
UiA
University of Agder
Norway

The use of Windsim in urban sites Buildngs as Obstacles

Presented by

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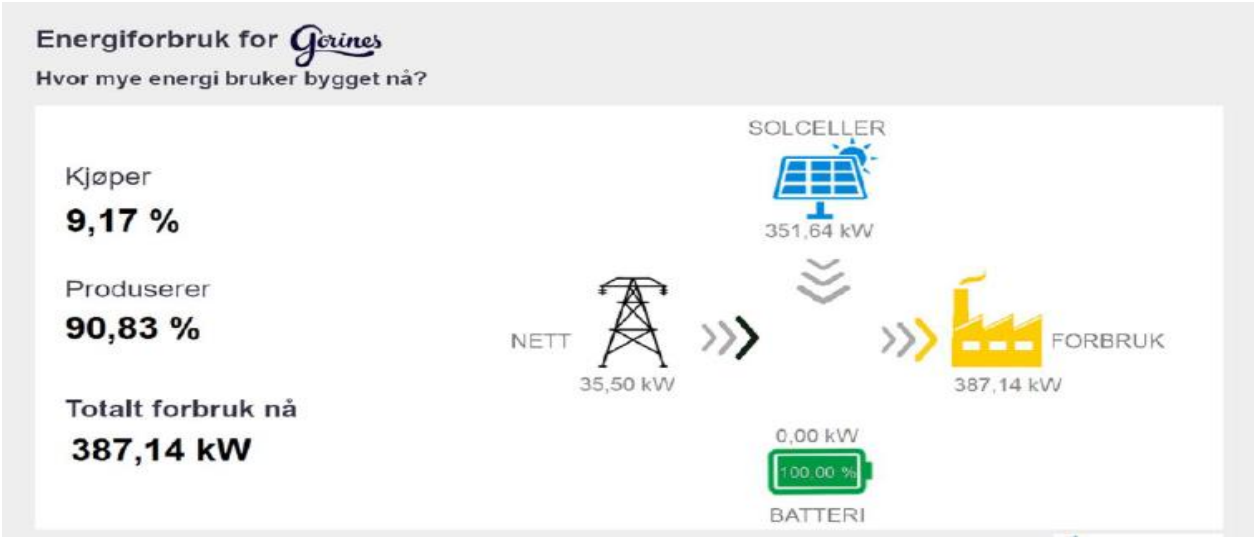
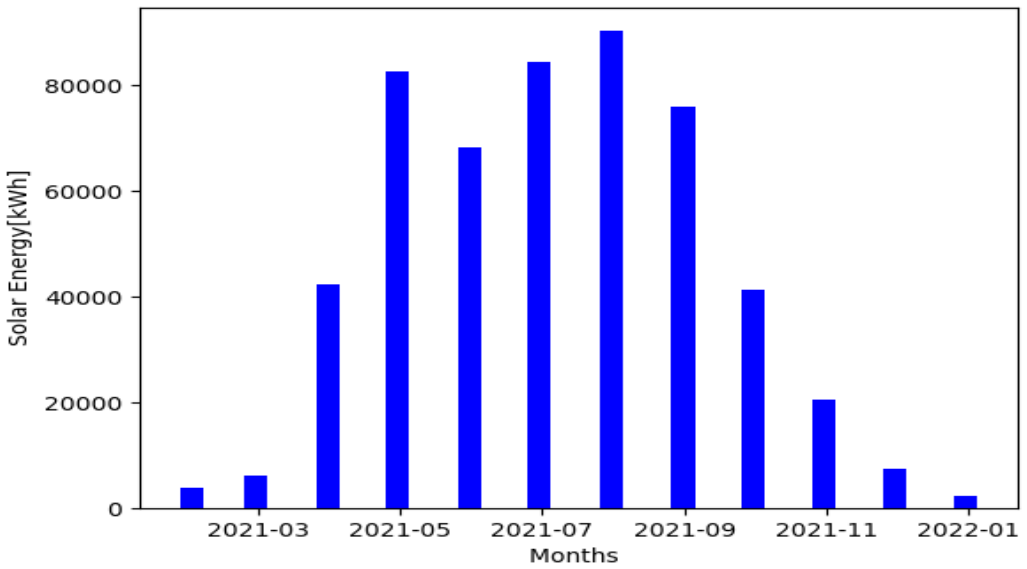
Study case (Location)

- Gorines has co-located at Kjerlingland in Lillesand municipality, in Agder county in the southern part of Norway
- Gorines has created a unique facility in terms of climate effects.

Study case (Energy consumption and production)

