
technology
flowgen

De-Carbonization

Decentralization – Battery, Solar and Wind 2.0

Digitization

A comprehensive and smart microgrid solution is required

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The Need for Clean Power!

Access to energy, particularly cleaner energy, is fundamental to human progress. The majority of the world's energy poor lives in Asia, Pacific and Africa. Many with access to power use diesel generators!

What if these people had access to clean energy?

We are convinced that a number of problems can be addressed effectively because clean energy produced with current technology makes the electricity much more affordable, helps decrease poverty and reduces or stops the burdening of the environment.

Power enables access to information technology and communication, and therefore, to online education which can be of general nature for children and adults or be it for specific groups such as farmers, small business owners, women, etc.

Thus, it improves the quality of life for millions of people. For example, electricity decreases the problem of women and children whose household responsibilities include spending hours collecting fuel and performing manual labor or fetching water. Energy allows them to pursue more productive undertakings and helps create opportunities for education and promote economic development.

What are the Problems, what is the Solution and how does FlowGen fit in?

Power problem in rural and urban areas in many countries?

Rural areas

- **No reliable access to power:** either no grid (approximately 1 billion people in Asia and Africa) or unstable grid with frequent power outages
- **Use of diesel generators:** very expensive; often subsidized, thus financial burden for many countries
- **Pollution:** CO2 emission; in conflict with the Paris Climate Accord; noise
- **But strong demand for power due to economic growth:** many countries and regions will see strong economic growth

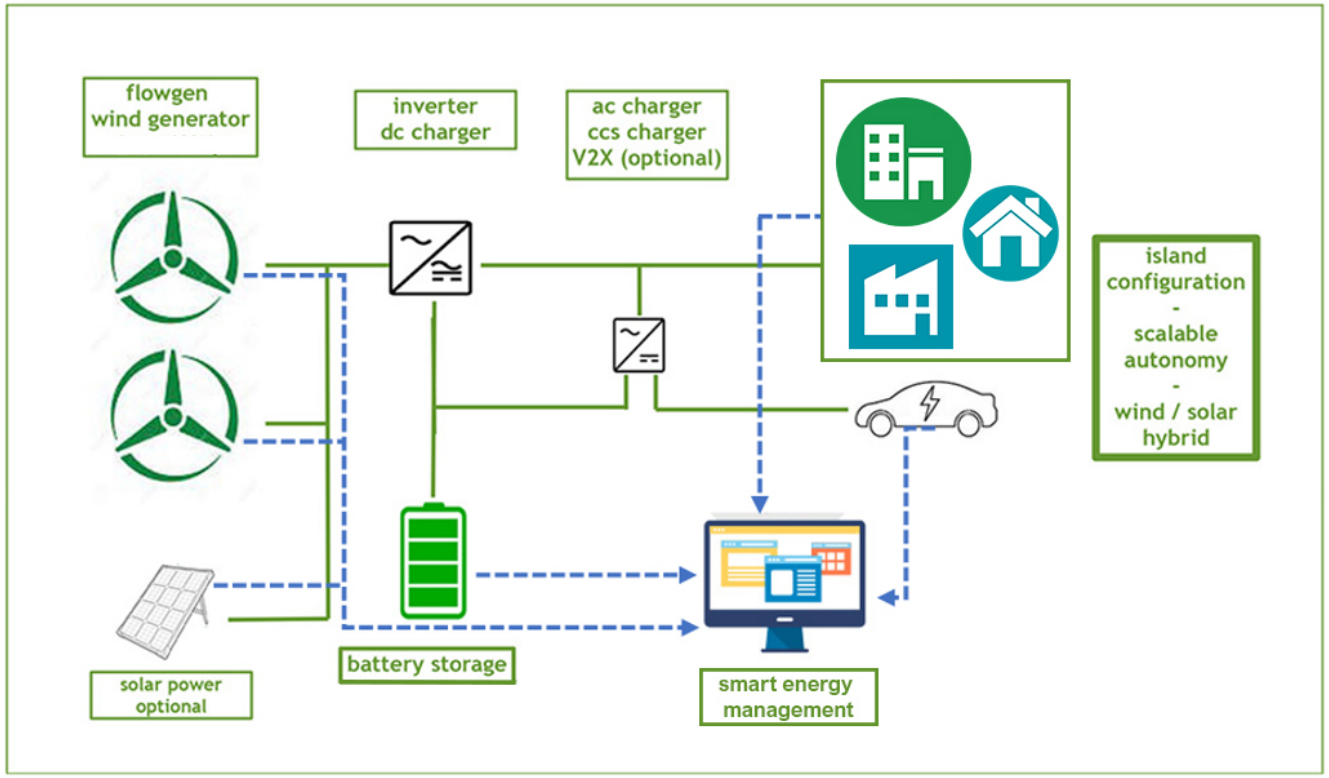
Diesel Generator

Urban areas

- **Continued and growing demand for power:** despite focus on power efficiency
- **Replacing existing fossil and nuclear power sources with** renewable energy
- **Overcrowded grid:** long timeframe to execute a new grid; complicated and long permission process, expensive
- **Ambitious CO2 reduction targets:** Paris Climate Accord; short timeframe to reach CO2 neutral by 2050
- **Pressure from various stakeholders to become green:** Corporate and private consumers, employees, shareholders, governments

What is the solution? – cost-effective smart microgrid embracing wind, solar and battery

- Independent of grid and energy supplier
  - Financial benefits through elimination of energy costs, grid and grid connection fee
  - Higher security of supply
- Easy solution for energy supply of remote areas with no existing grid
- New monitoring in real time



Who is Flowgen? **NOT** your traditional wind turbine company – **it is 2.0; part of a micro grid**

- Flowgen, a Swiss company transferred know-how, expertise and experience from the **Formula-1 racing industry** (prototype & aerodynamic) as well as from the **automotive sector (manufacturing processes)** to the wind industry and **offers a smart small wind system.**
- **Many years of research on type** of wind turbines needed in the future considering the opportunities and threats of users in the industrialized and developing world
- Close collaboration with other suppliers such as highly experienced manufacturers of generators, inverters, etc.
- **Test results were performed by the independent accredited measurement institute Windtest Grevenbroich in Germany (see test results in the Appendix)**
- **Result is a highly efficient wind turbine certified according to IEC 61400-2 by TÜV Rheinland**
- **Monitoring of the perfomance of the wind turbines and the whole system through sensors. Furthermore, FlowGen wind turbines can be meshed according to the master – slave concept.**
- The value proposition is completed by a rather easy logistics, local assembly, installation, maintenance

