COST WIRE and CITIES WORKSHOP, Weather Intelligence for Renewable Urban Areas

DATES: 2nd – 3rd June 2014

VENUE: Niels Bohr Auditorium, Technical University of Denmark (DTU), Risø Campus, ROSKILDE, DENMARK

Meteorological modelling for urban area management, planning distributed power plants, renewable energy forecasting, and energy efficiency

Key words: Urban areas, Smart cities, Smart grids

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This workshop is proposed to gather scientist within the community of the COST Action ES1002 WIRE (www.wire1002.ch) to discuss progresses of the urban area meteorology aiming at the well-functioning of a town with the main emphasis on the energy system.

The Workshop is organized in collaboration to the Smart Cities project *CITIES* - Centre for IT-intelligent Energy Systems in Cities, http://smart-cities-centre.org which is coordinated by DTU and funded by the Danish Science Foundation.

Workshop programme

MONDAY 2nd JUNE

12:00 Lunch & Registration

13:30-13:50

Alain Heimo and Anna Maria Sempreviva ***Welcome and Introduction to the Workshop***

George Kariniotakis ***Introduction to the brainstorming session on 3rd June***

13:50 – 18:00

- Measuring and modelling Key Performance Indicators (KPIs) for an effective Urban Control Center (UCC)
- Best practice of intensive and monitoring campaigns in urban areas from surface and ground-based and space-born remote sensing. (Wind, solar, Temperature, aerosol content, precipitation etc.)

13:50 – 15:00	**Chair: Anna Maria Sempreviva**
13:50 – 14:10 **Henrik Madsen**	*Intelligent energy systems in CITIES and solar power forecasting*.
14:10 – 14:30 **Sue Grimmond**	*Observing London: enough data to use for intelligent decisions about renewable energy?*
14:30 – 14:50 **Vincent Lonij**	*Chasing the sun: forecasting energy demand & solar power*.

10-Minute discussion

15:00-15:30	**Coffee break**
15:30-17:10	**Chair: Henrik Madsen**
15:30 – 15:50 **Martin Piringer**	*Boundary Layer in Urban Areas*.
15:50 – 16:10 **Andreas Kazantzidis**	*Estimating solar radiation via Sky Imager*.
16:10 – 16:30 **Wilfred Walsh**	*Solar radiation programme in Singapore*.
16:30 – 16:50 **Holger Ruf**	*Calculate electrical values of distribution grid with high PV shares using satellite and GIS data.*

10-Minute discussion
10-Minute “walk and talk” discussion

17:10- 17:50	**Chair: Gregor Giebel**
17:10 – 17:20 **Andrea Hahmann**	*Model databases at DTU Wind Energy, for urban area research*.
17:20 – 17:30 **Sven Erik Gryning**	*Regional-scale urban fluxes and mixed-layer height: towards a meteorological pre- processor for inhomogeneous terrain*.
17:30 – 17:40 **Enrico Ferrero**	*Urban Turbulence Project: a field meteorological campaign in the city of Turin (Italy)*.
17:40 – 17:50 **Kristian Pagh Nielsen**	*Advanced solar resource assessment and forecasting*.

17:50- 18:00 Discussion

TUESDAY 3RD JUNE

08:30 – 12:30

- ❖ Meteorology and Climatology for the strategic planning of urban areas development including planning storage capacity
- ❖ Weather and climate forecasting at different space and time scales for renewable energy production from distributed power plants and storage charge and discharge cycles
- ❖ Meteorology and climatology modelling for energy efficiency control systems and load forecast

08:30-09:40	**Chair: Sven-Erik Gryning**
08:30 – 08:50 **George Kariniotakis**	*NICE GRID/GRID4EU large-scale demonstration project on smart grids in urban areas and the role of forecasting*.
08:50 – 09:10 **Dario Ronzio**	*Operational short-term forecasting system for solar power plants.*
09:10 – 09:30 **Mattia Marinelli**	*Testing of a predictive control strategy for balancing renewable sources in a micro grid.*
10-Minute discussion	

09:40 – 10:10 Coffee Break, Group Picture

10:10-11:25	**Chair: George Kariniotakis**
10:10 – 10:30 **Alberto Troccoli**	*Urban solar irradiance and power prediction in Canberra*
10:30 – 10:50 **Daniel Robert Drew**	*Using observations from the actual (advanced climate technology: urban atmospheric laboratory) project to develop tools to optimise urban renewable energy generation*.
10:50 – 11:10 **Andreas Bechmann**	*Modelling of urban wind resources – from a wind atlas perspective.*
10-Minute questions 10-Minute walk and talk	

11:30 – 12:10 **Chair: Alain Heimo**

11:30 – 11:40 **Selahattin Incecik** *The wind power resource assessments in urban and semi-rural area. Istanbul area*

11:40 – 11:50 **Jaroslav Resler** *Fine resolution modelling of meteorological conditions and air quality in urbanized areas.*

11:50 – 12:00 **Ekatarzyna Starosta** *Meteorology in urban areas with an emphasis on modelling scattered renewable energy sources in cities*

10-Minute discussion

12:10 – 12:30 **Chair: George Kariniotakis**

Input from the walk and talk sessions?