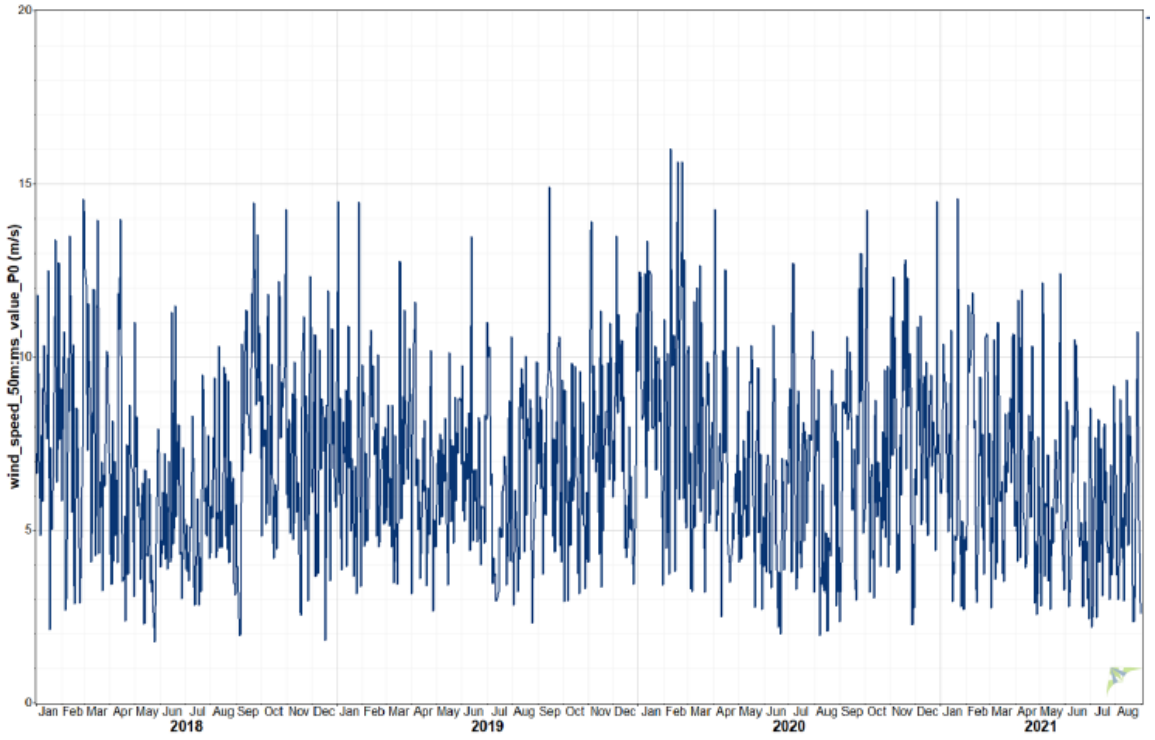
- Gorines` annual energy consumption exceeds 1000 MWh/yr
- Gorines has already installed a PV system cells on the rooftop with a capacity of 614 kW .
- Gorines is also equipped with a battery bank of 350 kWh, and 15 energy wells.
- The current annual solar cells and thermal production is around 500 MWh

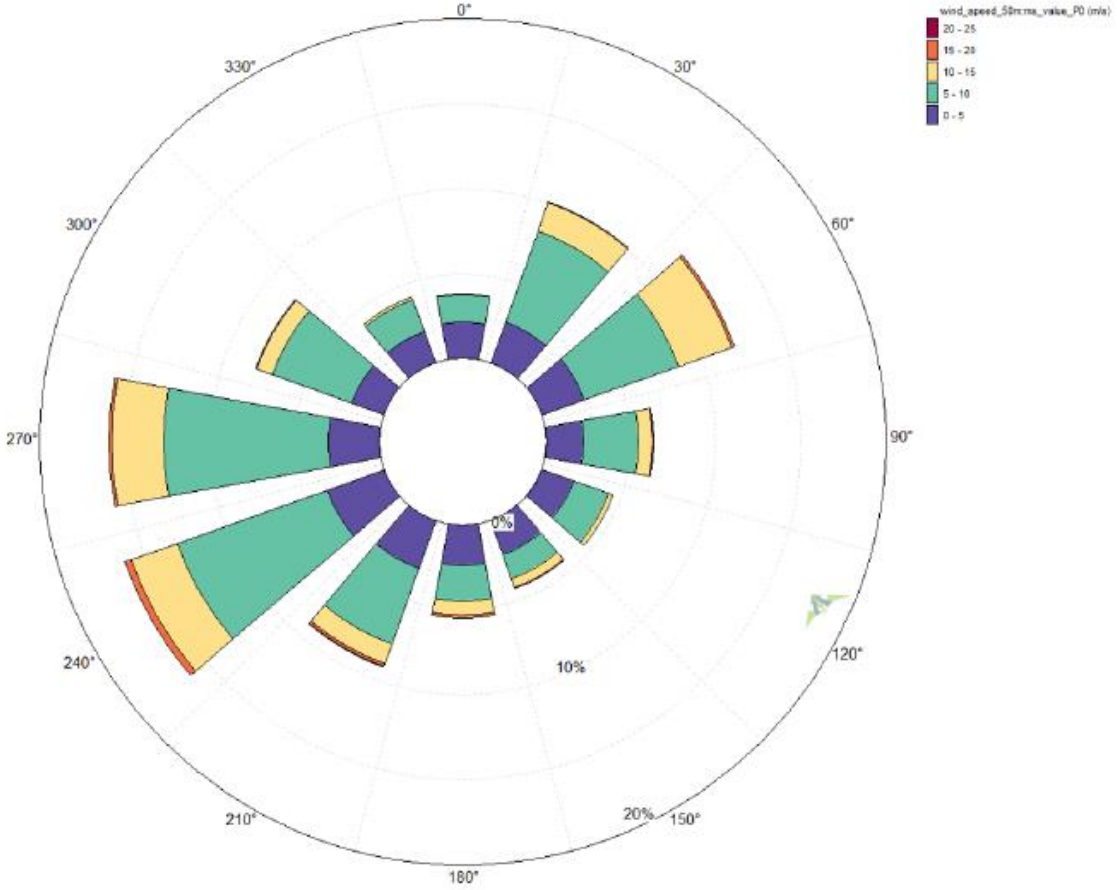




Study case (Wind resources)

- Historical reanalysis data ERA5
- An average hourly wind speed of 7m/s
- Dominant directions are, WSW-W, and NNE-NE .