Conclusion:

- Light and small highly efficient wind turbines with low noise and vibriation level to produce electricity in a decentralized manner where it is needed; integral part of a micro grid together with solar and battery system
- High quality mass manufacturing
- Offering good value for owners and operators

FlowGen's Matrix of Application

- Overview according to average international market prices and mean yearly power output for realistic and suitable locations

Financial Parameter

- The yearly power output was calculated with the FlowGen wind turbines power curve and a standard Weibull distribution of a location with a mean wind speed of 5m/s, 6m/s and 7m/s.
- The LCOE take into account all costs (investment, maintenance and operation with 150US$ per wind turbine and year for application 1-6 and 250US$ per years for the system in application 7, residual value on the wind turbines of 20%, interest rate 0.5%) over the life of 20 years in relation to the estimated energy output during this period.
- Time of amortization is the time needed for the payback of the investment if the produced kWh has a value of 20US$c/kWh, including also operation and maintenance with 150US$ per wind turbine and year for application 1-6 and 250US$ for application 7 per year.

1. Mast Applications

i. One 20m mast with 2 FlowGen Wind Turbines

Sales Quantity	Description	Total Investment excl. VAT/Taxes – estimate	Installed Power	Estimated Yearly Power Output[1] in kWh according to a standard Weibull distribution with a yearly mean wind speed[1]:			LCOE in US$c/kWh at yearly mean wind speed:			Amortization time in years for 20US$c/kWh at yearly mean wind speed of 6m/s:
				5m/s	6m/s	7m/s	5m/s	6m/s	7m/s	
Min. 21	20m mast with 2 FlowGen wind turbines with 5m rotor diameter and yaw system – *market-based cost reduction through scaling*	54.000US$	20kW	23.120	36.516	48.960	11.9	7.5	5.6	6.6

[1] Confirmation of data will be made by GPS-data of project location with satellite data and CFD analyses. Percentage adaption for different Weibull distributions.

2. The FlowGen Energy Hub

i. Steel Construction Tripod «Energy Hub» with 12 FlowGen Wind Turbines

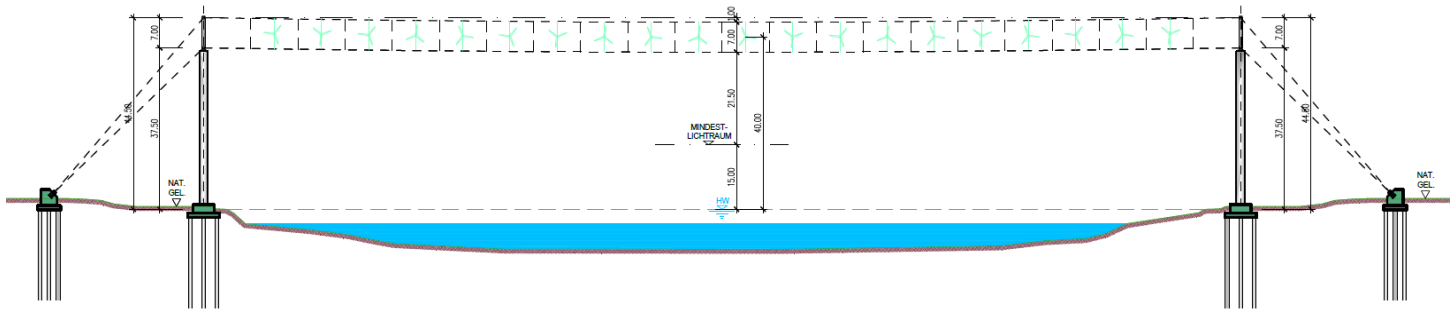
The system is scalable to 15 or 20 wind turbines.

Sales Quantity	Description	Total Investment excl. VAT/Taxes – estimate	Installed Power	Estimated Yearly Power Output[1] in kWh according to a standard Weibull distribution with a yearly mean wind speed[1]:			LCOE in US$c/kWh at yearly mean wind speed:			Amortization time in years for 20US$c/kWh at yearly mean wind speed of 6m/s:
				5m/s	6m/s	7m/s	5m/s	6m/s	7m/s	
Min. 10	Steel Construction Tripod with 12 FlowGen wind turbines with 5m rotor diameter on heights between 20 and 50m; typhoon and earthquake resistant *– market-based cost reduction through scaling*	462.000US$	180kW	138.720	255.000	408.000	17.1	9.3	5.8	8.4

[1] Confirmation of data will be made by GPS-data of project location with satellite data and CFD analyses. Percentage adaption for different Weibull distributions.

3. Cable Structures for On- and Offshore Applications

i. Cable Structure with 35 FlowGen Wind Turbines



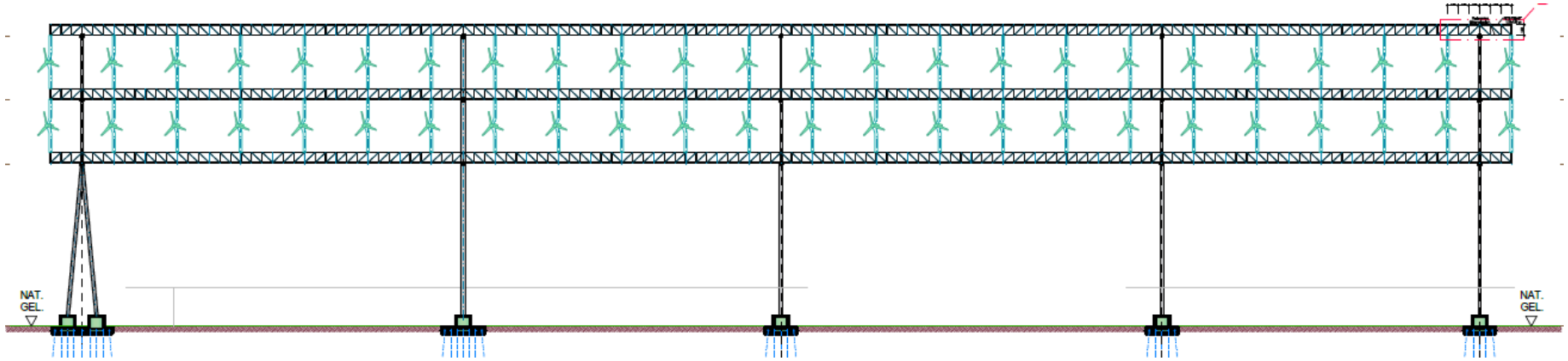
For offshore applications the system adjusts automatically to the tidal elevation