Sum up and introduction to the afternoon session

12:30 -13:30 Lunch

13:30 – 16:00 Afternoon Session **Chairs: George Kariniotakis and Anna Maria Sempreviva**

Brainstorming to discuss the current Technology Readiness Levels (TRLs) of the enabling and converging technologies

As a result of the meeting we plan to obtain

- A list of R&D priorities (short-medium-long term) for the area.
- A list of identified topics critical for urban areas (i.e. measurements, Urban Control Center technology, remote sensing, weather forecasting, climate forecasting, application forecasting etc.)
- To assign a TRL to each topic reflecting the state of the art and foresight a TRL advancement in the next years.
- A committee for a short position paper on the workshop topics.

ACCOMODATIONS

There are few hotels in Roskilde, we recommend

- Hotel Prindsen: www.hotelprindsen.dk
- Hotel Scandic: http://www.scandichotels.dk/
- DANhostel: http://www.danhostel.dk/hostel/danhostel-roskilde. Basic accommodation located at the Roskilde harbor
- Hotel Sofryd: http://www.hotel-sofryd.dk/. The hotel is located north of Roskilde but well connected to DTU and Copenhagen via bus 600S

Special conditions:

We have pre booked 10 rooms at the Prindsen Hotel (835 DKK, around 112 EURO per night).

Reservation should be made latest May 26th 2014. Booking ID: 1901491.

TRANSPORTATION

Please follow the link to the trip planner http://www.rejseplanen.dk/bin/query.exe/en

From: Copenhagen Airport

To: Frederiksborgvej 399, Himmelev, 4000 Roskilde, Roskilde (DTU, Risoe campus, in Roskilde)

In general the trip from the airport to Roskilde takes about 75 minutes. There is a direct train every hour at h: 39. Otherwise one must change at Copenhagen Central Station, direction Roskilde: usually the trains are starting from track 7/8.

In Roskilde there is the bus 600S, just outside the station on the left, which drives to DTU

Further information can be found at

http://www.dtu.dk/english/About/Practical-information/Directions/DTU-Risoe-Campus

1. INTRODUCTION TO THE WORKSHOP

Anna Maria Sempreviva
Technical University of Denmark, Wind Energy Department, Risø Campus, Denmark

This workshop is organised to discuss the progress of the urban area meteorology finalized to the well-functioning of a town regarding the energy system point of view; and to identify and reach a consensus on critical issues to be addressed in the meteorological modelling of renewable distributed power sources in towns.

The interest is based on the following arguments:
• Urban meteorology is a field that has been developed mostly for investigating environmental issues i.e. air quality; there are models/methodologies already developed which need to be adapted / applied to the energy sector.
• The "urban energy" field is relatively new. However there are several Smart Cities projects started in Europe that focus on renewable energy forecast research. Therefore, the current state of research needs to be surveyed.
• The development of models/methodologies requires measurements of meteorological variables for data assimilation / validation and data concerning energy production from existing power units and information on consumption patterns.
• The town system has different components: city, urban area, semi-urban area and rural, each with its characteristics to be taken into account which adds to the modelling complexity.

The following research areas are identified:
• Methodologies for providing meteorological Key Performance Indicators (KPIs) useful for a well-functioning urban management based on e.g. wind speed and direction, temperature, horizontal temperature difference, relative humidity, aerosols content for solar radiation, precipitation etc.)
• Tools for strategic planning of urban area energy networks: addressing the strategic directional development of the urban area with renewable plants (solar, wind, hydro, etc. integrated in the town structure while at the same time considering energy efficiency, demand side management and evolution of other energy infrastructures (e.g. gas network, heating etc.).
• Algorithms for forecasting distributed power plants production aimed at the integration of renewable production in the urban area energy system and storage capacity strategies.

At present, photovoltaic roof-mounted solutions are preferred for densely populated areas; an open question is if and when the urban wind energy will come to age.

2. REGIONAL-SCALE URBAN FLUXES AND MIXED-LAYER HEIGHT: TOWARDS A METEOROLOGICAL PRE-PROCESSOR FOR INHOMOGENEOUS TERRAIN.

Sven-Erik Gryning[1] and Ekaterina Batchvarova.[2]
[1] *Technical University of Denmark, Wind Energy Department*
[2] *National Institute of Meteorology and Hydrology, Bulgaria*

The distribution of mixed-layer height, sensible heat and momentum fluxes are critical factors in the dilution and spread of air pollutants and heat as well as the creation and maintenance of the urban heat island. In meso-scale models, the individual horizontal grid cells often enclose regions of pronounced inhomogeneities, while the incorporated parametrizations represents homogeneous areas. The estimation of the regional/aggregated mixed-layer height, momentum and sensible heat fluxes is therefore a central issue for those parametrizations and thus for the heat balance and spatial variability of the temperature in an urban area.
Here, we present a pre-processor for heat and momentum fluxes, which accounts for the inhomogeneties in the surface roughness and temperature within a spatial scale of the size of a typical grid cell (typical urban neighbourhood scale).