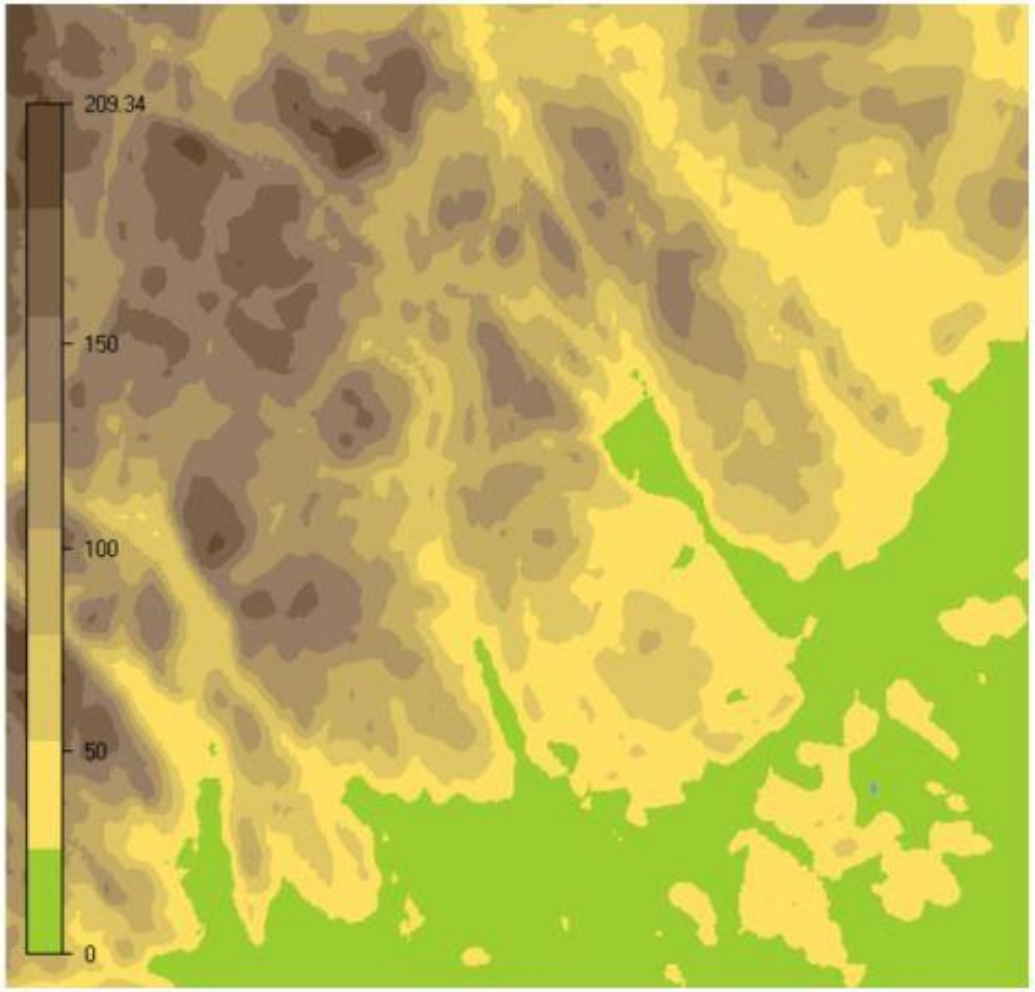
Methodology (Previous research)

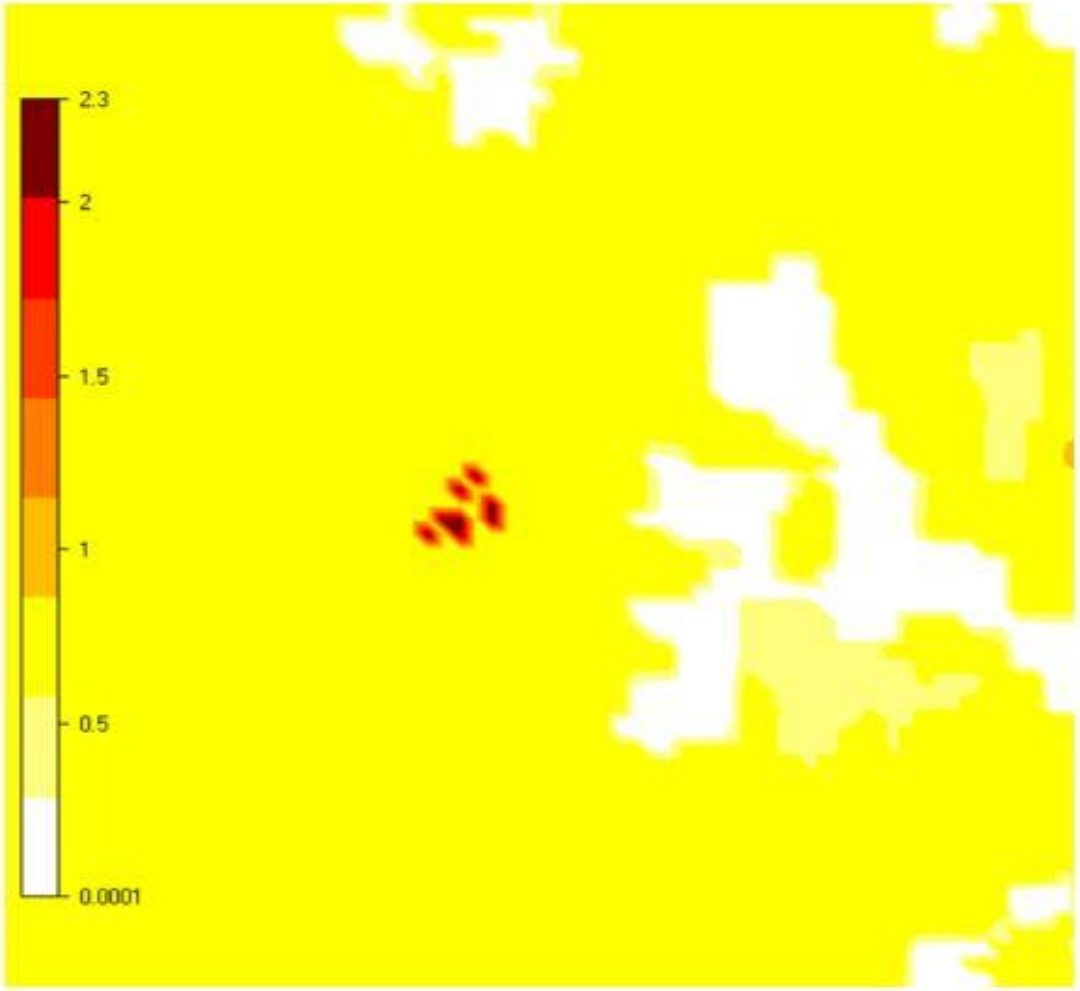
- A continuation of previous research
- Terrain Raw data vs. Modified data