Sales Quantity	Description	Total Investment excl. VAT/Taxes – estimate	Installed Power	Estimated Yearly Power Output[1] in kWh according to a standard Weibull distribution with a yearly mean wind speed[1]:			LCOE in US$c/kWh at yearly mean wind speed:			Amortization time in years for 20US$c/kWh at yearly mean wind speed of 6m/s:
				5m/s	6m/s	7m/s	5m/s	6m/s	7m/s	
Min. 6	Cable Structure with a height between 30 and 50m with 35 FlowGen wind turbines with 5m rotor diameter and yaw system; construction can be tide-balanced *– market-based cost reduction through scaling*	1.081.000US$	350kW	404.600	639.030	856.800	13.7	8.6	6.4	7.7

[1] Confirmation of data will be made by GPS-data of project location with satellite data and CFD analyses. Percentage adaption for different Weibull distributions.

4. Steel Structure for Onshore Applications

i. Steel Framework with 50 Wind Turbines

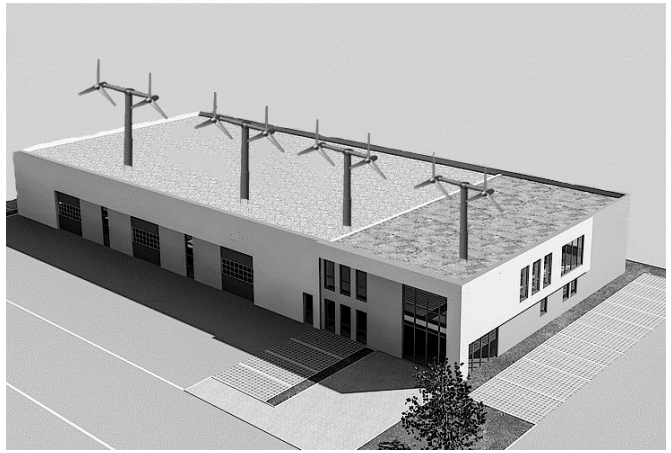


Sales Quantity	Description	Total Investment excl. VAT/Taxes – estimate	Installed Power	Estimated Yearly Power Output[1] in kWh according to a standard Weibull distribution with a yearly mean wind speed[1]:			LCOE in US$c/kWh at yearly mean wind speed:			Amortization time in years for 20US$c/kWh at yearly mean wind speed of 6m/s:
				5m/s	6m/s	7m/s	5m/s	6m/s	7m/s	
Min. 6	Steel framework with a height between 30 and 50m with 50 FlowGen wind turbines with 5m rotor diameter and yaw system – *market-based cost reduction through scaling*	1.277.000US$	500kW	578.000	912.900	1.224.000	11.5	7.3	5.4	6.3

[1] Confirmation of data will be made by GPS-data of project location with satellite data and CFD analyses. Percentage adaption for different Weibull distributions.

5. Building Applications

i. Standard Construction with a height of 10m above the rooftop edge with 2 FlowGen Wind Turbines



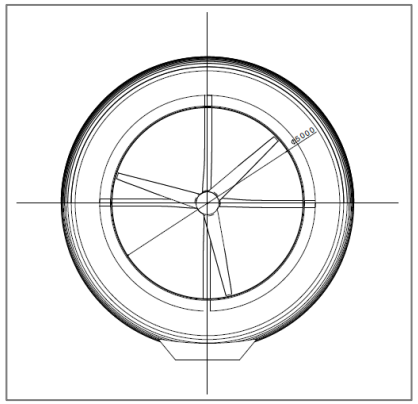
Sales Quantity	Description	Total Investment excl. VAT/Taxes – estimate	Installed Power	Estimated Yearly Power Output[1] in kWh according to a standard Weibull distribution with a yearly mean wind speed:			LCOE in US$c/kWh at yearly mean wind speed:			Amortization time in years for 20US$c/kWh at yearly mean wind speed of 6m/s:
				5m/s	6m/s	7m/s	5m/s	6m/s	7m/s	
Min. 21	Standard construction with a height of 10m above rooftop edge with 2 FlowGen wind turbines with 5m rotor diameter and yaw system – *market-based cost reduction through scaling*	45.000US$	20kW	23.120	36.516	48.960	9.8	6.2	4.6	5.3

[1] Confirmation of data will be made by GPS-data of project location with satellite data and CFD analyses. Percentage adaption for different Weibull distributions.

6. FlowGen's Ducted Wind Turbine for New Constructions

i. Reinforced Concrete Duct with FlowGen Wind Turbine Integrated in New Structures

The FlowGen ducted wind turbine is for new structures where the duct is integrated in the construction as moulding based on reinforced concrete.



Sales Quantity	Description	Total Investment excl. VAT/Taxes – estimate	Installed Power	Estimated Yearly Power Output[1] in kWh according to a standard Weibull distribution with a yearly mean wind speed:			LCOE in US$c/kWh at yearly mean wind speed:			Amortization time in years for 20US$c/kWh at yearly mean wind speed of 6m/s:
				5m/s	6m/s	7m/s	5m/s	6m/s	7m/s	
Min. 250	Reinforced Concrete Duct with FlowGen wind turbine with 5m rotor diameter for new constructions on the base of reinforced concrete – *market-based cost reduction through scaling*	19.000US$	15kW	11.560	21.250	34.000	8.6	4.7	2.9	3.8

[1] Confirmation of data will be made by GPS-data of project location with satellite data and CFD analyses. Percentage adaption for different Weibull distributions.