3. INTELLIGENT ENERGY SYSTEMS IN CITIES AND SOLAR POWER FORECASTING

Henrik Madsen, Niahm O'Connell, Peder Bacher
Department of Applied Mathematics and Computer Science (DTU Compute), Technical University of Denmark, Lyngby Campus, Denmark

Ambitious renewable energy targets in Denmark have sparked a flurry of energy research activity focusing on individual areas as diverse as: smart (electricity) grids, low temperature district heating, and the use of heat pumps for residential and industrial heat supply. However, without a holistic approach, the substantial energy, emissions and cost savings achievable by integrating the electricity, heating, cooling, water and transport systems cannot be accessed, and a fully renewable energy system will be difficult to achieve. The required focus on energy systems integration calls for advanced and intelligent data- and forecast-oriented solutions, and a broader view of the smart grids concept. With a large share of renewable power production in cities locally calibrated models and methods for forecasting become essential.
The central hypothesis of the new CITIES (Centre for IT-Intelligent Energy Systems in Cities) is that by intelligently integrating currently distinct energy flows (heat, power, gas and biomass) in urban environments, and by enabling methods for joint forecasting of production (mostly solar power) and load, we can enable very large shares of renewables, and consequently obtain substantial reductions in CO2 emissions. Intelligent integration will enable lossless 'virtual' storage solutions on a number of time scales. Such solutions are crucial to balance fluctuating power and energy production in areas with large amounts of fluctuating energy production.
The CITIES research centre, is established as a joint effort between the Technical University of Denmark and Aalborg University (Denmark) and a large variety of Danish and international academicals and industrial partners. Within this centre, we aim to tackle the challenges of energy system integration in the urban environment with a focus on forecasting, optimization and control. A flexible modelling approach will be exercised throughout our work, ensuring the ability to scale both in time and space, from forecasting the response of individual buildings to a price incentive, to simulating the response of the entire energy system to key policy decisions. New methods related to energy informatics will be established to match the challenges of managing and optimally employing the vast amount of data generated within an intelligent city environment. In this talk the CITIES project will be described, and as important example, methods for adaptive forecasting of local solar power production will be outlined.

4. MODELLING OF URBAN WIND RESOURCES – FROM A WIND ATLAS PERSPECTIVE

Andreas Bechmann
Technical University of Denmark, Wind Energy Department, Risø Campus, Roskilde, Denmark

The accurate prediction of wind speed and wind direction is essential to calculate the electricity output of any type of wind turbine. The Wind Atlas methodology, used by most professional developers, predicts the average wind speed at one location based on a measured climatological wind frequency distributions at another. That is, if one knows the wind resource at one position the method can be used to estimate the wind resource at another.
The Wind Atlas approach relies on flow models for the correction of measured wind data due to changes of roughness, orography and buildings and assumes that winds at the two locations are governed by the same large-scale forcing. In practice this means that the distance over which the method can be applied depend on the scales of the overall climate and of the scales introduced by surface inhomogeneity (roughness, hills and buildings).
Based on the Wind Atlas methodology, the present work will first give a fundamental description of how wind measurements and flow models are interconnected when estimating wind resources. Afterwards, some fundamental problems and challenges about modelling of wind resources in urban areas will be discussed.

5. USING OBSERVATIONS FROM THE ACTUAL (ADVANCED CLIMATE TECHNOLOGY: URBAN ATMOSPHERIC LABORATORY) PROJECT TO DEVELOP TOOLS TO OPTIMISE URBAN RENEWABLE ENERGY GENERATION

Daniel Robert Drew and Janet Barlow
Department of Meteorology, University of Reading, UK

The ACTUAL (Advanced Climate Technology: Urban Atmospheric Laboratory) project began in 2009 with the aim of providing robust, representative climate data for London, UK, which could be used to explore three interlinked research strands:

- Improving urban climate simulation
- Assessing the effect of building layout on city ventilation
- Developing tools to optimise urban renewable energy generation

A wide range of observations have been made to investigate the urban climate at various scales: from instruments located in and around a building studying air movement and building ventilation through to a sonic anemometer located on top of London's BT Tower (190 m), surveying the city at large. The work was also supported by wind tunnel experiments in the University of Surrey's EnFlo laboratory and the Department of Meteorology wind tunnel at the University of Reading.

Data collected throughout the project which highlight the nature of the winds in London both within and above the urban canopy will be discussed, including the characteristics of the turbulence and mean wind speed profiles derived from Doppler lidar observations. In addition, this presentation will outline how the data has been used to develop a new method for assessing the long-term mean wind speed across urban areas on a neighbourhood scale. The application of this model for optimising the placement of small wind turbines in urban areas will then be discussed, using Greater London as a case study.

6. OBSERVING LONDON: ENOUGH DATA TO USE FOR INTELLIGENT DECISIONS ABOUT RENEWABLE ENERGY?

Sue Grimmond
Department of Meteorology, University of Reading, UK

Urban areas are obvious places to try to enhance the use of renewable energy as there is high energy usage and short distribution distances for any surplus. However, urban areas also present numerous challenges for the prediction and provision of such energy. These include the horizontal and vertical variability of the urban form, which results in variability in meteorological variables over short distances. Urban materials and their variability, both spatially and through time, complicate this further. Additional complications relate to the sparsity of data and the representative of data that have been collected. In this talk, London will be used as a backdrop to consider these issues of: scale, quantity and quality of data, and consider current understanding and important gaps.

