Sun wind water earth life living legends for design

AR1U130 Territory (design) 4ECTS

AR0112 Civil engineering for dummies (calculations) 2ECTS

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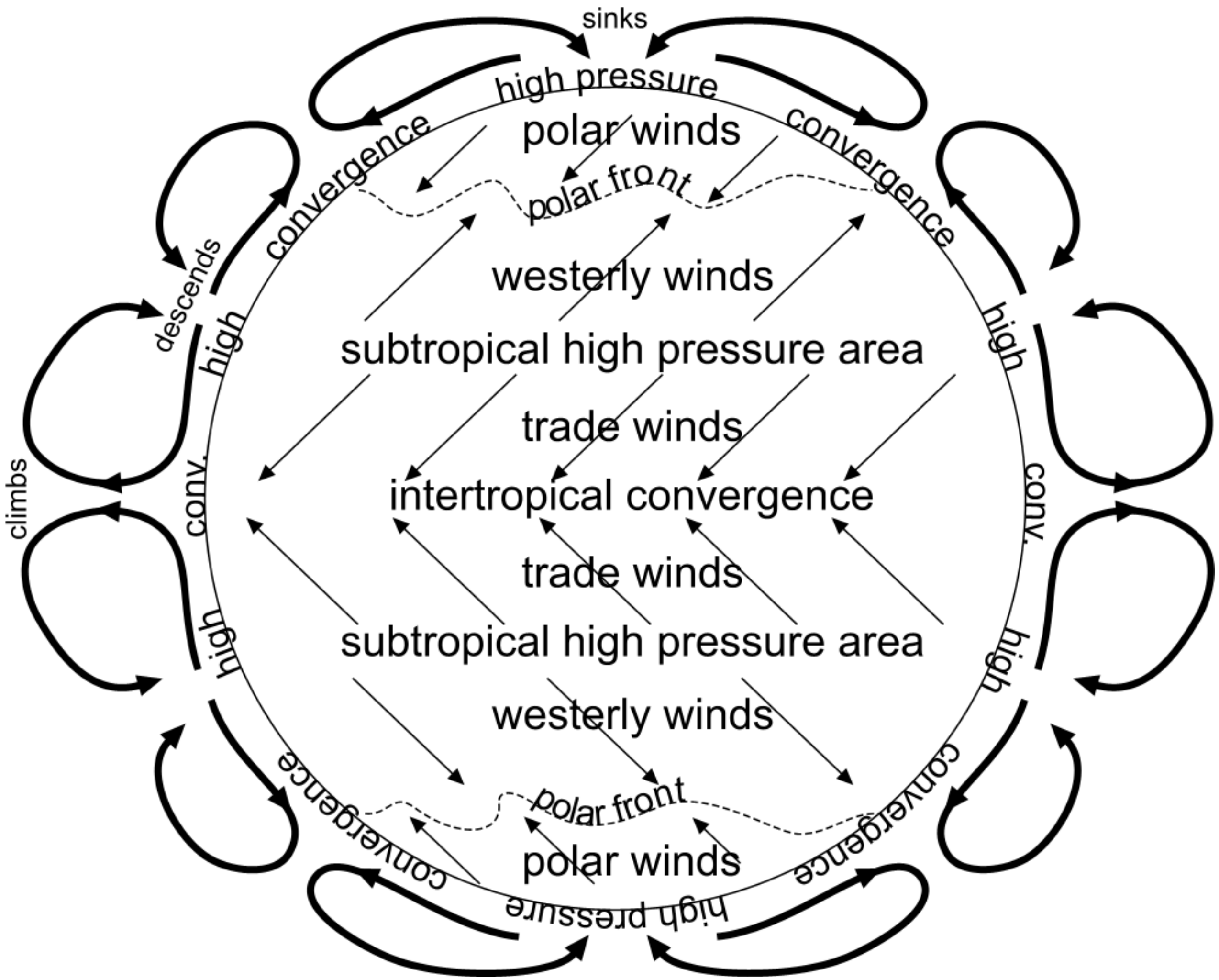
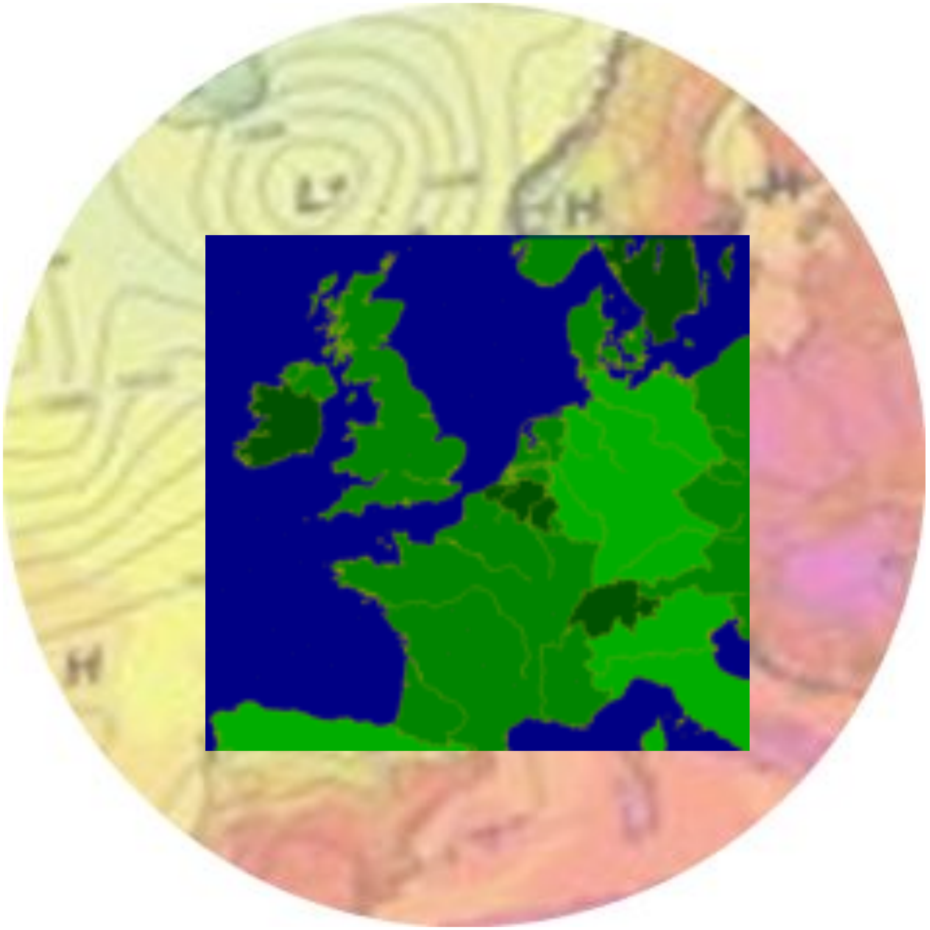
Wind