7. FlowGen's Independent Mobile Green Energy Supply Center

i. Container solution with FlowGen wind turbines, solar panels and battery storage as independent microgrid – scalable according to customer requirements

Sales Quantity	Description	Total Investment excl. VAT/Taxes – estimate	Installed Power	Estimated Yearly Power Output[1] in kWh according to a standard Weibull distribution with a yearly mean wind speed and 1200 full load hours for solar:			LCOE in US$c/kWh at yearly mean wind speed and 1200 full load hours for solar:			Time of Amortization in years for 20US$c/kWh at yearly mean wind speed of 6m/s
				5m/s	6m/s	7m/s	5m/s	6m/s	7m/s	
From 10	Container solution with 4 FlowGen wind turbines on two masts, 40kWp solar, battery storage and integrated backup system as key ready solution including controlling and monitoring data system – *market-based cost reduction through scaling*	165.000US$	40kW wind 40kWp solar	94.240	121.032	145.920	10.4	8.1	6.7	7.2

[1] Confirmation of data will be made by GPS-data of project location with satellite data and CFD analyses. Percentage adaption for different Weibull distributions.

7. FlowGen's Independent Mobile Green Energy Supply Center

ii. Components and features

FlowGen mobile energy solutions come ready to use in a 40ft-container setup, which includes the following components and features:

- 4 wind turbines with a rated power of 10kW each
- Powerful 30kW inverter per turbine set for small-grid installations - either as independent island system, but as well operational together with an existing island grid (e.g. from a diesel gen-set or other AC- or DC-power sources). Beyond the inverter always allows grid-parallel operation if desired.
- A 600V DC-Bus from the inverter is accessible for DC-coupling of battery-storages of different sizes or can be coupled to DC-fed speed inverters for water-pumps, compressors or other variable speed applications. By this a maximum efficiency is provided as ac/dc/ac - losses can be avoided
- The set further includes a ready to mount photovoltaic generator of scalable size - e.g. 40kW as a standard. The pv generator is dc-coupled and controlled by the wind turbine inverter for maximum energy efficiency.
- In cases where a high flexibility in power production is desired FlowGen can provide gen-sets powered by diesel or natural gas for backup in scalable sizes.
- The automation and control setup will always balance energy flows in the best possible way and harvest at maximum efficiency your natural resources.
- Besides local information via gauges, screens and a service-personnel app for remote control, the user may rely on the centralized services of the FlowGen data center, that gathers all additional information of the power system and allows predictive maintenance, hurricane protection by safe shut-down of the turbines and many other features which allows to permanently optimize the energy output of the installation.

The sets can be moved in standard containers to any location on the globe and set up for operation within short time to provide environmentally friendly produced energy at no grid cost wherever it is needed.

Example: FlowGen's Large-Scale Hybrid Micro Grid

i. FlowGen's Large Scale Micro Grid with 3MW from FlowGen wind turbines and 7.5MW solar panels

FlowGen Large Scale Micro Grid consisting of:

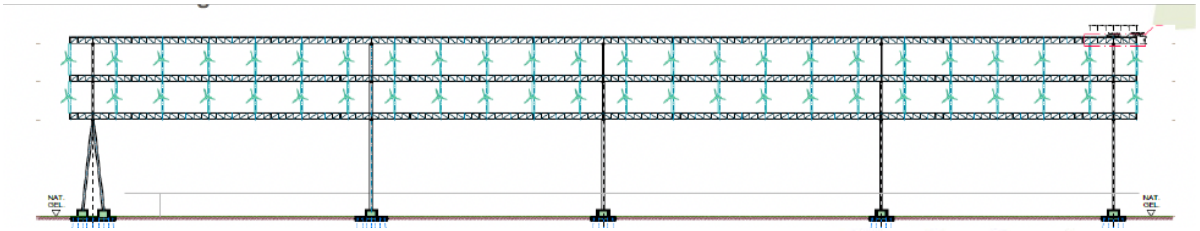
- 3MW from FlowGen wind turbines (300 units) in the FlowGen steel framework
- 7.5MW solar panels with an area of around 75.000m²

⟶ total capacity: 10.5MW

- Estimated Energy Output at 6m/s and 1200 full load hours for solar: 14.5GWh/year

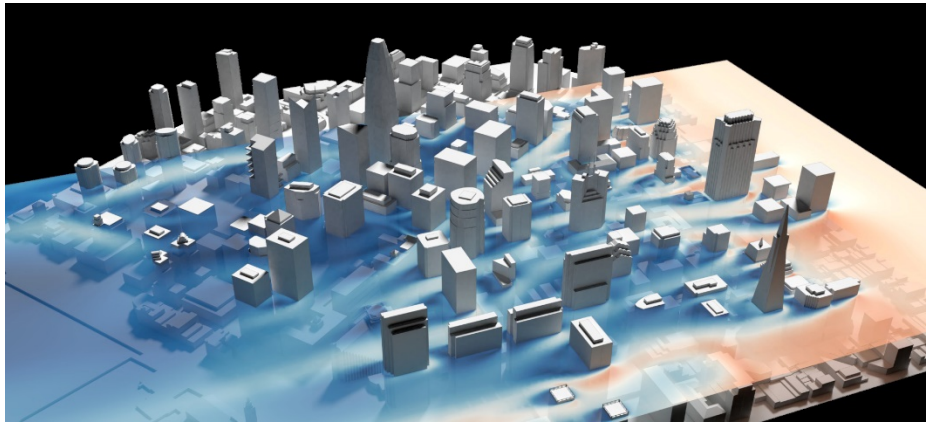
ii. Financial Aspects

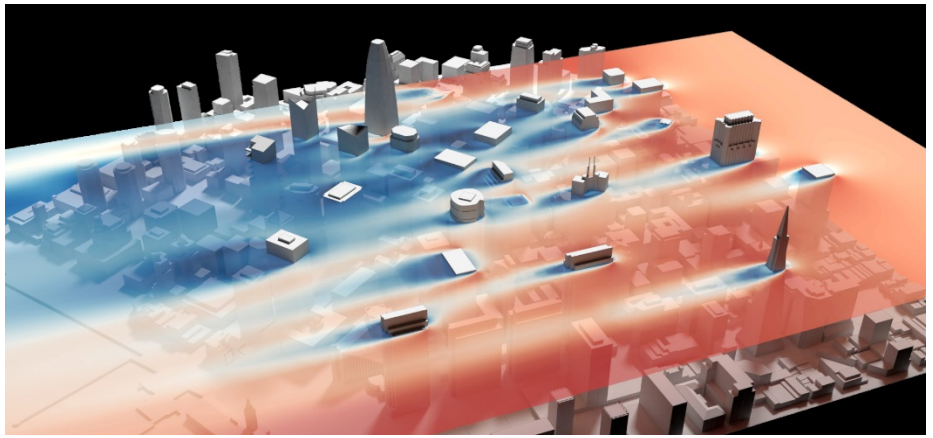
- Installed Costs: from 990US$/kW
- Levelized Costs of Electricity (LCOE): from 4.3US$c/kWh