7. THE WIND POWER RESOURCE ASSESSMENTS IN URBAN AND SEMI RURAL ATMOSPHERES BY WRF: A CASE STUDY FOR ISTANBUL AND CATALCA PROVINCE OF ISTANBUL, TURKEY

S.Mentes, E.Tan, Y.S.Unal., S.Incecik, B.Barutcu, S.Topcu
Istanbul Technical University, Istanbul, Turkey

We present an attempt to emphasize urban atmosphere effects by comparing atmospheric variables of urban and rural cities, namely Istanbul and Catalca with high resolution modeling capabilities of the WRF model.

The deterministic WRF modeling system was configured to cover mega city Istanbul including Catalca which is a rural district in Istanbul with 1 km grid spacing. Istanbul connects Europe and Asia with an area of 5343km^2 and its population is about 15 million whereas Catalca is in East Thrace on the ridge between the Marmara and the Black Sea with its area of 1343 km^2 and about 81,000 inhabitants (about 37,000 in urban and 64000 in rural).

We evaluated the model performance by using the hourly data for the selected cases of the year of 2010 which are selected for capturing seasonal effects. For winter a frontal passage system and a case for a calm day are determined;

for spring as well a calm day and the day has a high instability are chosen; for summer a day which was under the effect of Azores High Pressure system is studied as well as a calm day case; and for fall similarly a calm day case is compared to the day which has an effect of cooling land.
The resulting estimates of the selected days of 2010 are compared with observational temperature and wind data in terms of root mean square error (RMSE) and normalized root mean square errors (nRMSE).
The model results were evaluated for 24, 48, and 72 hours and seasonally (spring, winter, summer, and fall respectively).

8. NICE GRID/GRID4EU LARGE-SCALE DEMONSTRATION PROJECT ON SMART GRIDS IN URBAN AREAS AND THE ROLE OF FORECASTING

George Kariniotakis
MINES ParisTech, Nice, France

"The NICE GRID" project is one of the 6 demonstration projects on smartgrids taking place under the 7th FP project GRID4EU. NICE GRID, which was attributed recently an ISGAN award of excellence finalist project among numerous smartgrid projects worldwide, is a large scale demonstration taking place in France at the urban area of Carros near the city of Nice. Its aim is to demonstrate advanced solutions for the massive integration of PV generation, the impact of active demand, microgrid functionalities like islanding.
Initially an area of 1500 clients is targeted with domestic and commercial loads, grid and roof PV installations, active demand solutions, deployed smartmeters, local storage at the level of houses as well as network connected storage (batteries from 30 kW upt to 1 MW). To manage the distribution network, a market-based solution is developped, where the different actors propose flexibilities to the DSO.
Short-term forecasting is of primary importance for the different operations. It focuses mainly on PV generation and on demand forecasting the demand based on smart meter data.
The presentation focuses on advances on PV forecasting and aims at showing the results, the particularities and the different constraints of the demostration context. The presentation is a starting point for further discussion on the gaps on forecasting in urban areas and future directions of research.".

9. THE PERSPECTIVE OF USING ALL- SKY CAMERAS IN URBAN AREA STUDIES

Andreas Kazantzidis
Laboratory of Atmospheric Physics, Physics Department, University of Patras, Greece

The spatial and temporal variability of atmospheric parameters like clouds and aerosols is a challenging issue on solar radiation measuring and forecasting. In recent years, algorithms based on sky images can provide sufficient information about the cloud coverage, velocity, type and optical depth, the aerosol optical properties, the reconstruction the three-dimensional nature of clouds, the real-time resource and short- time (0-30 min) forecast of solar radiation.
The presentation aims to provide a broad overview of the current (but rapidly evolving) state of the art in all-sky cameras applications in meteorology and solar energy forecasting and examine the perspectives of using all-sky cameras in urban heat area studies.

10. URBAN SOLAR IRRADIANCE AND POWER PREDICTION IN CANBERRA

Zihao Chen[1,2] and Alberto Troccoli[2]
1 UNSW, Canberra, Australia
2 Weather and Energy Research unit, CSIRO Canberra, Australia

