Urban wind turbines
Potential and impact

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Overview

- Introduction
- Recommendations for a successful wind turbine project
- Brussels case studies: viability and impact
- Summary and conclusions

Introduction

Can cities be self-sufficient in energy?

- Renewables have low power per land area:
  - **Wind**: 1-3 W/m^2.
    Can be higher for offshore wind, but 6 W/m^2 is unusual
  - German **solar** farms reach 5 W/m^2
- Cities have high power use per land area: 20-50 W/m^2 (150 W/m^2 for Mumbai)
- Local renewable energy production will not provide a large fraction of the energy needs of any major city. This will always require large-scale generation

Large-scale production of renewable energy

- Essentially all renewable energy sources have low power per land area:
  - There is no such thing as centralised generation of renewable energy
  - A entirely non-fossil, non-nuclear electricity production of electricity means living around power plants
- Off-shore energy generation can partly mitigate this issue, but there is a cost problem

Why urban wind turbines?

- Every contribution counts
- There is a lot of unused space in cities: rooftops
- If there is wind, this space may be used cost-efficiently to produce wind power
- Bringing power production closer to people can create awareness and goodwill.
  This almost psychological dimension is important.
- It's time to stop dallying, and these are small projects
- The greening of a company's image has tangible value
- Secondary benefits only count if the energy production is economically viable in the first place

Urban wind turbines — How?

Question of this contribution:

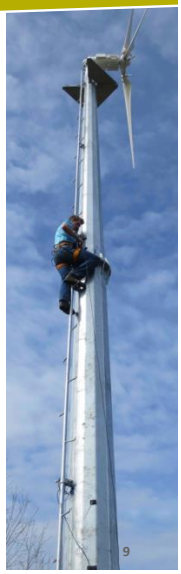
- Can wind energy produce local electricity in an urban area
  - in a economically viable manner
  - safely
  - with limited impact on surroundings ?

- **Feasibility** depends on **viability** and **impact**

Viability of small and medium wind turbines

Annual energy production

- In good conditions
  - A 5 kW (d ~ 5 m) turbine will produce around 13 000 kWh/yr
- The average Belgian household consumes 3500 kWh/yr of electricity



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Feasibility of a SMWT project

- **Economic viability**: measured with a metric such as
  - levelised cost of energy (LCOE)
  - payback period
  - internal rate of return (IRR)
  - secondary benefits (e.g. of greening of company image) have tangible monetary value
- **Impact**: safety, shadow flicker, noise, vibrations, biodiversity, air traffic

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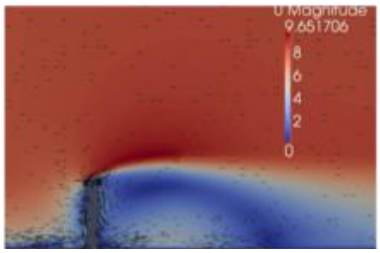
Rule 1: Know the market

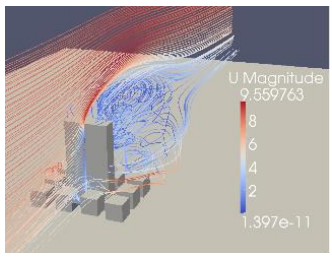
Rule 2: know the wind resource

- Estimate the available wind resource with the aim of predicting the energy production for an appropriate wind turbine
- On-site measurements are advisable in most cases
- This is in practice not always easy to do cheaply and reliably. (Measurement period at least 3 months).

Rule 3: proper micrositing

- Wind conditions change over a few metres.
- Optimal location and height of the turbine determined by:
  - 3-D model of the site or building
  - Combined with computational fluid dynamics ('virtual wind tunnel')

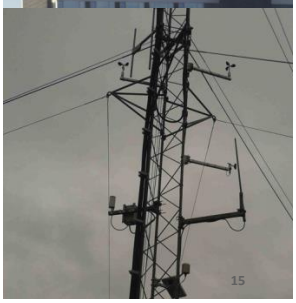




Wind energy in Brussels

Wind measurements: results

- The Hotel:
  - building height 94 m
  - close to porte de Namur
  - Over 1 yr of measurements
  - Average wind speed: 5.8 m/s
  - This is comparable to the wind at the Belgian coast (at normal hub height)



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Wat would a wind turbine on The Hotel produce?