Methodology (Modifying the .gws)

```
WindSim version    : 470

area name          : Gorines

#nodes nxp nyp     :          269          275

co-ordinate system :            3

ext. xmin xmax     : 454101.573 464288.057
ext. ymin ymax     : 6450404.716 6460819.256
ext. zmin zmax     :         -3.0       210.0

extgeo. minx maxx  : 8.217236 8.392547
extgeo. miny maxy  : 58.192472 58.286949

Horizontal datum   : WGS84
Projection         : UTM
Zone               : 32
Source terrain     : SRTM Worldwide Elevation Data (1-arc-second Resolution, SRTM Plus V3)

Source roughness   : CORINE Land Cover Europe 2006 (100 m Resolution)

 134
 112.983      115.986      120.294      130.738      143.179      152.394      159.524      164.758       166.76      163.149
 164.623      170.295      173.469      174.648      173.248      171.387      169.158      167.326      163.587      156.128
 148.521       142.86      136.192      127.069      119.244      113.534      109.804      103.998       98.332       97.363
  99.519       100.12       93.489       84.448       78.785       74.038       66.776         61.3       56.405           56
      56        54.83           54       54.274       56.892       68.084       85.663      107.924       128.61      148.379
 163.587      171.532      176.177      179.944       184.37      188.538      188.755       186.67      183.765      180.893
 175.086      168.823      159.466      148.687      139.748      131.392      121.899      114.446          109      110.316
 113.991       116.75      119.756      121.642       122.51      122.929      121.294      119.749       121.06      124.705
 124.974      122.407      117.832       114.72       113.85       115.01      112.984      108.977          107      106.664
 104.982      100.704       95.713       90.063           86       88.202       92.449       90.312       81.314       73.084
  69.442       71.183       74.226       75.326       75.627       73.486       68.704       61.161       53.458       50.502
  48.366       44.123       44.295       56.681       70.762       79.714       85.654        87.95           89       88.936
 1089.168         91.0       91.935       92.806      1093.99        94.694     1095.616       95.867       93.614       88.896
  89.308       92.136       94.005       94.211       95.535      100.341      104.146       105.71      106.308      107.282
 106.798       104.01      100.174       96.022       93.893       91.601       88.118       81.907        73.92       65.088
  55.169       48.263       44.404       41.886       38.968       36.543       35.654       34.673       33.258       31.374
      30       29.152       29.148       31.107       36.858       39.854           42           42       43.087       45.362
  45.891        44.19       38.469       30.993       27.109       28.551       29.709        31.63       31.655       30.318
  27.407       24.562       21.675       17.148       15.129       16.913       21.534       26.998        31.84       34.638
   34.76        35.55       37.168       39.707       40.646       42.852       45.841       49.663         51.4        52.37
   52.95       51.382       49.404        48.06       48.096       48.366       52.307       56.059       57.271       53.143
   46.22        38.74       33.476       31.181           30       30.105       32.746       34.379       36.305       38.067
  36.718       33.679       30.709       28.697       25.759       24.713       20.301       17.138       14.959        15.47
   16.01       16.967       18.082       19.942       20.914       20.143       18.339       17.242       14.349         8.12
   1.113            0            0            0            0            0            0            0            0        0.589
   8.093       12.829       17.795       17.781        15.13        13.85       13.061       12.942       12.034       12.949
  12.457       13.945       16.977       21.464       23.816       24.219       23.328       20.981       16.185
```