sinks
high pressure
polar winds
convergence
convergence
polar front
descends
convergence
westerly winds
high
subtropical high pressure area
high
trade winds
climbs
conv.
intertropical convergence
conv.
trade winds
high
subtropical high pressure area
high
westerly winds
convergence
convergence
polar front
polar winds
convergence
convergence
high pressure

Left aroud Low



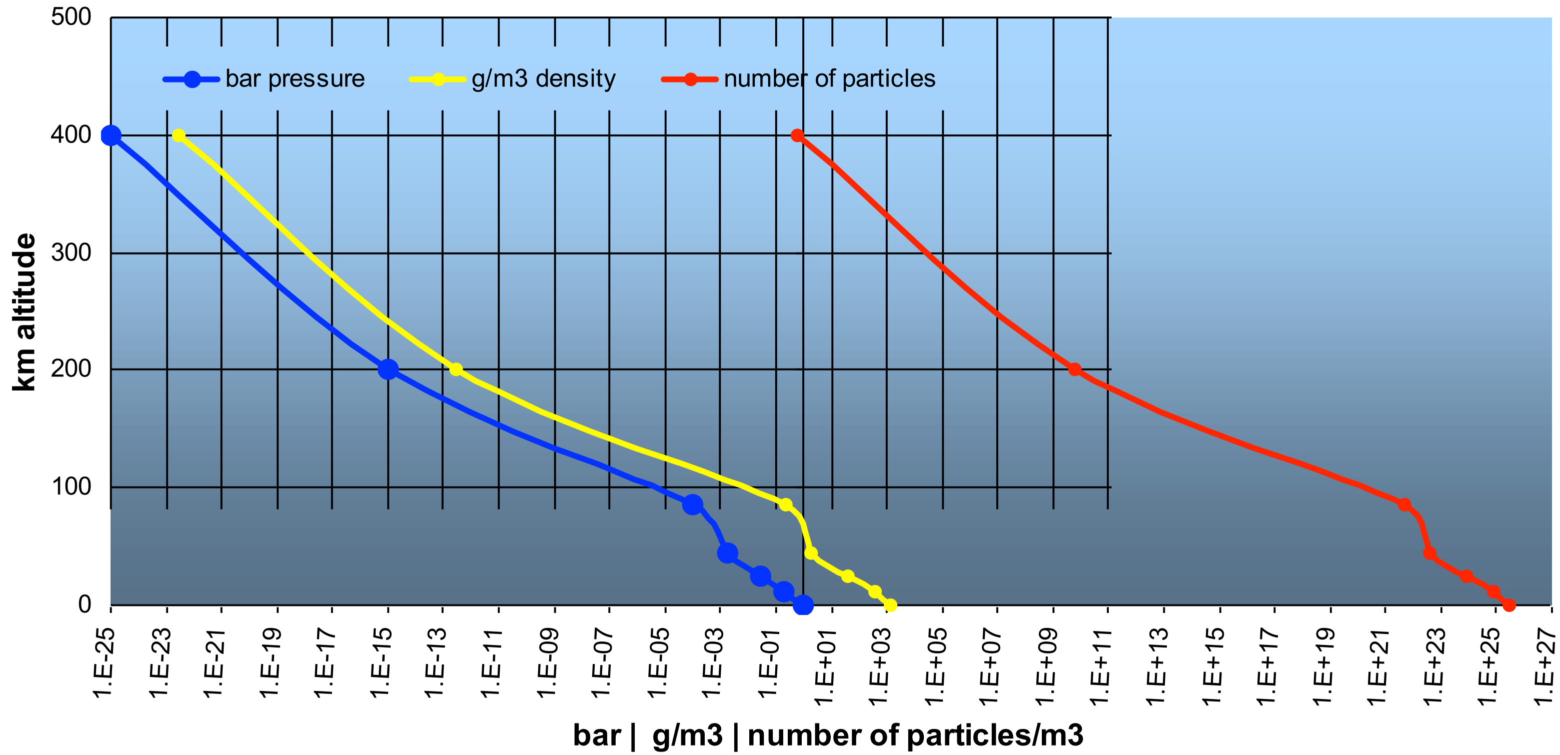
http://www.buienradar.nl/h.aspx

Mass of atmosphere

500km air above $1m^2$ = 10 000kg

That equals $10m \times 1m^2 = 10m^3$ water

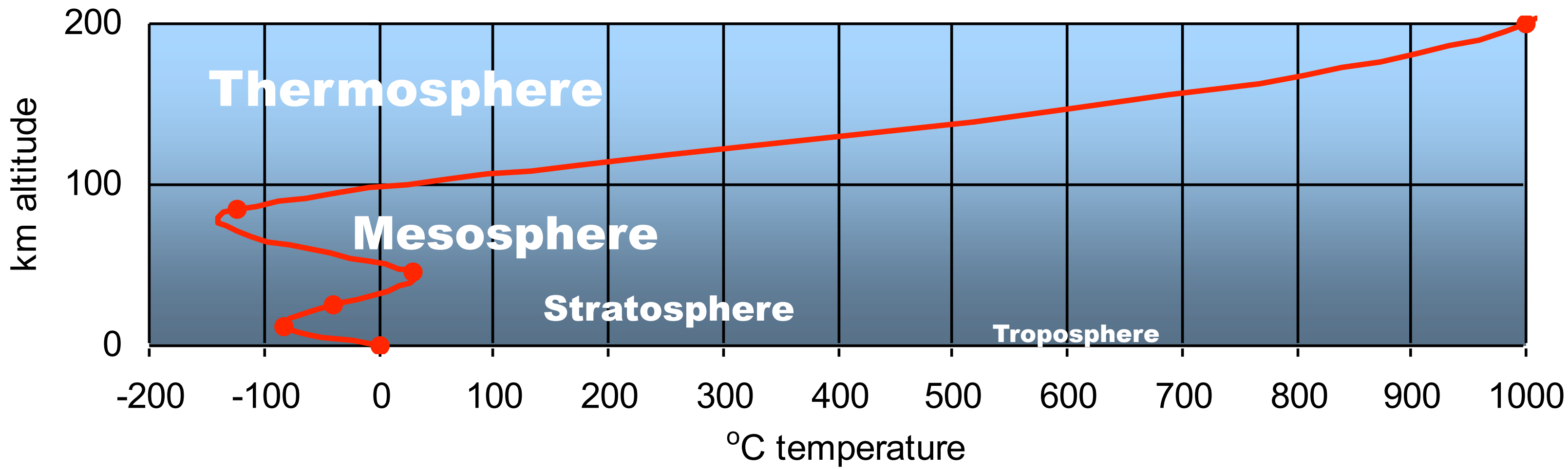
Air density and pressure



