



Wind Turbines on CO2 Neutral Luminaries in Urban Areas

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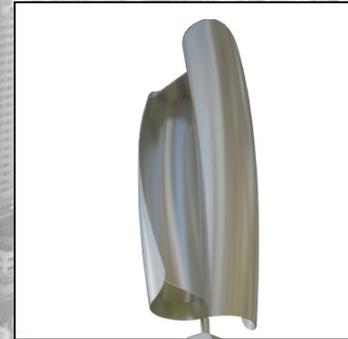
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Wind Turbines on CO2 Neutral Luminaries in Urban Areas



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Why Bother?

- Decrease the infrastructural cost
- Deploy where the grid is either underdeveloped or non-existent
- Increase people's awareness of renewable energy

Challenges?

- Low and unpredictable wind resource
- Low solar radiation in winter in northern countries
- Lack of experimental verification of the performance
- Uncertain cost functions
- Low lift-drag ratio for small Reynolds numbers
- Lower power efficiency than for mega-watt turbines

Development of a carbon neutral luminaire for the urban environment

- Model the wind characteristics in urban environment
- Develop a time-marching simulation algorithm for the luminary
- Simulate some of the existing designs
- Design a new autonomous luminary

Exemplary hybrid luminary equipped with a horizontal axis wind turbine and a photovoltaic panel; *United Electricity*



Tools and methods

Assessment of wind climate

- **Simulated environment: 1-2 story single family buildings with gable roofs**
- **1-year long time series were measured 20 km north of Copenhagen**
- **Data was corrected to account for building height and density using the roughness step method**

Computational model for the luminary

- **Turbines modeled by table lookup using the corrected wind measurement and producer-supplied power curves**
- **PV panels modeled using third-party supplied illumination data for the considered Copenhagen district**
- **Device parameters (effective areas, height etc.) were assumed identical for all the luminaries**