Digital terrain data based on Modifying the .gws





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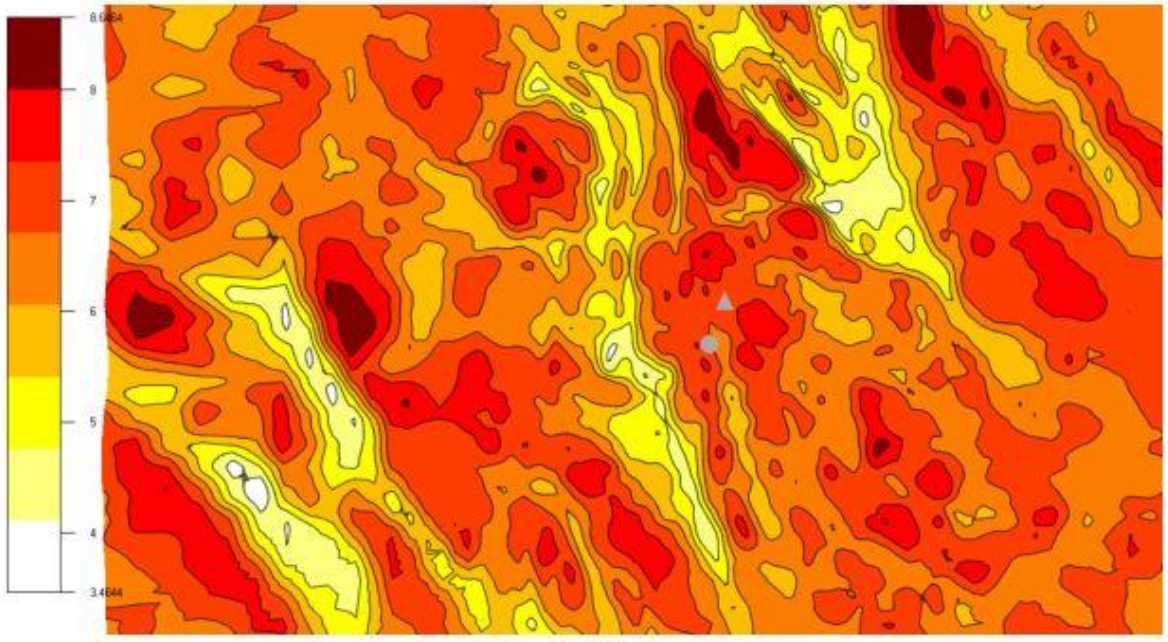
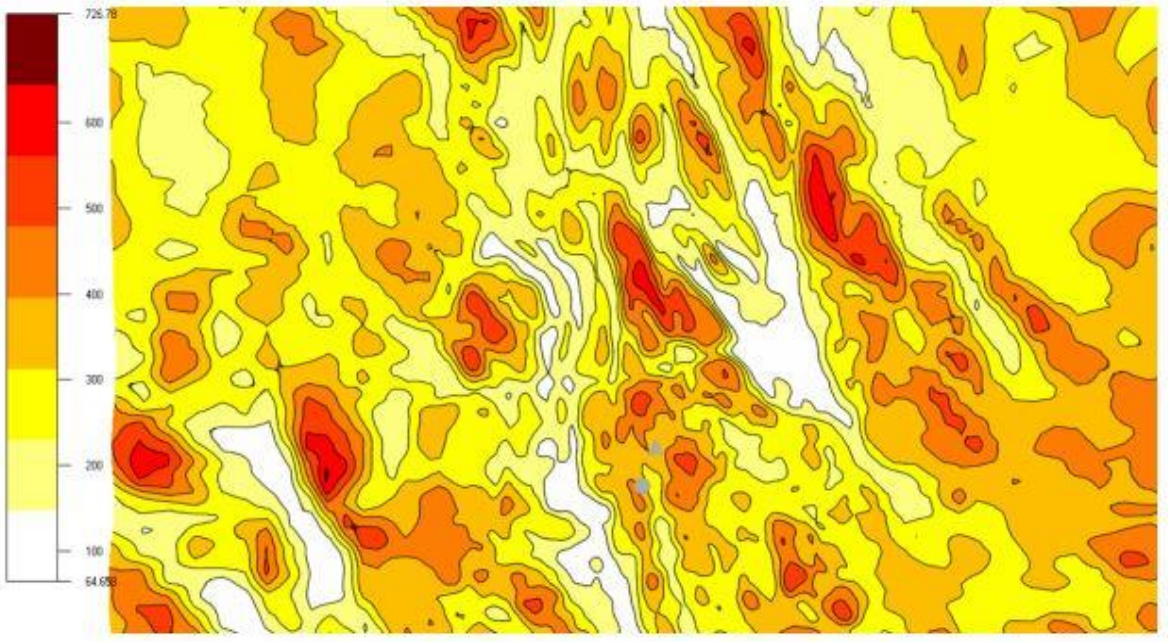
Wind Resource maps





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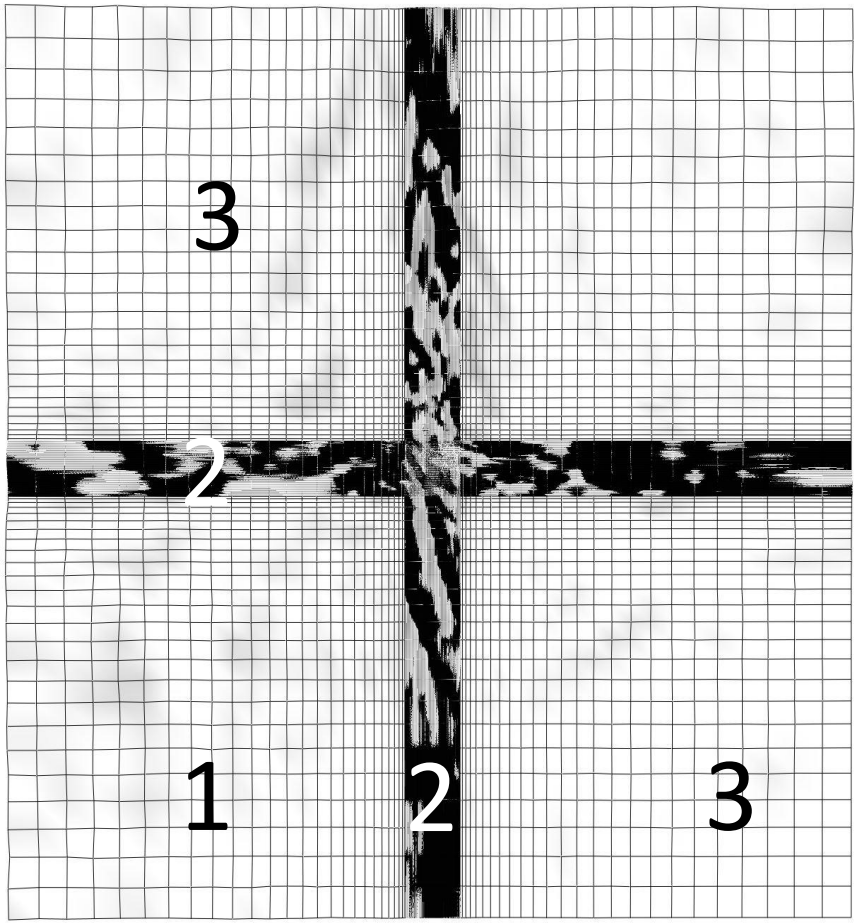
Approach (Modifying the .bws)

```
WindSim version    : 480

local_co-ordsys    :  type  x_trans  y_trans    angle

i-logical          :    line_i  points   distribution
                           1      24   12.5140
                           2     168    1.0000
                           3      24    0.0799

j-logical          :    line_j  points   distribution
                           1      24   12.8320
                           2     172    1.0000
                           3      24    0.0779

k-logical          :    line_k  points   distribution  z_upper
                           1      24    0.1000       10.0
                           2      24    1.0000       2200.0

junctions          :         i       j       k  co-ord       x          y          z
                             1       1       1       3   454101.5625  6450404.5000        0.0000
                             2       1       1       3   459066.4600  6450404.5000        0.0000
                             3       1       1       3   459182.2147  6450404.5000        0.0000
                             4       1       1       3   464288.0625  6450404.5000        0.0000
                             1       2       1       3   454101.5625  6455497.5000        0.0000
                             2       2       1       3   459066.4600  6455497.5000        0.0000
                             3       2       1       3   459182.2147  6455497.5000        0.0000
                             4       2       1       3   464288.0625  6455497.5000        0.0000
                             1       3       1       3   454101.5625  6455618.5000        0.0000
                             2       3       1       3   459066.4600  6455618.5000        0.0000
                             3       3       1       3   459182.2147  6455618.5000        0.0000
                             4       3       1       3   464288.0625  6455618.5000        0.0000
                             1       4       1       3   454101.5625  6460819.5000        0.0000
                             2       4       1       3   459066.4600  6460819.5000        0.0000
                             3       4       1       3   459182.2147  6460819.5000        0.0000
                             4       4       1       3   464288.0625  6460819.5000        0.0000

junctions_obstacle :         i       j       k  co-ord       x          y          z

surfaces_obstacle  :       i_s     i_e     j_s     j_e     k_s     k_e    type

volumes_obstacle   :       i_s     i_e     j_s     j_e     k_s     k_e    kind    type      c1      c2     turb_sources
```