- The Hotel:
  - Yearly production
    - » Turbine with d ~ 6 m: 14200 kWh/yr
    - » Turbine with d ~ 4 m: 8170 kWh/yr
  - Dynamic payback time
    - » SME: 7 yr (10-12 yr without support)
  - IRR:
    - » Turbine with d ~ 6 m: 17.2 %
    - » Turbine with d ~ 4 m: 15.1 %

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Wind conditions in Brussels

- Other high-rises (Manhattan-tower): comparable results
- Intermediate-height buildings (40 - 50 m): conditions vary (e.g. Peterbos ~ 4.5 m/s)

- Not considered: potential for medium-sized turbines in semi-open terrain

Impact of rooftop-mounted wind turbines

Building-mounted small wind turbines

- Turbine should not affect structural health of building
- Impact on occupants and surrounding should be negligible
- Impact on air traffic should be negligible
- Impact on biodiversity should be negligible

Portland, Oregon (2009)

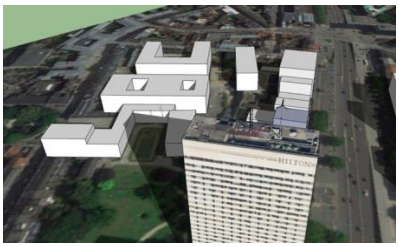
Results: structural impact of vibrations

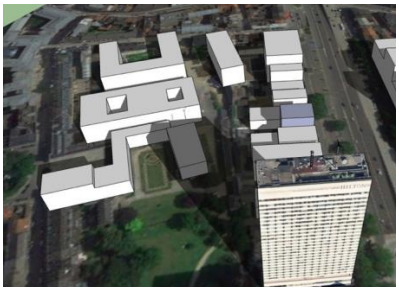
- Structural impact negligible if wind turbine is mounted on the supporting structure of the building
- Local reinforcements may be necessary when turbine mounted away from supporting column

Dallas, Texas (2011)

Shadow flicker

- Guideline
  - max 30 h/yr
  - max 30 min/day
- The Hotel
  - Shadow moves fast enough
  - Similar conclusions for most high-rises, not necessarily for lower, more complex buildings

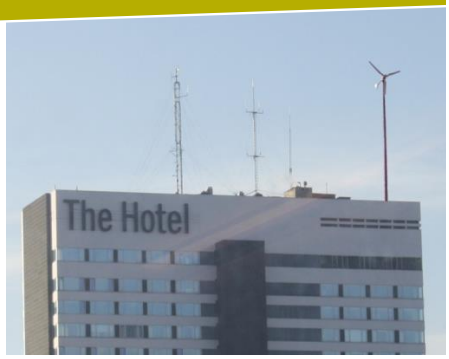




Impact of rooftop-mounted wind turbines

- Visual impact →

(but of course a picture does not move)



- Noise:
  - direct: inaudible
  - through vibrations: limited effect, but hard to predict
- Biodiversity: very little impact
- No risk for air traffic

Pilot projects

- We have drawn up full feasibility for four sites in Brussels: Peterbos, UZ Brussel, Tour du Midi, The Hotel
- Decision to submit building permits is up to the owners

Long-term potential

- In the long term, and providing the problem of rooftop crowding can be managed, there is the potential for roughly 50 sites for rooftop-mounted wind turbines in Brussels, resulting in a power production of the order of 1.5 GWh/yr

Summary & conclusions

- There is a potential for wind energy in the BCR
- Projects can be economically viable with low impact
- Brussels has the expertise and assets required
- Now is the time for pilot projects
- Who is willing to invest?

(25 kEUR would do fine, thank you)

Thank you

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