Density decreases from ample 1kg to 1g/m3 at 50km altitude.

So, aeroplanes meet less resistance the higher they fly (until 20km), but propellers and wings will work less as well.

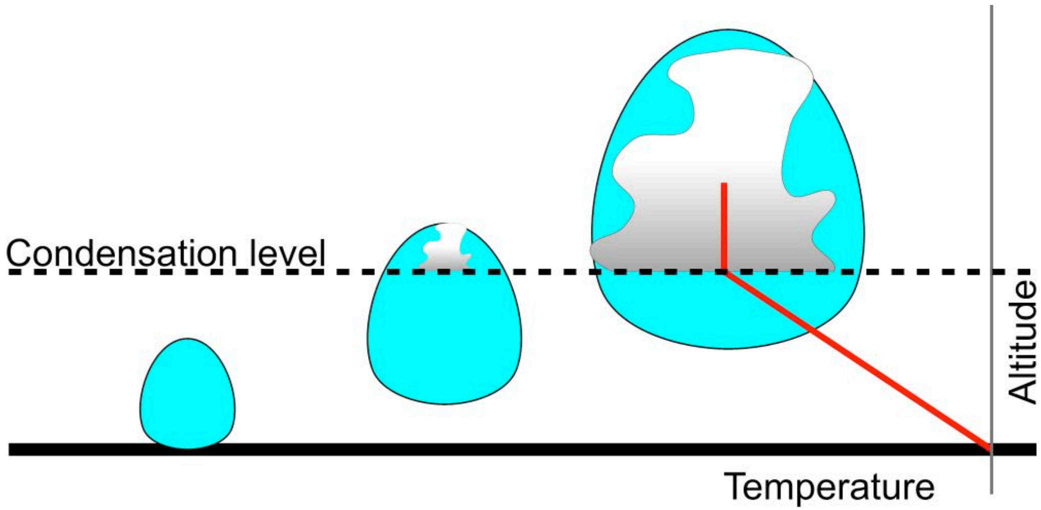
Temperature(altitude)



‘Weather’ occurs in troposphere.

Expanding (cooling) clouds stop raising as soon as their temperature equals their environment, sometimes loosing moist as rain.

Clouds

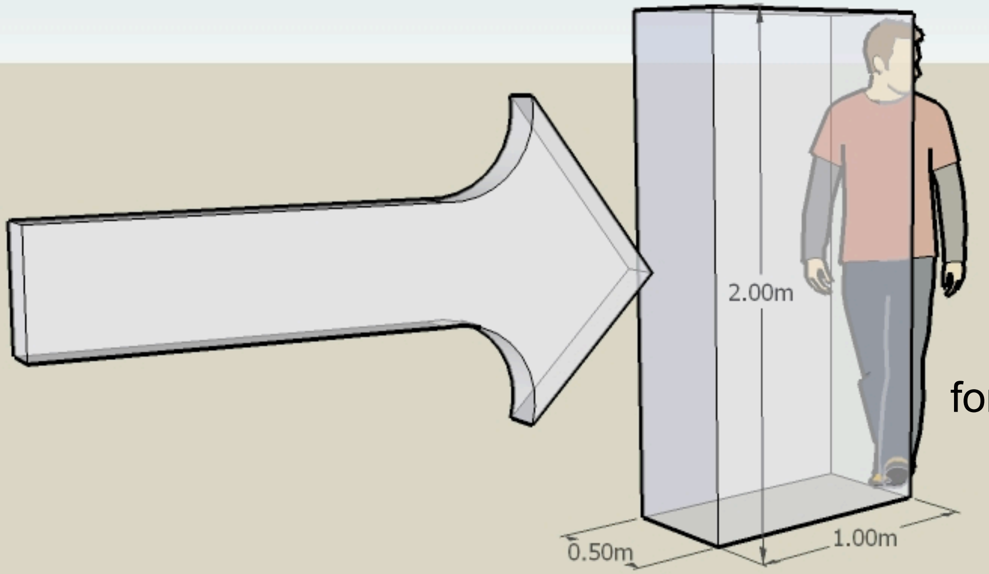


Expanding (cooling) air bubbles stop raising as soon as their temperature equals their environment, sometimes loosing moist as rain.