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Approach (Modifying the .bws)

WindSim version : 480

local_co-ordsys : type x_trans y_trans angle

i-logical : line_i points distribution

1	24	12.5140
2	1	1.0000
3	1	1.0000
4	1	1.0000
5	1	1.0000
6	1	1.0000
7	1	1.0000
8	1	1.0000
9	1	1.0000
10	1	1.0000
12	24	0.0799

j-logical : line_j points distribution

1	24	12.8320
3	1	1.0000
4	1	1.0000
5	1	1.0000
6	1	1.0000
7	1	1.0000
8	1	1.0000
9	1	1.0000
10	1	1.0000
11	1	1.0000
12	24	0.0779

k-logical : line_k points distribution z_upper

1	24	0.1000	10.0
2	24	1.0000	2200.0

junctions :

i	j	k	co-ord	x	y	z
1	1	1	3	454101.5625	6450404.5000	0.0000
2	1	1	3	458877.6888	6450404.5000	0.0000
3	1	1	3	458945.2256	6450404.5000	0.0000
4	1	1	3	459012.7625	6450404.5000	0.0000
5	1	1	3	459080.2993	6450404.5000	0.0000
6	1	1	3	459147.8361	6450404.5000	0.0000
7	1	1	3	459215.3730	6450404.5000	0.0000
8	1	1	3	459282.9098	6450404.5000	0.0000
9	1	1	3	459350.4466	6450404.5000	0.0000
10	1	1	3	459417.9835	6450404.5000	0.0000
11	1	1	3	459485.5203	6450404.5000	0.0000
12	1	1	3	464288.0625	6450404.5000	0.0000
1	2	1	3	454101.5625	6455244.5925	0.0000
2	2	1	3	458877.6888	6455244.5925	0.0000
3	2	1	3	458945.2256	6455244.5925	0.0000
4	2	1	3	459012.7625	6455244.5925	0.0000
5	2	1	3	459080.2993	6455244.5925	0.0000
6	2	1	3	459147.8361	6455244.5925	0.0000
7	2	1	3	459215.3730	6455244.5925	0.0000
8	2	1	3	459282.9098	6455244.5925	0.0000
9	2	1	3	459350.4466	6455244.5925	0.0000
10	2	1	3	459417.9835	6455244.5925	0.0000
11	2	1	3	459485.5203	6455244.5925	0.0000
12	2	1	3	464288.0625	6455244.5925	0.0000
1	3	1	3	454101.5625	6455308.2540	0.0000
2	3	1	3	458877.6888	6455308.2540	0.0000
3	3	1	3	458945.2256	6455308.2540	0.0000
4	3	1	3	459012.7625	6455308.2540	0.0000
5	3	1	3	459080.2993	6455308.2540	0.0000

junctions_obstacle : i j k co-ord x y z

surfaces_obstacle : i_s i_e j_s j_e k_s k_e type

volumes_obstacle :

i_s	i_e	j_s	j_e	k_s	k_e	kind	type	c1	c2	turb_sources
4	5	5	6	1	2	obstacle	0.0	0.000	0.000	false
7	8	8	9	1	2	obstacle	0.0	0.000	0.000	false
8	9	9	10	1	2	obstacle	0.0	0.000	0.000	false