Simulated turbines



Green Power

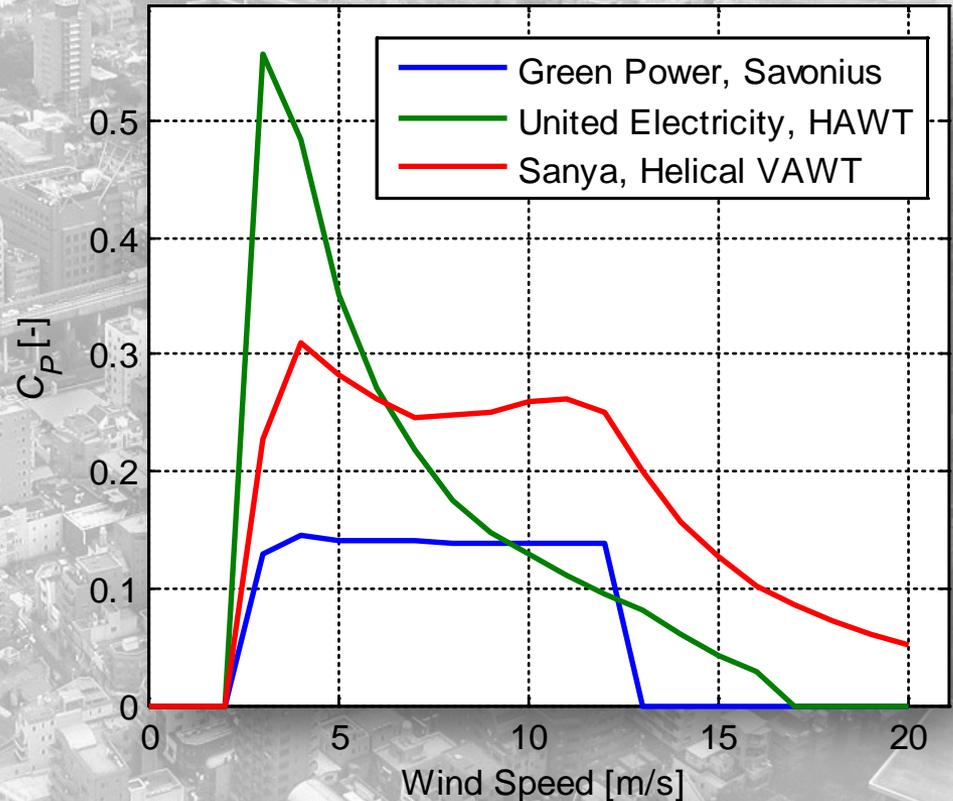


United Electricity



Sanya

Producer-supplied power curves



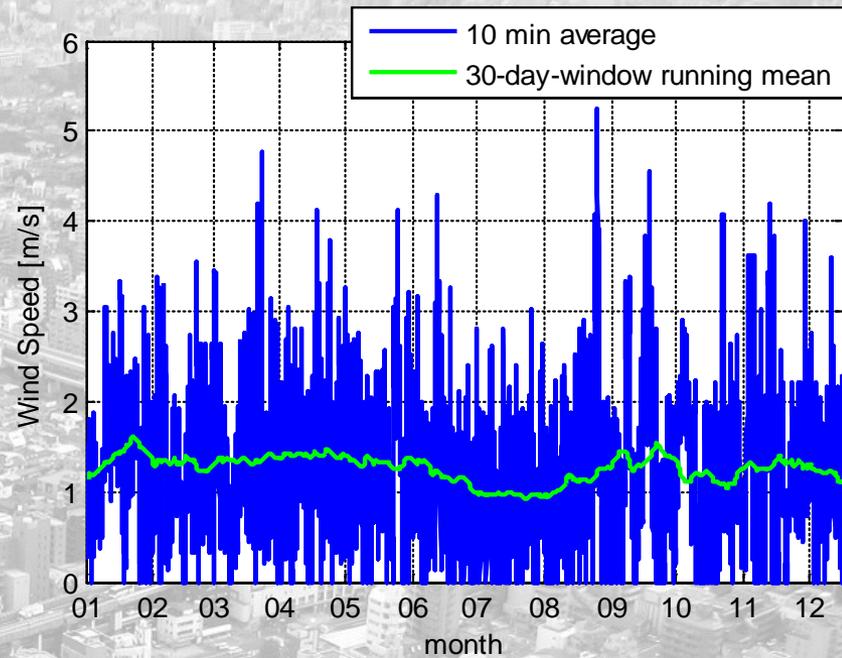
Results

Wind climate

Time series of the 10-min-average wind speed used in the simulations together with the 30-day-window running mean; 8 m reference height



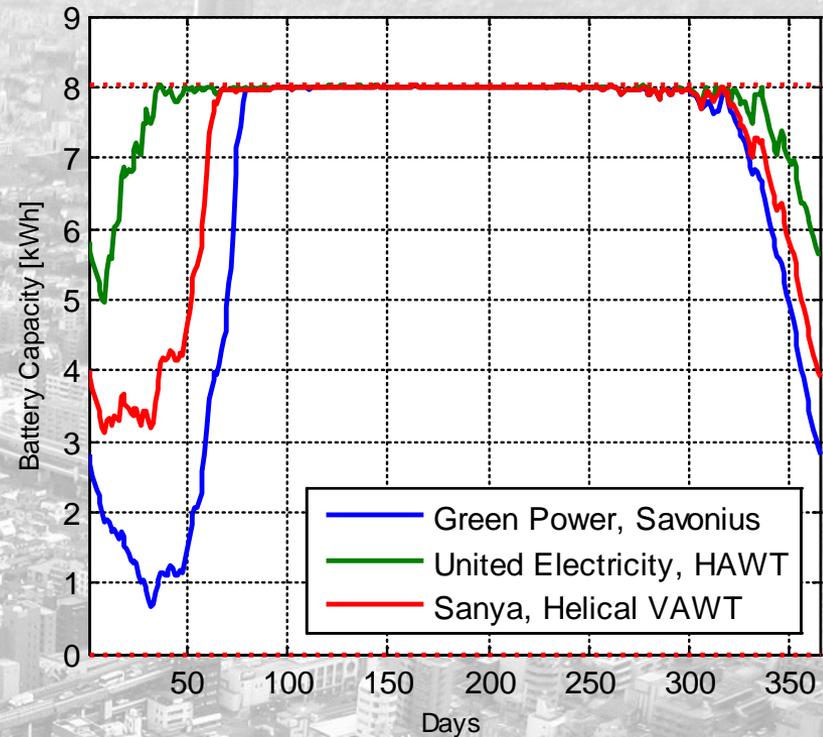
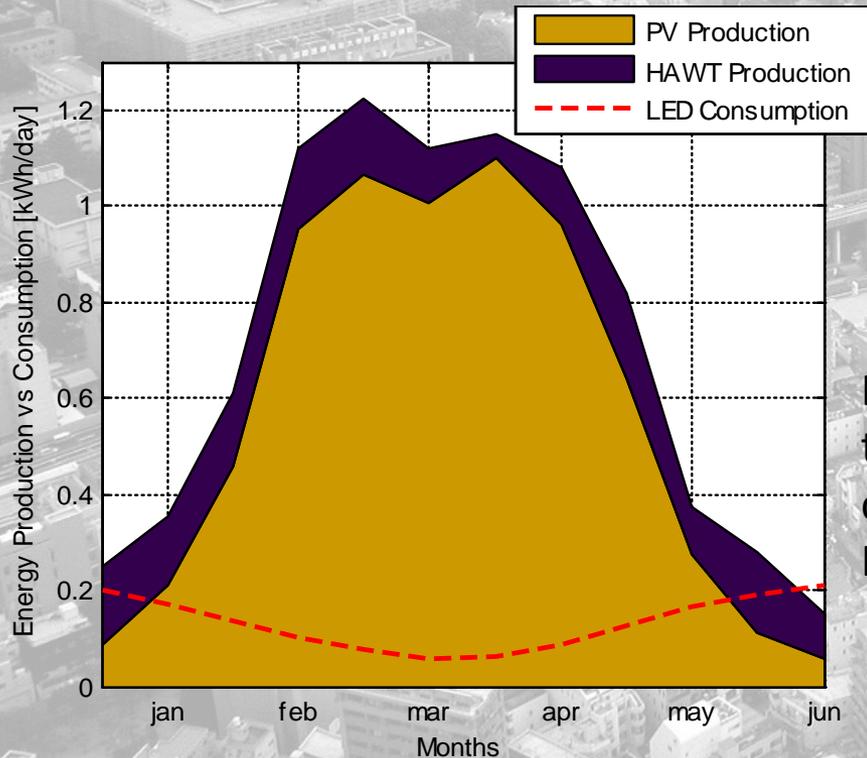
One-week extract from the time series of the 10-min-average wind speed used in the simulations; 8 m reference height