Wind force(velocity^2)

volume = surface · length   length = velocity · time

volume = surface · velocity · time



force = mass · acceleration

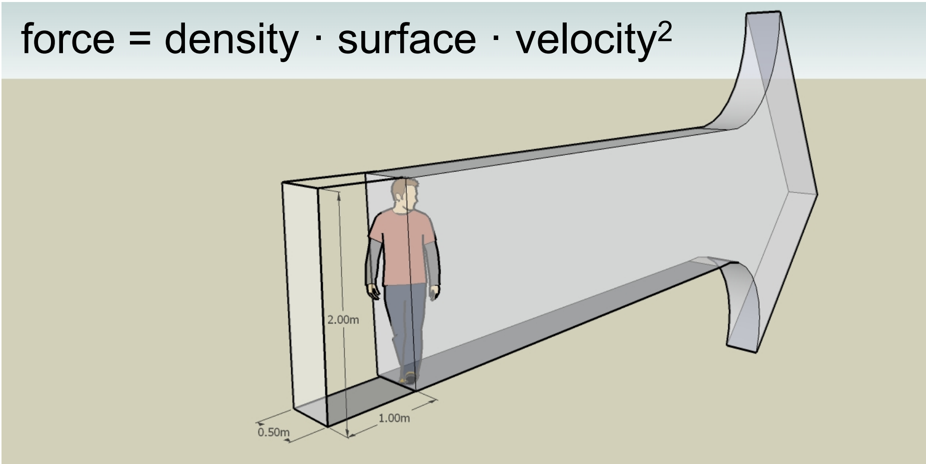
mass = density · volume

acceleration = velocity / time

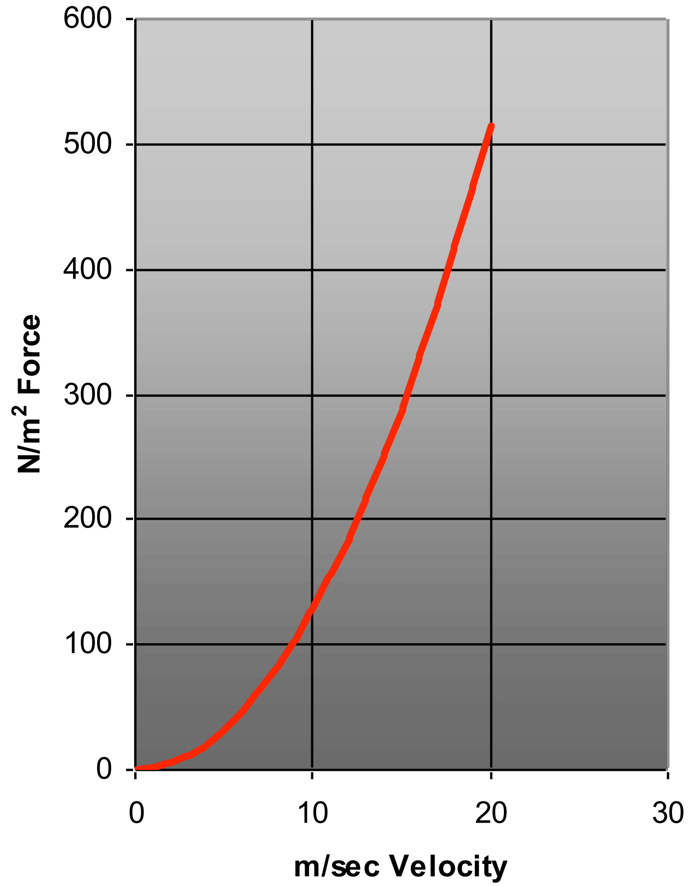
force = density · surface · velocity · time · velocity / time

force = density · surface · velocity^2

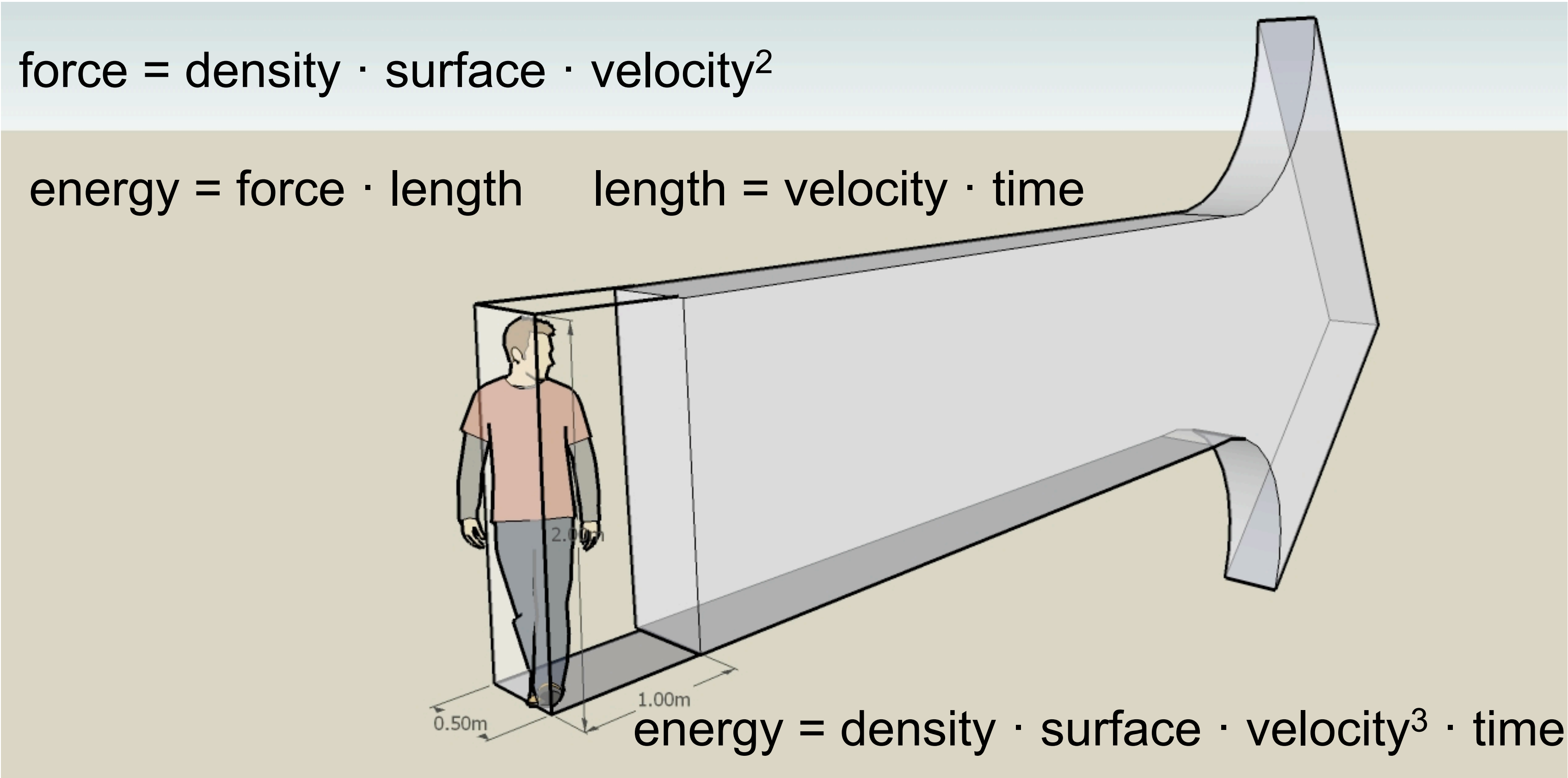
Wind force



Velocity occurs two times in the formula for wind force, so force increases parabolically by the square of velocity.