Installations of solar photovoltaic (PV) panels are rapidly growing worldwide, mainly spurred by government incentives, increasing energy prices and reductions in the cost of solar power. Specifically for Australia, the latest estimates indicate about 2.5 GW in installed small scale PV power. With progressively lower PV production costs, growth in installations in the near future is projected to be even stronger: based on a moderate growth scenario the Australian Energy Market Operator (AEMO) estimated an installed capacity of 5 GW by 2020 and 12 GW by 2031. This prospect has raised a significant amount of concern in the electricity industry about how the electricity grid will cope with increasingly variable net energy flows operating over a network not designed for two–way operation. Prediction of solar radiation and PV-produced power at the residential and business level becomes therefore key to allowing a smoother integration of power into the electricity grid, especially into the distribution network. In this work, we use statistical models to predict solar radiation and solar power at a target site using observations from other two sites. Key to this work is the pilot urban observation network based around Canberra, which simultaneously monitors meteorological and electrical variables of co-located PV systems. Five stations are operating at present, and collect electrical variables such as current and voltage from which power is derived and meteorological variables such as global irradiance, both on horizontal and PV panel planes, PV panel temperature, air temperature, wind speed and direction, humidity, pressure and precipitation. All variables are logged every 1 second. However, in order to reduce the degrees of freedom of the prediction methods, 5-minute averages are considered here. We study the relevant importance of various atmospheric and electric predictors, and we assess the performance of the models under winter and summer conditions. In addition, by making use of the three solar radiation components at one of the stations, we are able to de-compose and subsequently re-compose the global radiation onto a generic PV plane and produce skillful power predictions.

11. CHASING THE SUN: FORECASTING ENERGY DEMAND & SOLAR POWER

Vincent Lonij
Exploratory Predictive Analytics Smarter Cities Technology Centre IBM Research, Ireland.

Accurate forecasting of energy demand and generation plays a key role for utility companies, network operators, and energy producers. These forecasts are utilized for unit commitment, market bidding, network operation and maintenance, integration of renewable energy sources, and for novel dynamic pricing mechanisms, e.g., demand response. In order to achieve accurate forecasts with high spatial and temporal resolution, data from various sources needs to be integrated: Smart meters, SCADA, weather forecasts, physical, statistical and geographical models.
In this talk I will give an overview of recent work within IBM Research on an intelligent large-scale energy demand forecasting solution that will provide forecasts at different aggregation levels, quantify uncertainty in demand, and estimate the amount of distributed renewable energy behind the meters. The solution has been validated with leading electric utility companies world-wide. I will also present recent work, performed at the University of Arizona that uses ground measurements of solar power to make hour-ahead forecasts of power production from photovoltaic systems in urban environments.

12. TESTING OF A PREDICTIVE CONTROL STRATEGY FOR BALANCING RENEWABLE SOURCES IN A MICROGRID

Mattia Marinelli
Technical University of Denmark, Risø campus, Roskilde, Denmark

This work presents the design of a control strategy for the energy management of a grid-connected micro grid with local distributed energy resources as: 10-kW photovoltaic plant, 11-kW wind turbine, and 15-kW–190-kWh vanadium-based electric storage system. According to future regulations, the renewable energy producers will also have to provide a day-ahead hourly production plan. The overall idea is, by knowing the meteorological forecasts for the next 24 h, to dispatch the micro grid in order to be able to grant the scheduled hourly production by means of proper management of the storage system. The usage of the storage system is, however, minimized by the energy management strategy. The system design is validated by experimental testing carried out in SYSLAB, a distributed power system test facility at Risø Campus, Technical University of Denmark.

13. BOUNDARY LAYER IN URBAN AREAS – SELECTED EXPERIMENTAL RESULTS

Martin Piringer
Central Institute for Meteorology and Geodynamics, Vienna, Austria

The urban boundary layer is more complex than the well-studied classical homogeneous atmospheric boundary layer due to disturbing features like buildings (introducing a large amount of vertical and impervious surfaces as well as artificial materials) and anthropogenic heat sources (traffic, domestic heating, industry). Specific features of urban boundary layers are e.g. the night-time urban heat island and local to regional modifications of flow regimes. Numerous theoretical, experimental and modeling studies exist tackling specific aspects of urban boundary layers. In many cities, the near-surface wind and temperature field can be strongly modified by the local topography. Results from field campaigns in the Austrian cities Graz and Linz will be presented, which often experience stagnations, leading to high local concentrations of primary pollutants. In these cities, wintertime air pollution episodes are mainly caused by high loads of particulate matter (PM10) and nitrogen dioxide. These occur predominantly in anticyclonic conditions, characterized by low near-surface temperatures and wind speeds and night-time inversions with low-level jets above the stagnant air pool. Increased domestic heating due to low temperatures can further increase pollution levels. A careful investigation of the causes of such episodes can help to better estimate peak energy and heating demands of cities.

14. FINE RESOLUTION MODELLING OF METEOROLOGICAL CONDITIONS AND AIR QUALITY IN URBANIZED AREAS

J. Resler[1,2], P. Jurus[1,2], K. Eben[1,2], J. Liczki[2], M. Belda[2,3], I.Kasanicky[2], E. Pelikan[1,2], J. Karel[4], R. Jares[4], O. Vlcek[5], N. Benesova[5] and M. Kazmukova[6]

[1] Faculty of Transportation Sciences, Czech Technical University, Prague, Czech Republic, [2] Institute of Computer Science, Academy of Sciences of CR, Prague, Czech Republic, [3] Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic, [4] ATEM - Studio of Ecological Models, Prague, Czech Republic, [5] Czech Hydrometeorological Institute, Prague, Czech Republic, [6] City Development Authority, Prague, Czech Republic

Both air quality and meteorological conditions constitute an important part of quality of life, particularly in urban areas where the impact is higher due to high population density. On the other hand, urban environment has a considerable influence on meteorology and air quality and any attempts to model pollutant concentrations and meteorological quantities should account for the effect of urbanization.