Results

Modelling the luminary

Time series of the energy level in the batteries in the simulated luminaries

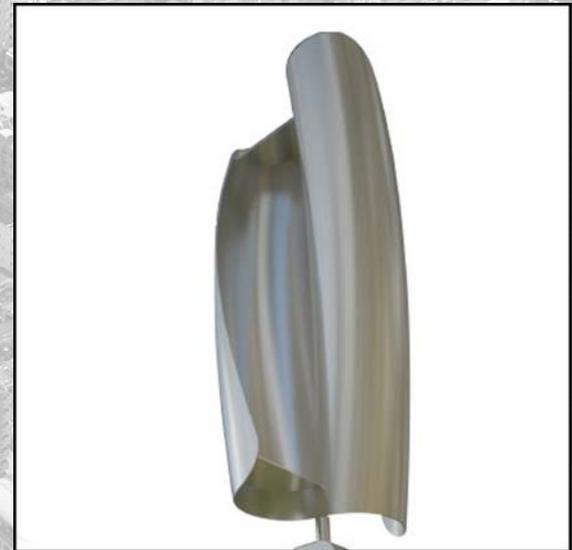


Balance between energy production by the turbine and the photovoltaic panel, and the consumption by the LED; *United Electricity HAWT*

Choice of the present rotor

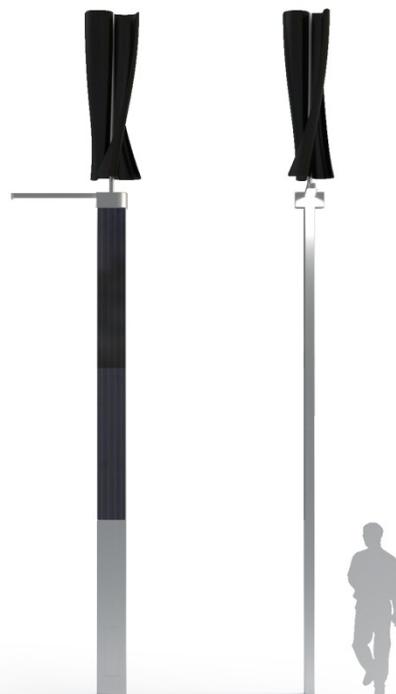
- **Current producer-supplied power curves should be verified experimentally (in progress)**
- **Low operational wind speeds point at a Savonius rotor**
- **Savonius' low tip speed would be beneficial in urban environment for safety reasons**
- **Vertical-axis turbines are easier to fit aesthetically**
- **Rapidly changing wind direction points at vertical-axis**

Present design 90-degree-twist single-stage Savonius wind turbine with small-size end plates mounted and the top and bottom of the rotor; source: Henning Larsen Architects A/S



Conclusions:

- **Three different wind turbines used in hybrid luminaries were presented**
- **Wind climate in Copenhagen district comprising 1-2 story single family buildings was simulated**
- **Luminaries with the turbines were modelled using producer-supplied power curves**
- **The analysis showed the need for balancing the size of the wind turbine, the photovoltaic panels, luminary and the battery the best way**
- **A new 90-degree-twist single-stage Savonius wind turbine with small-size end plates mounted and the top and bottom of the rotor was proposed**



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“Development of a carbon neutral
luminaire for the urban
environment”.

Thank you!