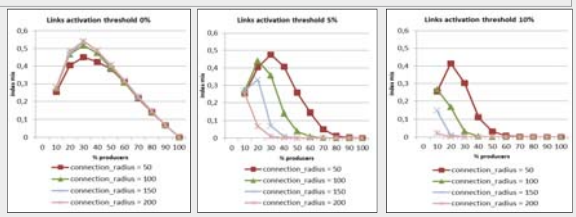
0,67 km^2
370 nodes



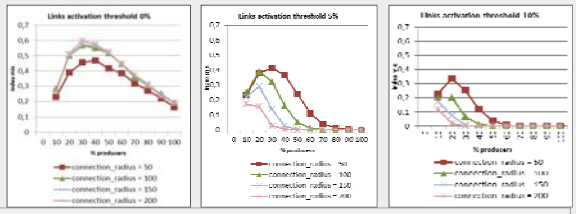
Hub

Dynamic simulations – test area

Constant energy consumption and energy prodution profiles

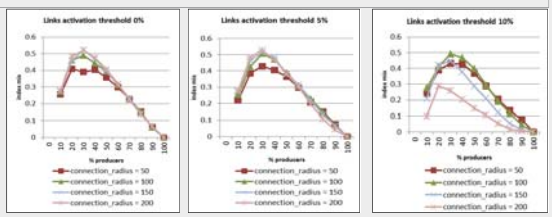


Variable energy consumption and energy prodution profiles

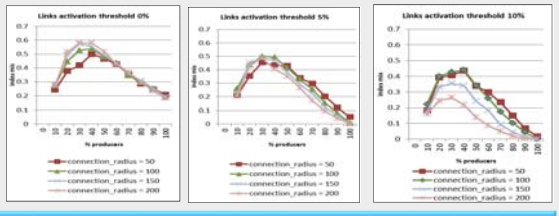


Dynamic simulations – Nesima

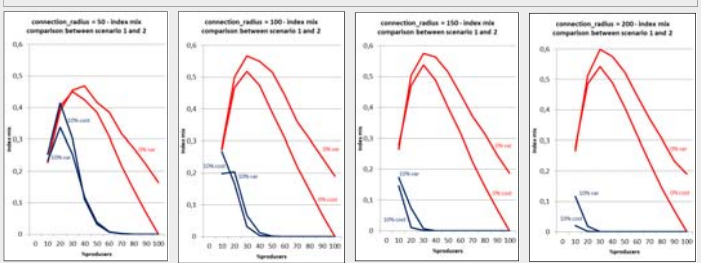
Constant energy consumption and energy prodution profiles



Variable energy consumption and energy prodution profiles



Thresholds comparison



CONCLUSIONS

- The increase of the energy production among nodes cannot be planned indiscriminately, since a threshold of a **maximum energy production equal to 80% of the energy demands** of the network has been observed both in the numerical and the real case study
- The number of nodes does not influence the design of the energy distribution network
- The design of the energy distribution network should contemplate the **usability** of the links, beyond the evaluation of both the parameters of distance of connections and percentages of producers
- Low distances, typically around **50 m**, coupled with **20-30% of producers** ensure a major exploitation of the energy distribution network