Traditionally, global and mesoscale Eulerian models do not have sufficient resolution to model urban areas. Considering the air quality, they are used mostly for the modelling of background concentrations and additional steps are required to model the urban environment, e. g. statistical post processing and downscaling. Similar situation is in meteorology where the effects of urban heat island are not well captured by generic numerical weather prediction models. The increase of computational power in recent years however allows a refinement of the resolution of the models to the order of hundreds of meters. New parameterizations of atmospheric processes suitable for high resolution simulations have been developed together with special models of effects of the urban surface. Thus urban modelling systems based on Eulerian meteorological and chemical transport models have arisen, with all advantages of this approach.

Our goal is to test the performance of a very detailed model (both in resolution and in description of its inputs) for the urban area by means of a long-term simulation, so as to capture the statistical behaviour of the model during different seasons of the year and different modes of weather. In particular, we investigated the effect of going down to very fine scale and the effect of urban meteorology parameterization on weather and air quality. The present study shows the results of one year simulation of a coupled meteorological and air quality model for the year 2010. The modelling system consists of the meteorological model WRF-ARW v.3.5.1 and the chemical transport model CMAQ v.5.0.1. The models are configured on five nested domains with horizontal resolutions 27km, 9km, 3km, 1km and 333m covering areas from Europe to Prague. Special data sets (land use, statistical characteristics of urban surface, etc.) have been prepared so that urban parameterizations of the WRF model uses could be used, especially the BEM (Building Energy Model). Also, detailed emission inventories including special models for transportation have been used.

As a reference, a simulation with a standard model configuration has been run. The two simulations, one with the model of urban surface BEM enabled and the other one without it, have been compared. The meteorological data (T2, wind speed, etc.) and air pollution concentrations (NO, NO2, O3, CO, NH3, PM10, PM25) were compared with observations. First results indicate a strong positive impact of the urban parameterizations on accuracy of wind speed modelling. In other variables the effect is not so pronounced and may differ according to the type of meteorological situation.

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15. OPERATIONAL SHORT-TERM FORECASTING SYSTEM FOR SOLAR POWER PLANTS

Dario Ronzio
Ricerca di Sistema Elettrico, RSE SPA, Milan, Italy

The huge increase of power plants using non-programmable renewable sources (RES) requires radical changes in the management of control systems, and of Medium Voltage and Low Voltage distribution networks, also as a result of technical-regulatory actions undertaken to ensure the safety of the entire electrical system.
In particular, the demand for more and more accurate forecasts of electric RES plant production has increased significantly in the recent years, and these forecasts are necessary both to provide input to control systems of Smart Grids to make them more efficient, and to try to reduce the costs of imbalance.
In RSE has been developed an operational forecasting system for solar power plants. The method is based on the outputs of a numerical weather prediction model – RAMS – in which the radiative transfer model has been modified in such a way that the direct and the diffuse component are both calculated directly.
Inasmuch as we are interested on short-term prediction, and the intrinsic stochastic behavior of the atmosphere system becomes dominant for prediction horizons longer than 9-12 hours, at least for some weather variables such as cloudiness, a statistical point of view is advisable and has been adopted.
More precisely, in RSE a system based on two different post-processing, the Analog Ensemble (AN) and the Neural Network have been implemented and tested for some PV power plants, both small (few kVA) and relevant (larger than 10MVA).
These two methods require power measurements, which must be carefully validated. Because the radiation measurements were not available for all plants, the validation have been performed estimating the power production by means of time series of surface global irradiation, retrieved using a statistical method based on satellite data (Meteosat Second Generation, using SAFNWC software to retrieve the local cloudiness typology). In such a way it is possible to validate measurements at the MSG horizontal resolution, just about 3kmx4.5km at the Italian latitudes.
The forecast errors for some solar power plants have been evaluated to define the optimal size of a storage system that might reduce the unbalancing of the network. The power predictions are currently used by the RSE Test Facility control system.

16. CALCULATE ELECTRICAL VALUES OF DISTRIBUTION GRID WITH HIGH PV SHARES USING SATELLITE AND GIS DATA

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Motivation. There was no need for real time monitoring in the low voltage distribution grid but this changed during the last years with the increasing amount of photovoltaic systems. Nowadays, more than 1.5 million photovoltaic systems are connected to the grid and over 85% are installed in the low voltage level. The responsibility for grid stability and power quality at this level rests on the distribution system operators (DSO). They have to plan, operate and maintain the grid in an economic way that ensures voltage band violations and overloading of grid elements do not occur.