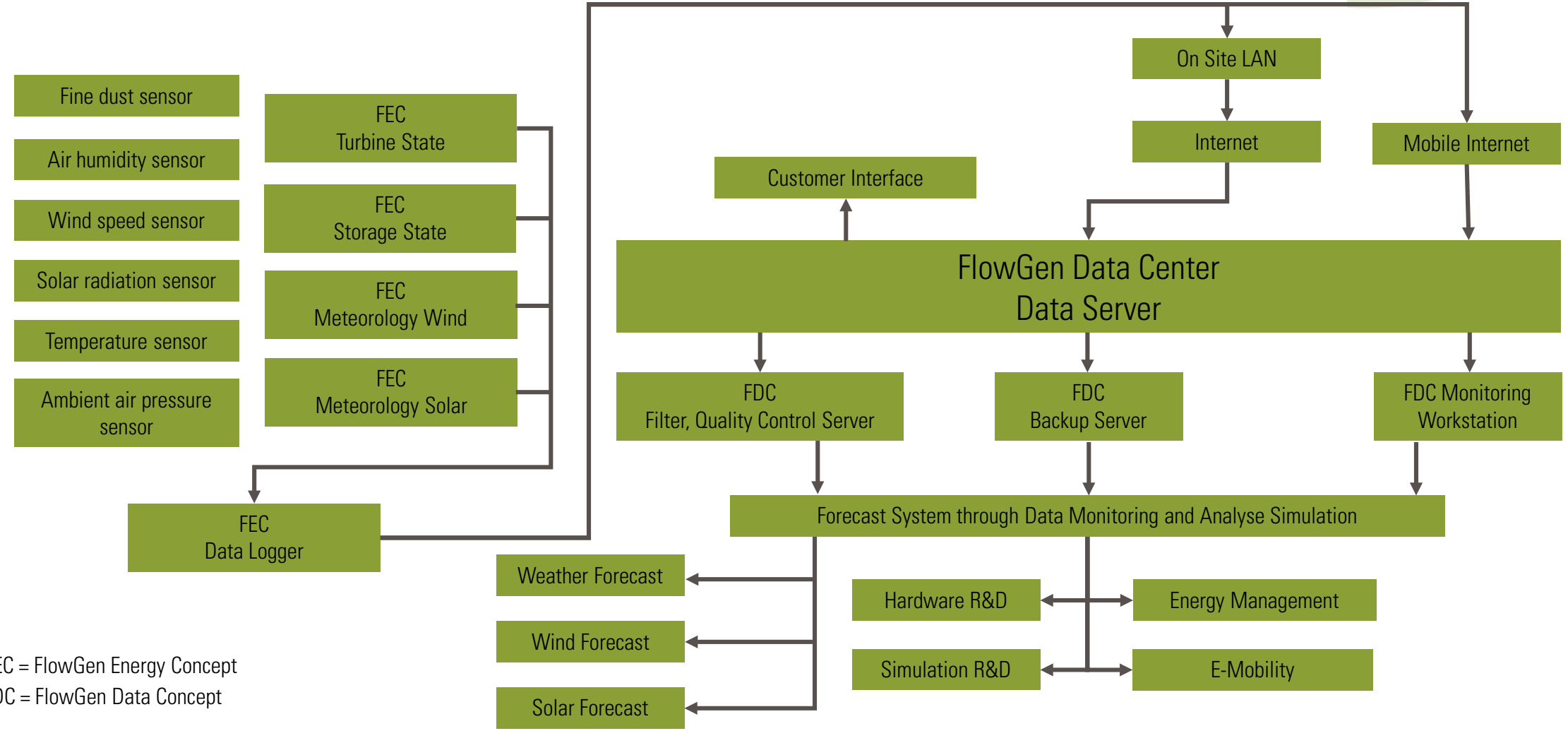
CFD – Location analysis service

- Customization through CFD (Computational Fluid Dynamics)
  - → we analyse the best locations in a certain area with the help of special and proven software as well as official satellite data.
- Enables to optimize the energy output and increase kWh through detailed analysis of surrounding and installations