Wind energy



Velocity occurs *three* times in the formula for wind energy, so energy increases by the *third* power of velocity.

Effective power from a wind turbine

energy = density · surface · velocity³ · time

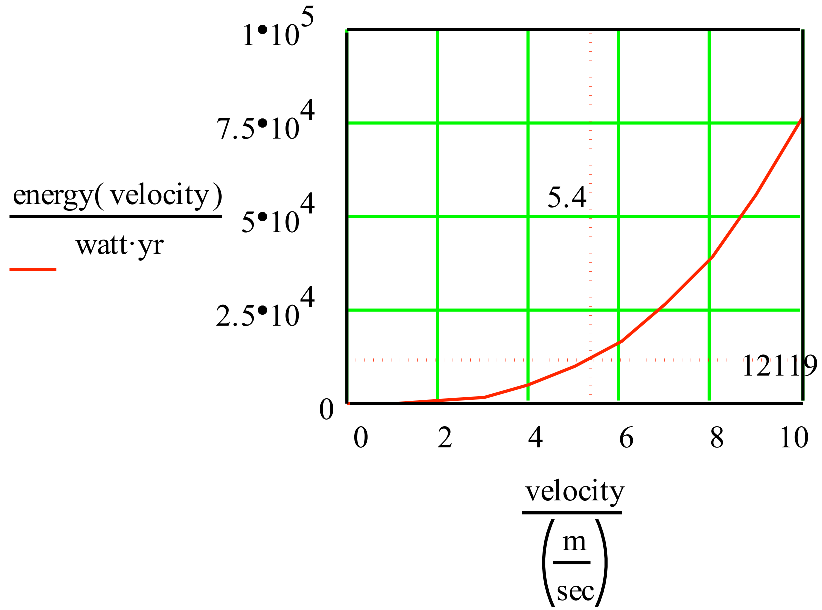
density = 1.29 kg/m³

surface = π · 10² = 314 m²

velocity = 5.4 m/sec

time = year = 60 · 60 · 24 · 365 sec

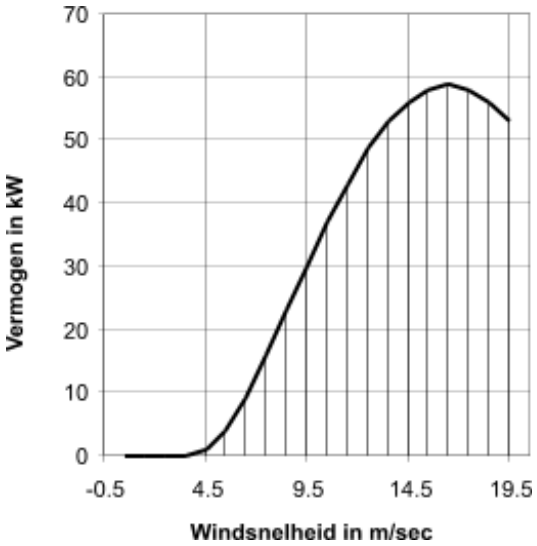
efficiency = 19%

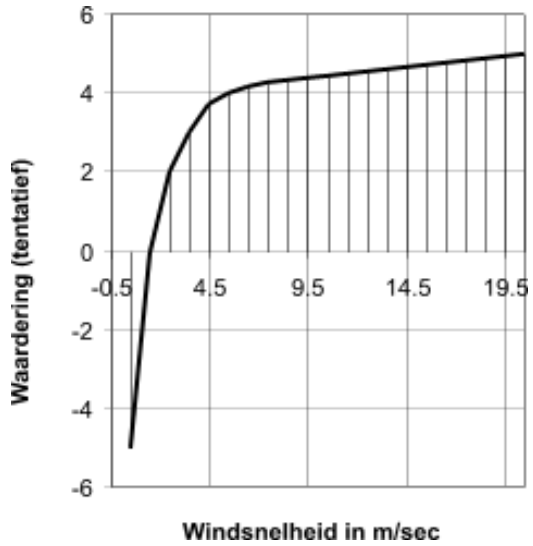


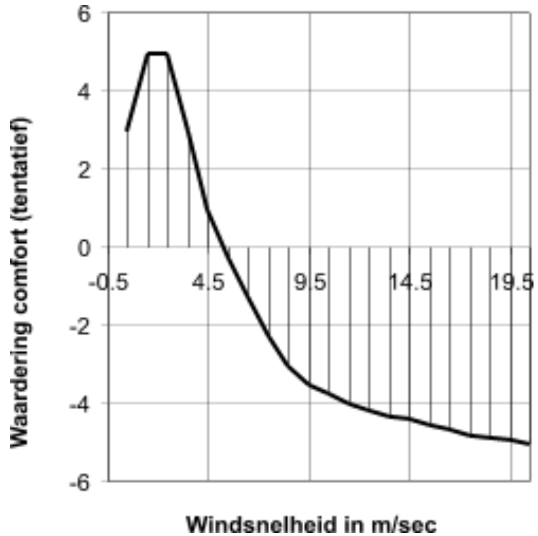
effective energy = 1.29· 314 · 5.4³ · year · 19% =12119Wa

Power, dispersion, comfort

Our appreciation of wind differs if we want power from a wind turbine, dispersion of pollution or comfort in public space







Urban impact of wind (scale)

Measures can be taken at the level of

- national choice of location (R=100km)
- regional choice of location (R= 30 km)
- arrangement of rural areas; form of conurbations (R= 10 km)
- local choice of location (R= 10 km)
- form of town and town edge (R= 3 km)
- lay-out of districts and district quarters (R= 1 km)
- allotment of neighbourhoods and neighbourhood quarters (R= 300 m)
- allotment, urban details and ensembles divided in 4 hectares (R= 100 m)
- buildings (R= 30m), and
- the micro climate, important for humans, plants and animals (R= 10m).