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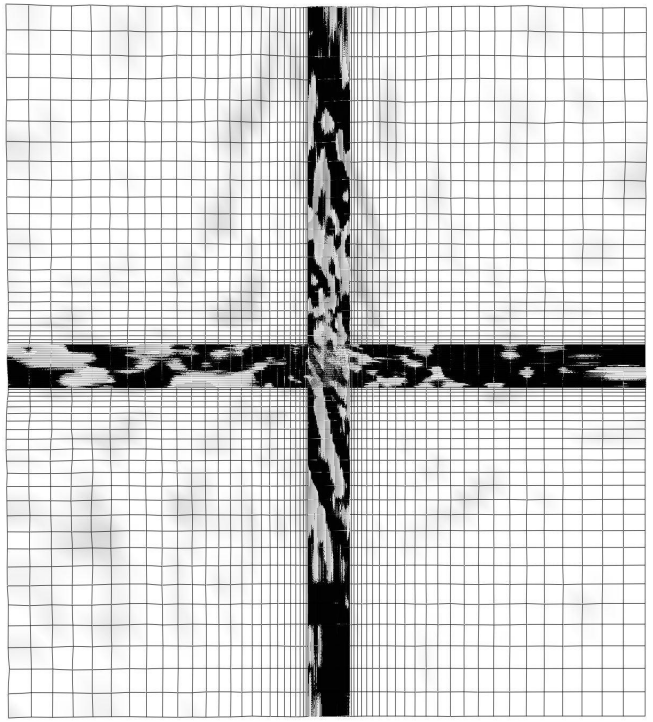
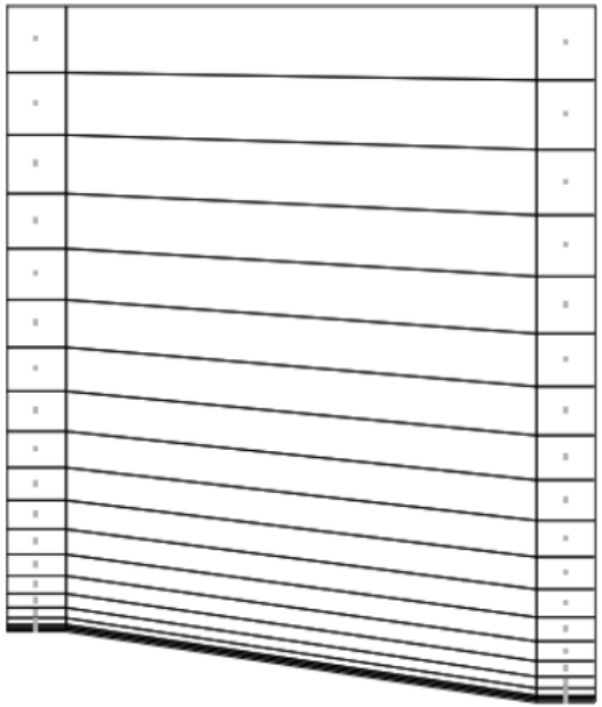
Digital terrain data based on Modifying .bws

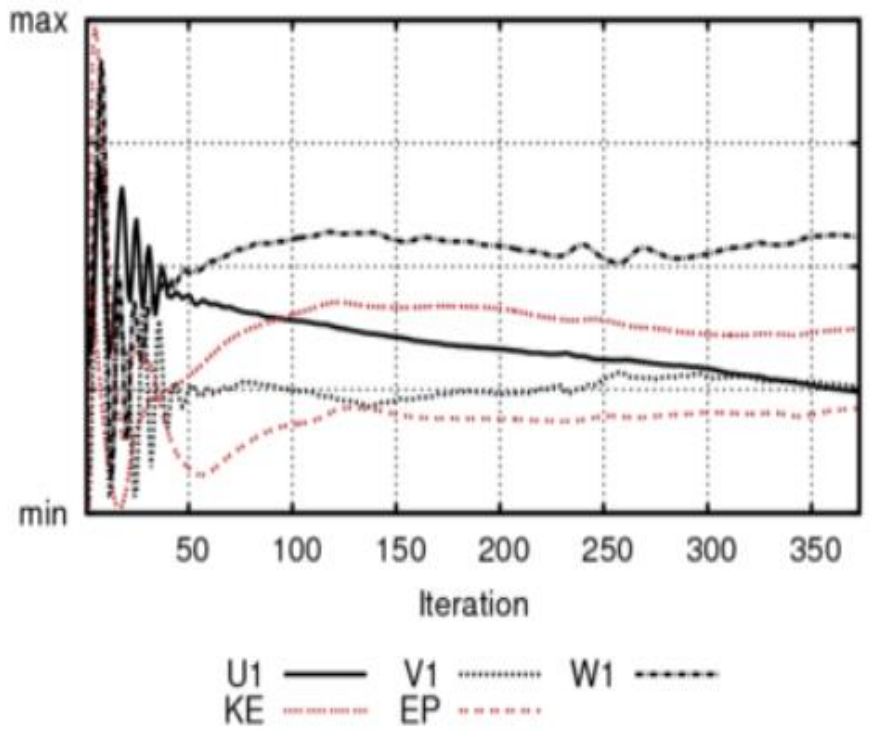
- Integrate the buildings as obstacles in the domain
- Terrain Raw data vs. Modified data vs. Buildings integrated