FlowGen - Data & Data Monitoring with Forecast



FEC = FlowGen Energy Concept
FDC = FlowGen Data Concept

Local Content – We bring jobs

Delivery of Parts in Containers

Tools and Instructions for easy Assembling

Manpower

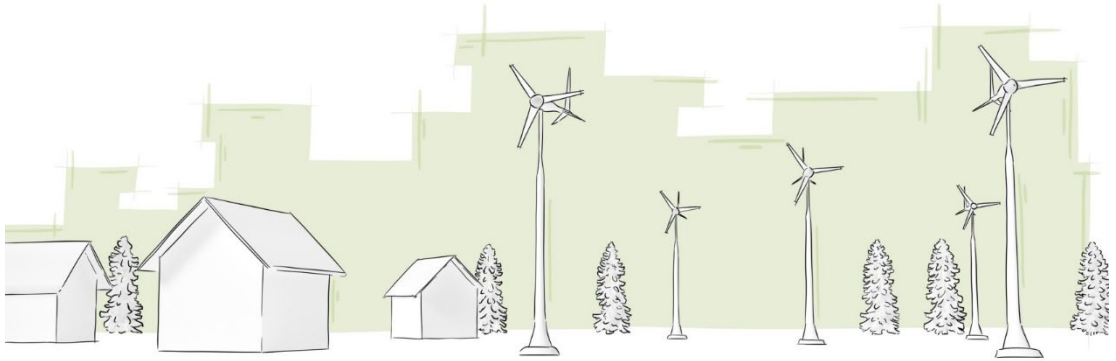
Completion

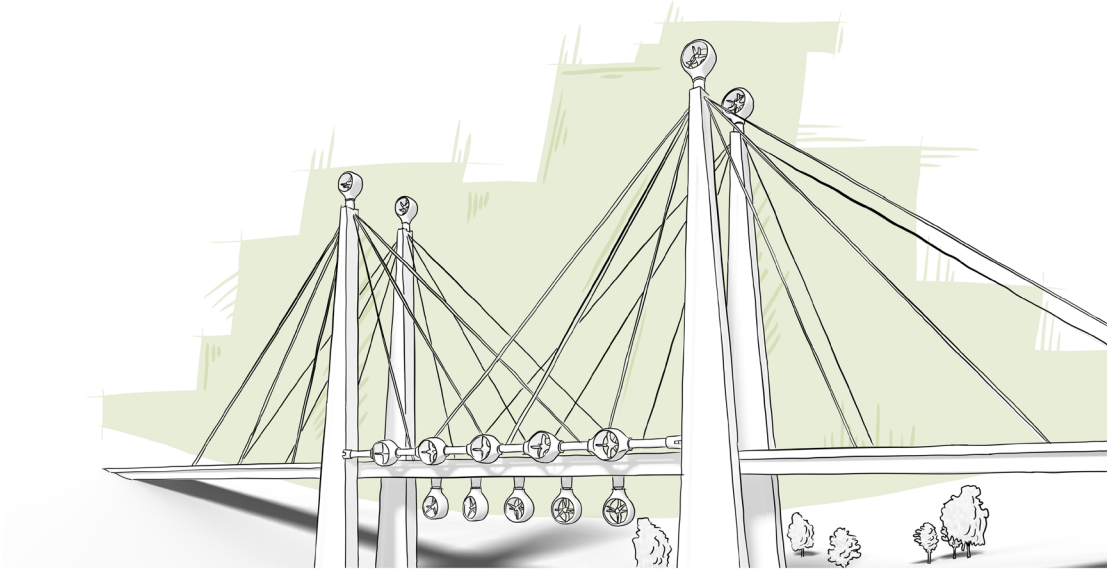
We bring jobs in the sectors assembling, installation and maintenance. Furthermore, there is the possibility to bring part production and we are happy to work together with regional companies for energy management, battery, solar and steel construction.

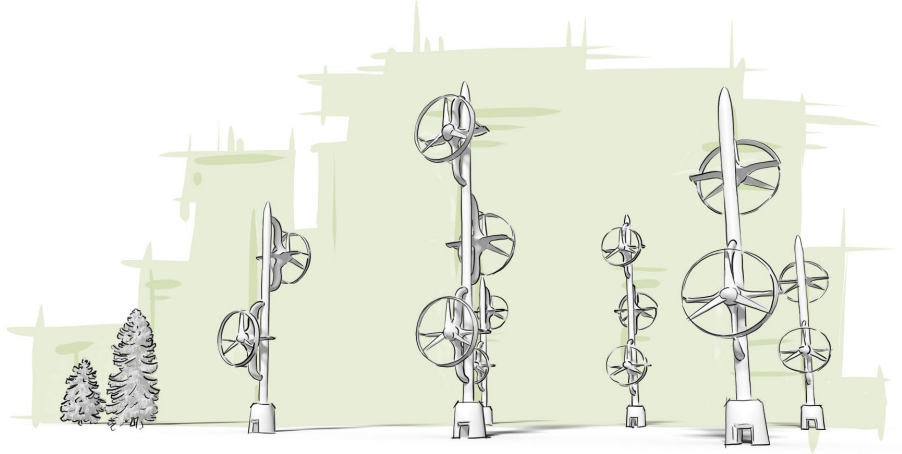
How do you benefit from a smart microgrid with FlowGen's system 2.0?

- FlowGen's wind turbines and solar are very complimentry
  - Production of electricty where it is consumed
- Storage
  - Complimented by battery solution addressing the needs of the users
- Microgrids are highly scalable
  - Managed through smart software
- Less dependency on expensive diesel generator, better use of roofs, existing and new infrastructure
  - Reduction of pollution
  - Reduction of CO_2 emission
  - No relevant noise
- Not dependent on grid or poor grid, but can be connected to the grid and even support the existing grid
  - Important for businesses and private households
- Substantial cost savings
  - therefore low payback period

Applications in Urban and Rural Areas







Smart Energy Hub for Rural and Urban Areas

- The Smart Energy Hub with FlowGen wind turbines with integrated solar panels and battery storage according to customer needs with attractive cost setup
- Optional extension to charging station
- Scalable in the number of wind turbines, solar panels and battery storage according to customer requirements

Hybrid Application for Rural and Urban Areas

Combination of FlowGen wind turbines with solar panels as perfect symbiosis.

Contact Details

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Appendix

- Windtest Grevenbroich GmbH's official results

windtest grevenbroich gmbh

To:	FlowGen - Dirk Küster	Date:	2019-03-11
From:	windtest grevenbroich gmbh		
	Marvin Sotomayor	Project no.:	LK19004

Results of a blower test on the Flowgen FND1 Prototype in Grevenbroich

The following graphs and table show the measured results for the FlowGen FND1 prototype small wind turbine with a rotor diameter of 4.94 m. The test was performed on the 6th of March 2019. The measurement was not performed under IEC conditions but a site calibration was performed. In the power measurement the self consumption of inverter and brake are taken into account.

Table 1: Results of power performance - statistical values

Wind Speed	Air Density	Wind Power	Power Output	Power Output	Power Output	cp
10 min mean	10 min mean	10 min mean	10 min mean	10 min min	10 min max	10 min mean
[m/s]	[kg/m³]	[W]	[W]	[W]	[W]	[%]
4.52	1.21	1070	437	-66	823	41
5.21	1.21	1639	688	197	1035	42
5.84	1.21	2308	1187	389	1756	51
6.77	1.21	3596	2157	1269	2827	60
8.00	1.21	5934	3726	2007	4825	63

M. Sotomayor

B. Eng. Marvin Sotomayor
Project Manager
Loads / Power Performance

Grevenbroich, 2019-03-11

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Steuer-Nr. / Tax-ID. 114/5860/4068