Approach. The general approach is using remote sensing technologies for planning and operates electric distribution grids. The remote sensing techniques have a higher uncertainty than direct measurements but have also the possibility to integrate forecasting approaches. The presentation will give an overview over an approach to calculate the load flow at a low voltage distribution transformer using GIS and remote sensing technologies and gives an outlook to the challenges of calculate single feeders and possible improvements. The main idea is the usage of GIS data and solar potential analysis data to collect additional data of PV systems for modelling e.g. tilt, azimuth and shadowing influence. Furthermore, the irradiance data are provided by the MSG weather satellite. This respects the spatial distribution of the PV systems in the grid area. The necessary load data are provided by the local distribution grid operator. A real test site is the demonstration case in the background and a measurement at the transformers is for the validation available. These data sources are combined with a grid simulation to calculate the load flow at the low voltage grid transformer.

Results. Figure 1 shows the RMSE of the calculation of each month in the observation period from April 2011 to December 2012. The validation base is measurement values at the transformer in a test site close to Ulm.

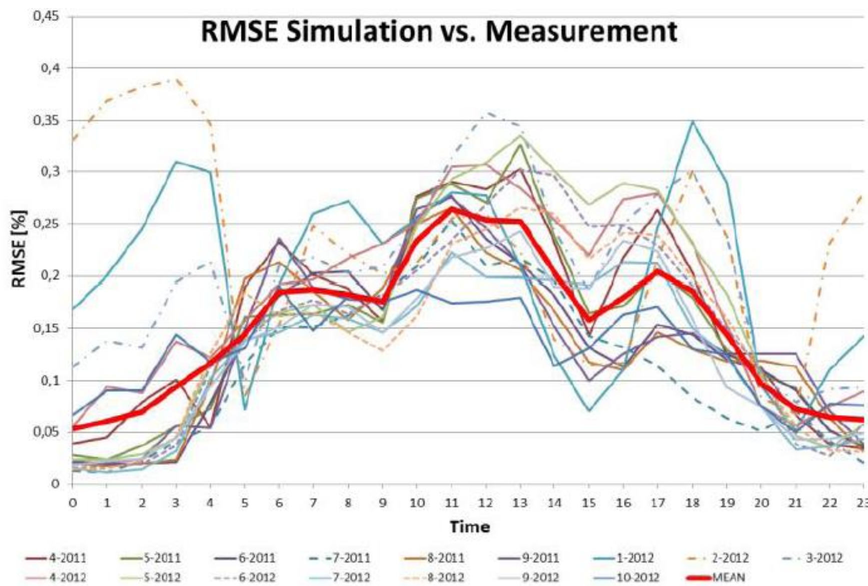

Figure 1: Root mean squared error between simulation and measurement of the load flows over the transformer in the test site.

17. SOLAR IRRADIANCE FORECASTING IN THE TROPICS - SINGAPORE AS A CASE STUDY

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In the long term, photovoltaics (PV) is predicted to contribute a significant fraction of the electrical power in countries located in tropical zones. In Singapore, up to 30% of current demand is expected to be met by PV systems. Tropical solar irradiance is subject to rapid time evolution: the resulting time variability of the PV electricity generation has implications for grid supply and management. To mitigate the effects of this variability, accurate forecasting is generally a more cost-effective component of a modern smart grid than, for example, energy storage systems. To this end, SERIS has embarked on a solar electricity forecasting system based on an island-wide grid of solar irradiance monitoring stations. Each station also designed to incorporate RF telemetry, allowing it to communicate with nearby rooftop PV systems. SERIS is also making a 3D model of the entire city-state to allow high-resolution shadowing analyses. A full electrical grid simulation is also underway. Combining these datasets with time series irradiance data from the monitoring stations allows short timescale forecasting of up to one hour. When combined with data from a representative sample of actual PV systems and the grid model, PV power can be forecast and the grid operator advised of likely future shortfalls in PV supply that need to be met with enhanced alternative generation. For medium and longer term forecasts we make use of sky imaging from ground-based and satellite images together with novel 2D forecasting algorithms. The numerical weather prediction software WRF is used to produce one to three day-ahead forecasts of irradiance in Singapore.

18. URBAN TURBULENCE PROJECT: A FIELD METEOROLOGICAL CAMPAIGN IN THE CITY OF TURIN (ITALY)

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One year of continuous wind and turbulence measurements at three levels (5, 9 and 25m) on a mast located in the suburb of the city of Turin were collected. The data were continuously collected (from January 18th 2007 to March 19th 2008) at the urban meteorological station of the Dipartimento di Fisica Generale at the University of Turin, in the southern outskirts of Turin, Italy (Lat.: 45◦ 1′ 4.00′′ N; Lon: 7◦ 38′ 34.21′′ E; 240 m a.s.l.). The site is characterized by a horizontal grassland surrounded by trees and high (30-35 m, approximately) buildings at a distance of about 300 m in the northern side, and smaller constructions (max 15 m high) in a range of about 200 m in the other directions. A 25 m mast is located at the center of the area. Standard measurements include soil temperature (at -5, -10, -15, -25, -35, -55 cm), dry and wet bulb temperature at screen height, air temperature at 5, 9 and 25 m height, relative humidity at 25 m height, wind speed and direction at 25 m height, global radiation, underground heat flux (at -8 and -15 cm). During the field campaign three sonic anemometers were installed on booms at 5 m, 9 m and 25 m height on the mast. They measured at a 21 Hz rate the u,v,w components of wind velocity and the temperature. KH20 krypton hygrometers were placed near each anemometer to measure humidity fluctuations. In the data-set both stable and unstable conditions are statistically well represented. The Turin area is characterized by low-wind conditions, and 80% of the wind speed data are less than 1.5 m/s.
The recorded data are analyzed and their main characteristics are presented and discussed with particular focus on the effect of the urban fabric and the low wind speed conditions on the turbulence. The results suggest that the usual parameterizations, developed for flat terrain and open country regions, cannot be used in the numerical models.