Measuring wind

Wind stations register gusts of more than 5 seconds duration.

All measurements are averaged for one hour resulting in the ‘hour average wind velocity’.

From these hour averages a year average can be calculated, the ‘year average wind velocity’.

Standard wind

Wind data differ locally by surrounding obstacles (‘roughness’).

Standarised into the ‘year average potential wind velocity’

with a ‘ground roughness 3’ (grass land) and

at an altitude of 10 metre.

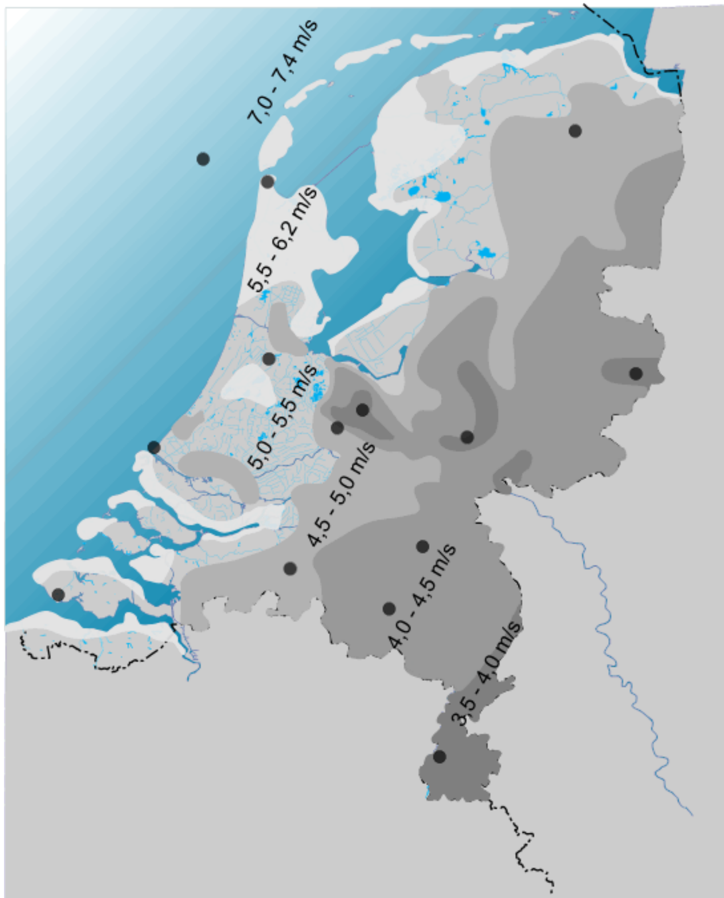
From that standard you can calculate the wind velocity

at other locations

with different local roughness and

at other altitudes

Measuring year average potential wind velocity



Data lost in the average

However, in the year average wind velocity some data are lost, relevant for:

- potential energy profit by wind turbines,
- dispersion of air pollution,
- comfort of outdoor space and
- energy use in buildings.

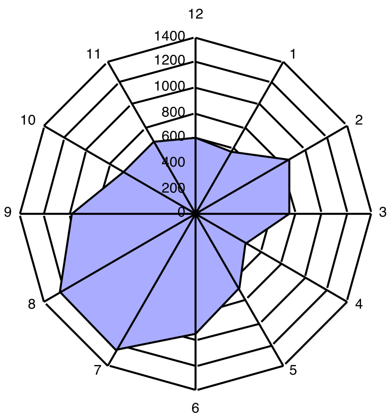
You miss a specification of:

- wind directions,
- wind velocities throughout the year and
- how often these occur.

So, we have to go back to the sources.

Mea-
sure-
ments

Table 1 Velocity Class*	Still or variable			E**			S			W			N	TOTAL
m/sec	0	1	2	3	4	5	6	7	8	9	10	11	12	
vk	w													
0,5	348	10	8	11	10	12	16	14	16	15	9	13	14	148
1,5	78	39	43	50	51	58	72	53	66	51	36	44	55	618
2,5	15	59	82	98	80	97	132	111	119	84	68	79	102	1111
3,5	2	88	118	133	94	118	155	160	125	106	84	94	107	1382
4,5		86	132	136	86	124	150	170	113	110	77	87	87	1358
5,5		82	110	101	55	86	121	157	113	112	74	76	71	1158
6,5		74	112	82	46	71	100	163	119	109	73	76	66	1091
7,5		46	88	52	22	47	73	113	123	98	58	62	42	824
8,5		38	59	29	8	27	51	92	90	77	48	37	26	582
9,5		21	44	17	5	17	32	68	84	59	40	29	15	431
10,5		13	29	14	3	10	21	52	70	45	30	17	7	311
11,5		8	14	6	1	4	13	32	53	32	19	10	4	196
12,5		4	8	3		2	8	25	45	26	14	7	3	145
13,5		1	3	1		1	4	15	30	17	7	4	2	85
14,5		1	2	1			1	8	20	9	4	3		49
15,5			1				1	6	12	6	3	1		30
16,5								3	8	4	3	1		19
17,5								2	8	4	2			16
18,5								2	5	3	1			11
19,5								1	2	1	1			5
20,5									2	1				3
21,5									1	1				2
22,5									1					1
TOTAL	443	570	853	734	461	674	950	1247	1225	970	651	640	601	10000