DAkkS Deutsche Akkreditierungsstelle D-PL-11233-01-00

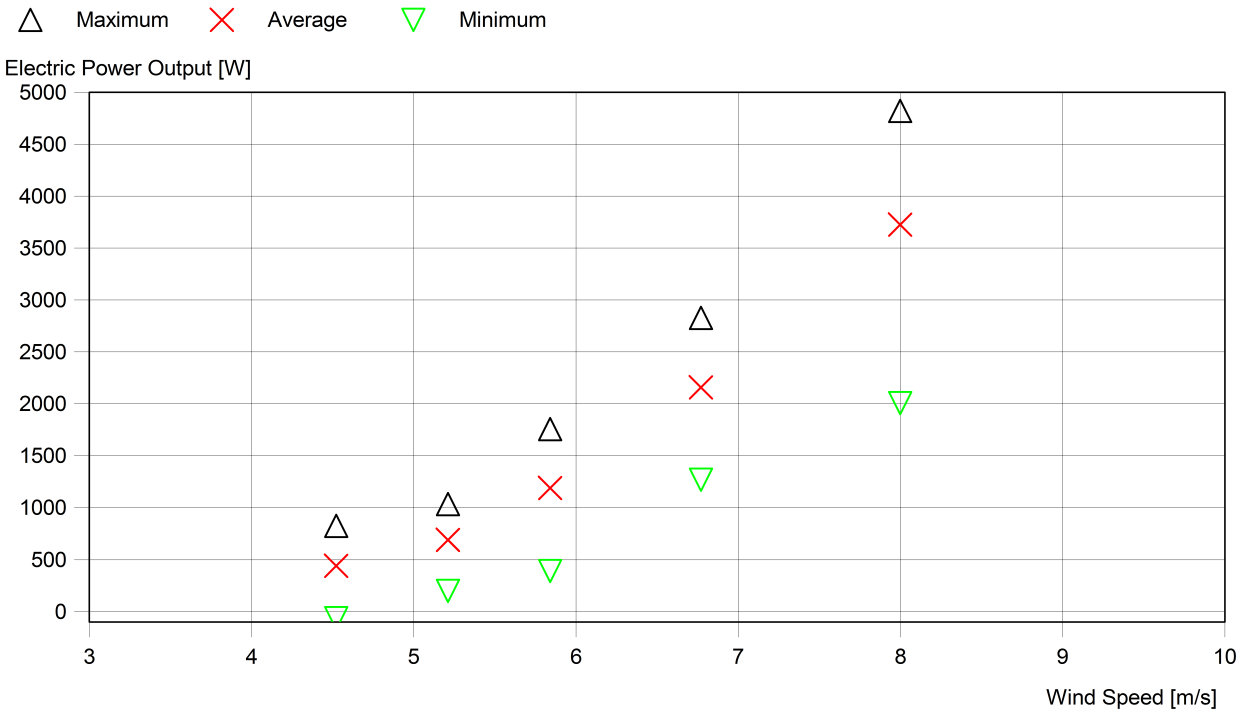

Figure 1: Results of power performance - statistical values

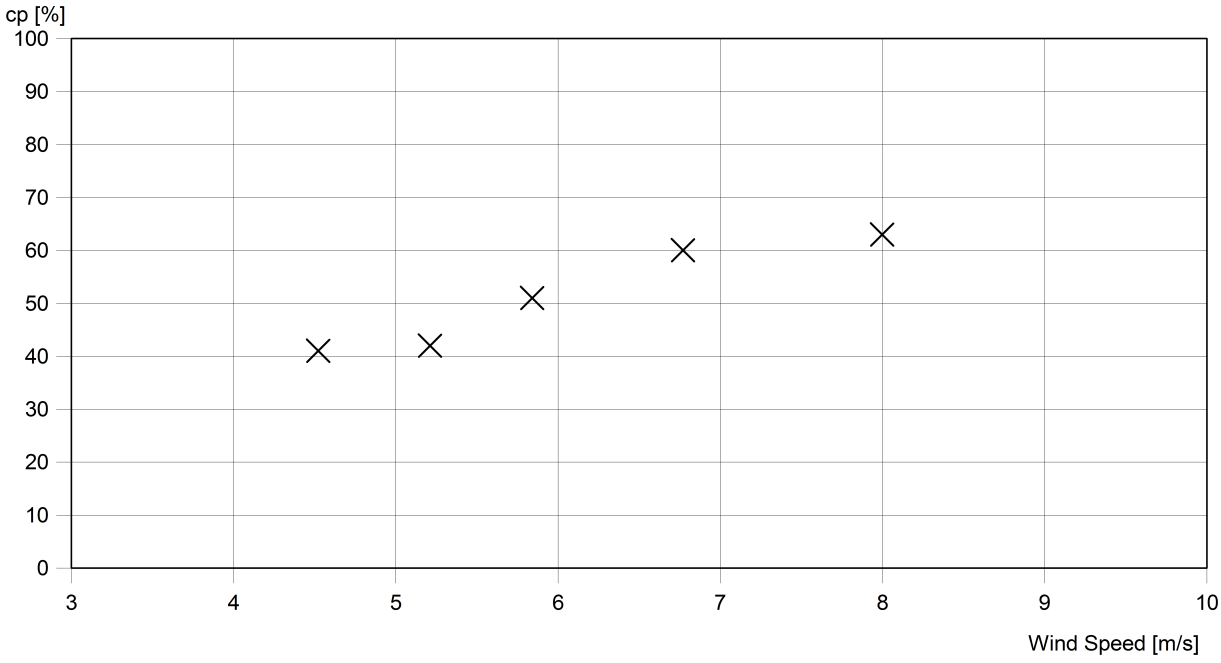

Figure 2: Results of power performance - cp

windtest grevenbroich gmbh

To:	FlowGen - Dirk Küster	Date:	2019-03-11
From:	windtest grevenbroich gmbh		
	Marvin Sotomayor	Project no.:	BM18002

Results of a blower test on the Flowgen Prototype 1 with duct in Grevenbroich

The following graphs and table show the measured results for the FlowGen prototype 1 with duct small wind turbine with a rotor diameter of 3 m. The test was performed on the 17th of September 2018. The measurement was not performed under IEC conditions but a site calibration was performed. The reason for the high cp values is that the calculation used for the cp value is actually not designed for turbines with a diffusor. For this evaluation instead of the electric power output the mechanical power derived from shaft torque and rotational speed was taken into account.