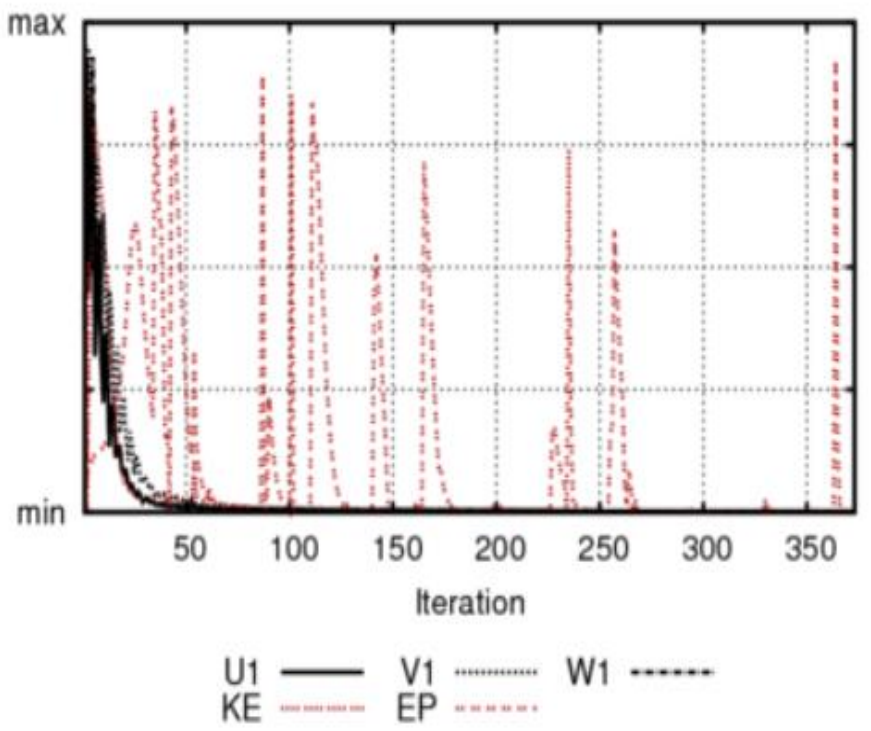




Results (k-epsilon)

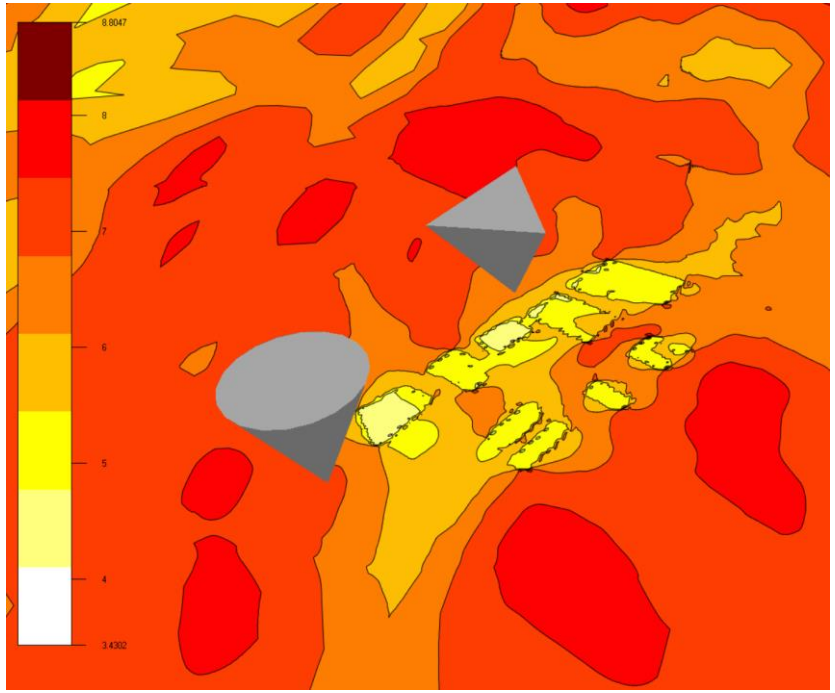
- On average, 330 iterations across the sectors
- Increased number of iterations due to increased the complexity

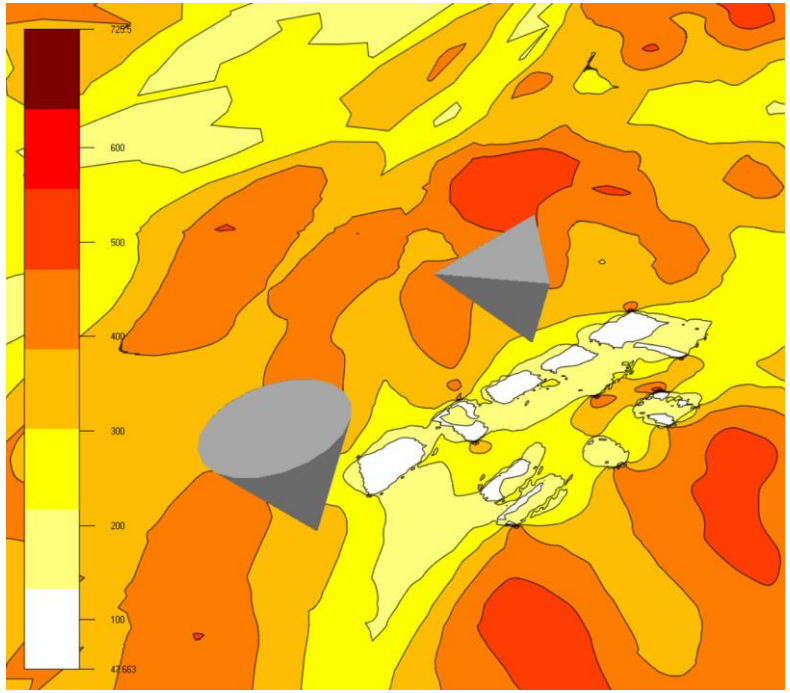




Results (k-epsilon)

- Mean wind speed of 6.2 m/s
- Power density of 273 W/ m^2
- wind speed is less by 10% compared to previous results
- Full load hours is not affected
- Similar AEP compared to simulation on raw grid data





K-epsilon Simulations	Raw grid data*	Modified grid data*	Buildings integrated grid data
Wind speed [m/s]	6.96	6.94	6.25
AEP [MWh/y]	1874.5	1960	1875.3
Full load [hours]	3124	3267	3125.3

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