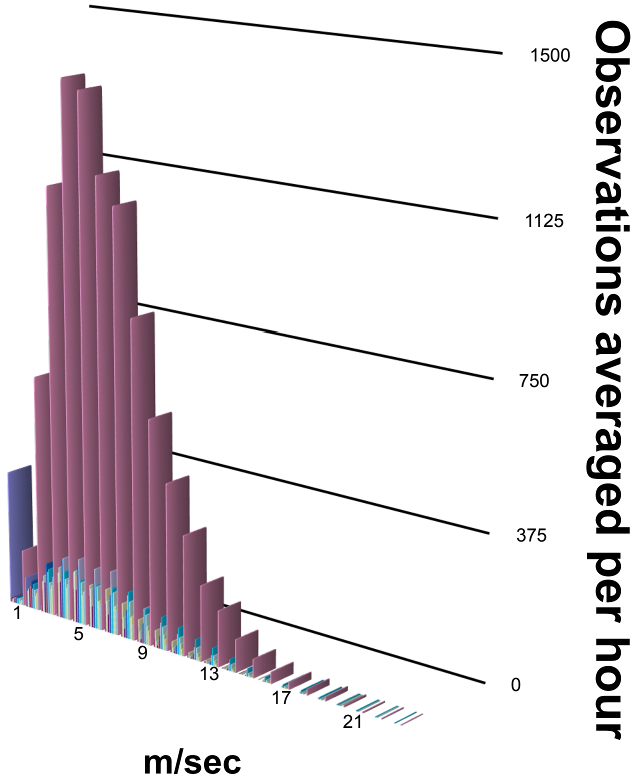


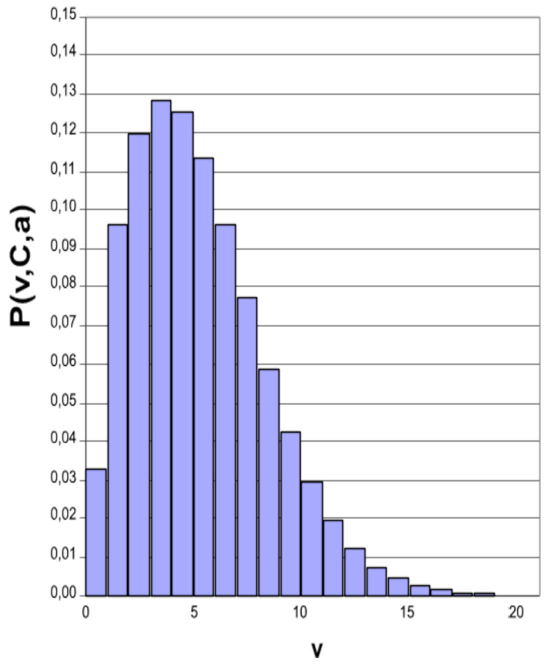
Data lost in the average

How to get for a specific location:

wind directions,
wind velocities throughout the year and
how often these occur.

Modelling wind velocity





$$P(v, C, a) := a \cdot C \cdot v^{C-1} \cdot e^{-a \cdot v^{C}}$$

Modelling data for calculations

Fortunately the form of the graphs is very similar to a Weibull probability graph with different form and scale (‘C’ and ‘a’) per location.

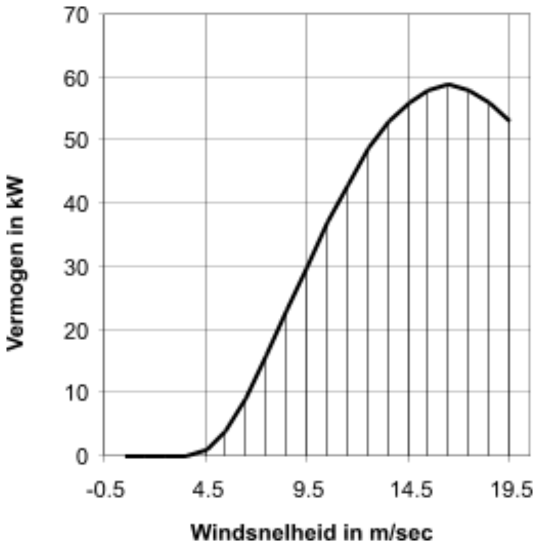
$$P(v, C, a) = a \cdot C \cdot v^{C-1} \cdot e^{-a \cdot v^{C}}$$

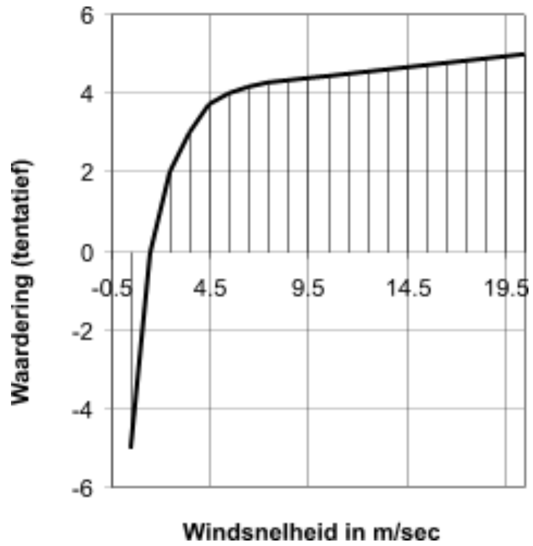
Also %wind per direction differs per region:

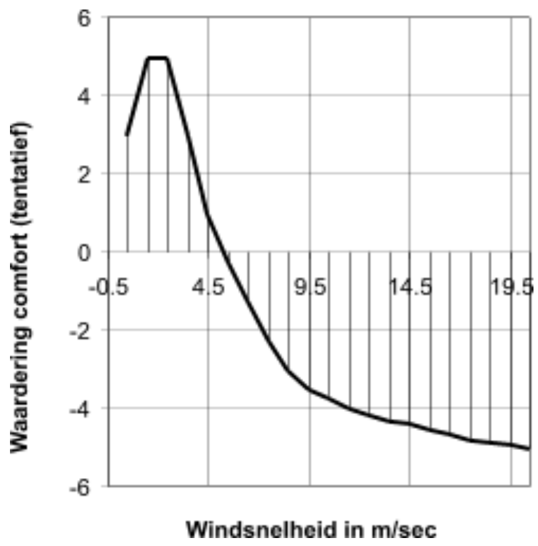
	form	schale	% from direction (‘hours’ from North, 0 is calm or variable)													
						E			**S**			**W**			**N**	**total**
	C	**a**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	%
Beek	2,01	0,042	2	7	9	7	3	4	10	20	17	8	4	4	4	100
Den Helder	2,00	0,014	1	6	7	8	6	5	10	13	12	10	8	8	7	100
Eelde	1,74	0,059	3	6	8	8	7	5	9	14	14	10	7	5	4	100
Eindhoven	1,86	0,052	8	7	8	5	6	6	7	13	16	9	6	5	4	100
Schiphol	1,86	0,032	4	6	9	7	5	7	10	12	12	10	7	6	6	100
Vlissingen	1,95	0,025	1	9	9	6	4	5	9	13	13	11	6	7	7	100