Table 1: Results of power performance - statistical values

Wind Speed	Air Density	Wind Power	Mechanical Power	Mechanical Power	Mechanical Power	cp
10 min mean	10 min mean	10 min mean	10 min mean	10 min min	10 min max	10 min mean
[m/s]	[kg/m³]	[W]	[W]	[W]	[W]	[%]
6.87	1.30	1489	698	480	943	47
7.03	1.29	1583	966	637	1248	61
7.43	1.29	1869	1009	639	1316	54
8.56	1.29	2858	2017	1562	2412	71
8.27	1.29	2577	2011	1172	2527	78
8.32	1.30	2644	2046	1085	2695	77
9.33	1.30	3730	2768	1874	3497	74
9.01	1.30	3359	2918	2334	3577	87
9.46	1.29	2858	2835	1715	3611	73
9.11	1.29	2445	2663	1858	3301	77

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Steuer-Nr. / Tax-ID. 114/5860/4068

DAkkS Deutsche Akkreditierungsstelle D-PL-11233-01-00

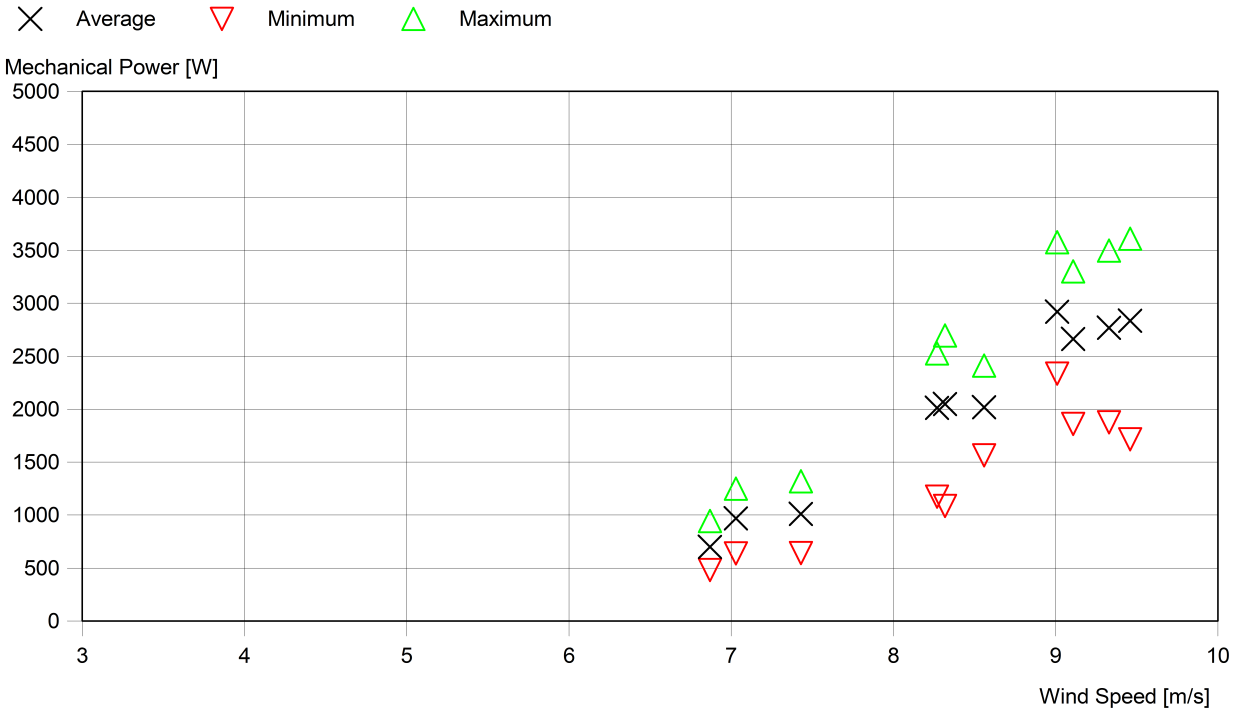

Figure 1: Results of power performance - statistical values

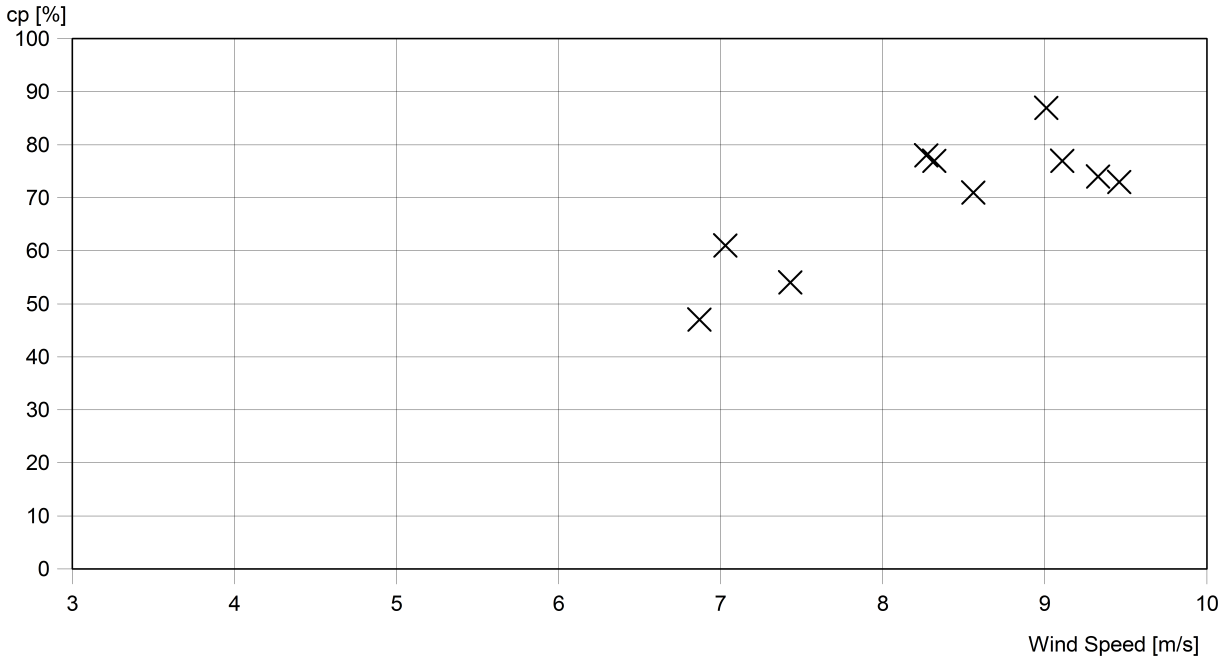

Figure 2: Results of power performance - cp

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