19. VALIDATION AND SENSITIVITY OF THE WRF NUMERICAL WIND ATLAS AND APPLICATIONS TO URBAN COASTAL AREAS RENEWABLE ENERGY INTEGRATION

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Coastal areas are the most populated regions in the world and the urbanization process is not likely to stop, however, it might be carefully planned. One of the major issues is to provide renewable energy to those developing areas for a sustainable development. Photovoltaic is the most used right now but the use of small wind turbine in semi-urbanized areas might come to age soon. To help the use of renewable energy, atlases for the major parameters needed for the well-functioning electrical system must be provided. Tools for strategic planning of urban area energy networks and for the renewable energy integration from distributed power plants include weather forecast models used in hindcast (for mapping) or forecast (for integration). There is a variety of processes that drive the climate of a coastal region: thermally driven jets, breezes, and strong synoptic-scale systems. The complex terrain in the interior also has a significant effect on the climatology. In particular, using models to simulate the mesoscale wind climatology of use for regional wind atlases is challenging. At DTU Wind, the WRF reanalysis method was used in the production of numerical wind atlases in several part of the world. Here, we present the in house numerical wind atlas methodology, were time-dependent simulations on region of interest are performed using the state-of-the-art WRF model. The resulting winds from these simulations are combined into a wind climatology. Local terrain, surface roughness, and land use effects are taken into account in

both the modeled and observed wind speeds, prior to validating the model wind climate against the observed wind climate. This allows us to identify the best WRF model configuration to be used and to explore the sensitivity of the wind climate to various aspects of the WRF configuration, including horizontal grid spacing.
As a case study, we present the project "The Wind Atlas for South Africa (WASA)" a 4-year project with the objective to develop and employ numerical wind atlas methods and develop capacity to enable planning of large-scale exploitation of wind power in South Africa. Results from the method are validated against 3 years of measurements from WASA's ten high-quality 62-meter masts.
This methodology can also be applied for studying the yearly spatial and temporal variability of parameters such as temperature and solar radiation, humidity precipitation of use for the planning and managing and integrate into the grid power from distributed.

20. ADVANCED SOLAR RESOURCE ASSESSMENT AND FORECASTING

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Advanced solar resource assessment and forecasting is necessary for optimal solar energy utilization.
This work will be done with the collaborators in the IEA SHC Task 46 expert group, and will be based on a focused analysis of both historic and new detailed measurements, and the newest theoretical models for modeling solar resources. A particular focus is to measure the directional distribution of radiance across the sky. For this purpose DTU have set up pyranometers that simultaneously monitor radiances from 16 directions of the sky. The direct and diffuse fractions of the solar irradiance are also studied. This work is aimed at improving Design Reference Years (DRY) datasets.
DMI investigates the quality of different types of numerical weather prediction (NWP) models with respect to forecasting potentially available solar energy in the coming two days. This is done both for Danish global radiation stations and for global radiation stations in the IEA SHC Task 46 member countries that are covered by the NWP models.

21. METEOROLOGY IN URBAN AREAS WITH AN EMPHASIS ON MODELING SCATTERED RENEWABLE ENERGY SOURCES IN CITIES

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The problems of climate change along with the local variability of the meteorological conditions in cities are very important for the development of urban areas. The detailed knowledge of meteorological conditions including these in cities is also an important factor for the growing industry of renewable energy.
The use of renewable energy sources in Poland increased significantly in the last few years, this includes tendency of the energy production in a close proximity to the end customers. Many small installations have been created in residential areas, farms and small businesses. In Warsaw, there have been several renewable energy investments. Many houses are using solar panels for insulation and to heat the building and hot water: for example the photovoltaic technology (PV) panels installed on the roof of a school in Wawer district, the billboards powered by solar panels and a small windmill on St. Boniface street in Warsaw. However the efficiency of the solar panels is low in the period from November to March, thus in Poland the main source of renewable energy is based on the wind. With the current progress in the production of micro-installations, the awareness of the public to the renewable energy development in the urban space becomes an important topic and opens potential directions for new research activities.
In our team, we are starting new studies on the meteorology in urban areas with an emphasis on the scattered renewable energy sources in cities. The meteorological analysis of the wind power potentials will be based on the IMGW_PIB network of meteorological data measurements (SYNOP, TEMP, radar data, satellite images) and data from numerical weather forecasting model COSMO (Consortium for Small-scale Modelling). An operational model COSMO, version 4.8, is run using two nested domains at horizontal resolutions of 7 km and 2.8 km with 78 hour and 36 hour

forecasts respectively. In Warsaw, several weather stations and a lidar measurements run at the universities, from which we can also access the data.

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