Power, dispersion, comfort

Remember:

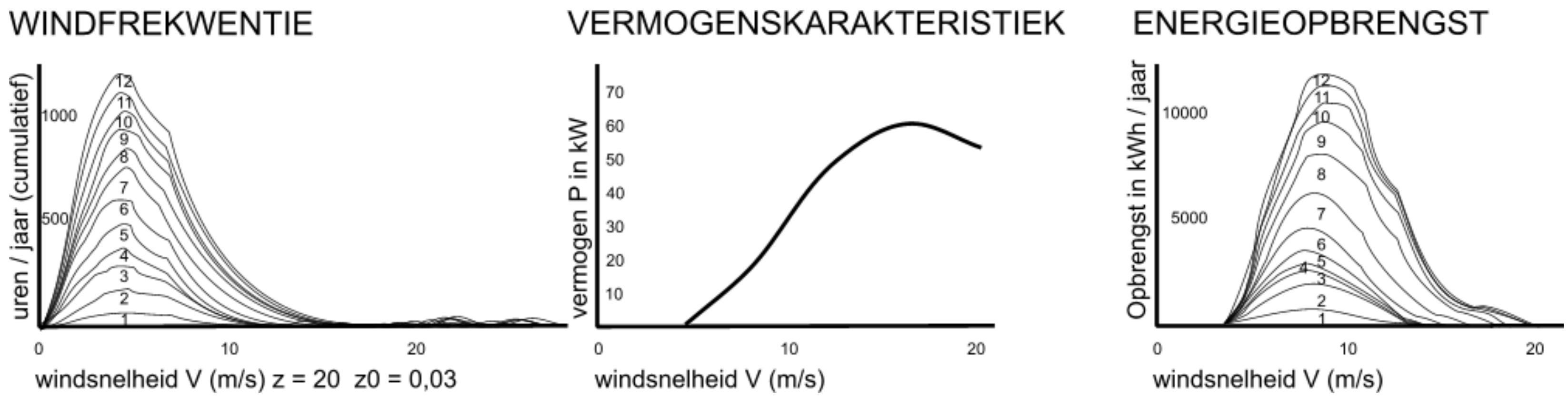




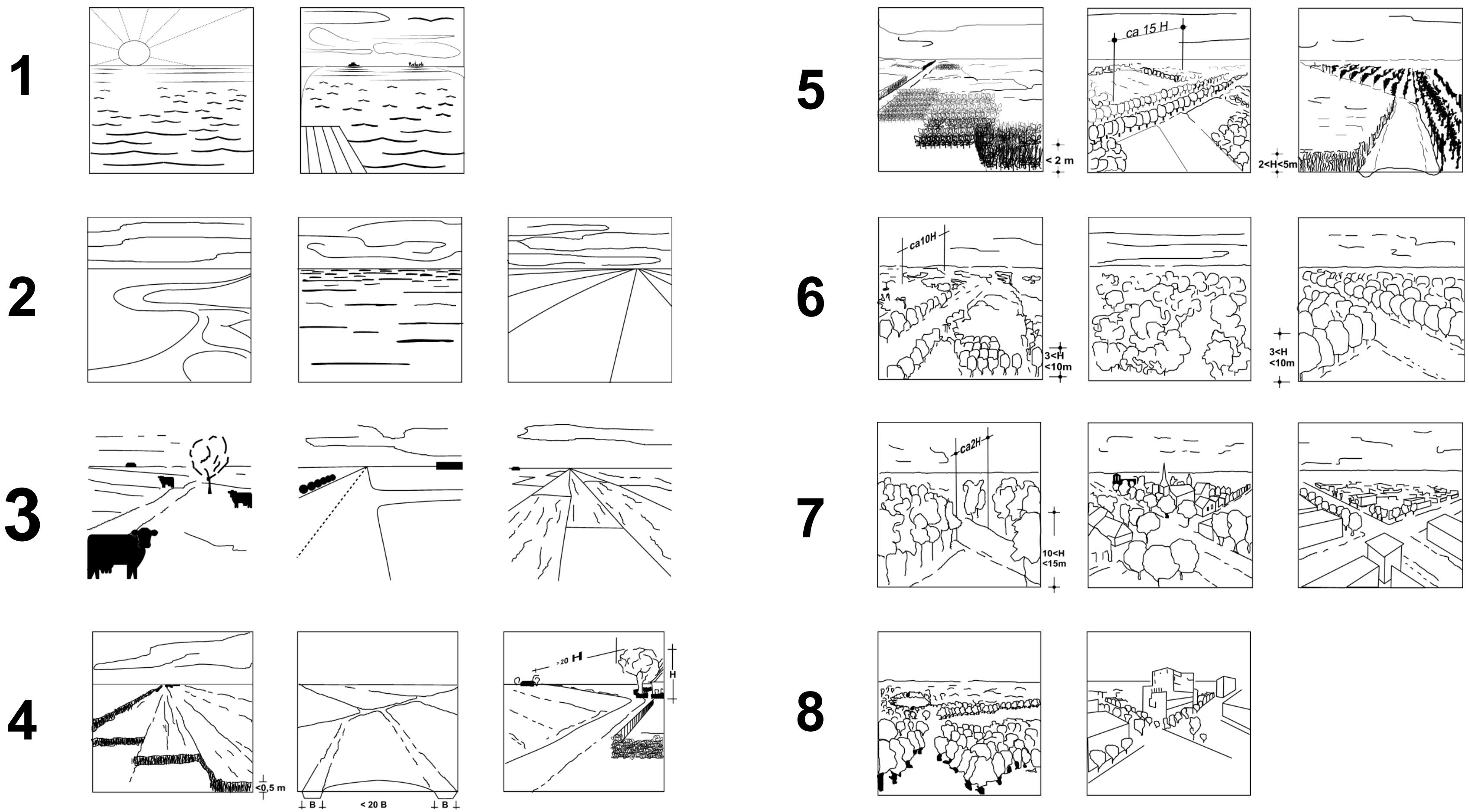


Energy from a wind turbine

But, that differs per wind direction:

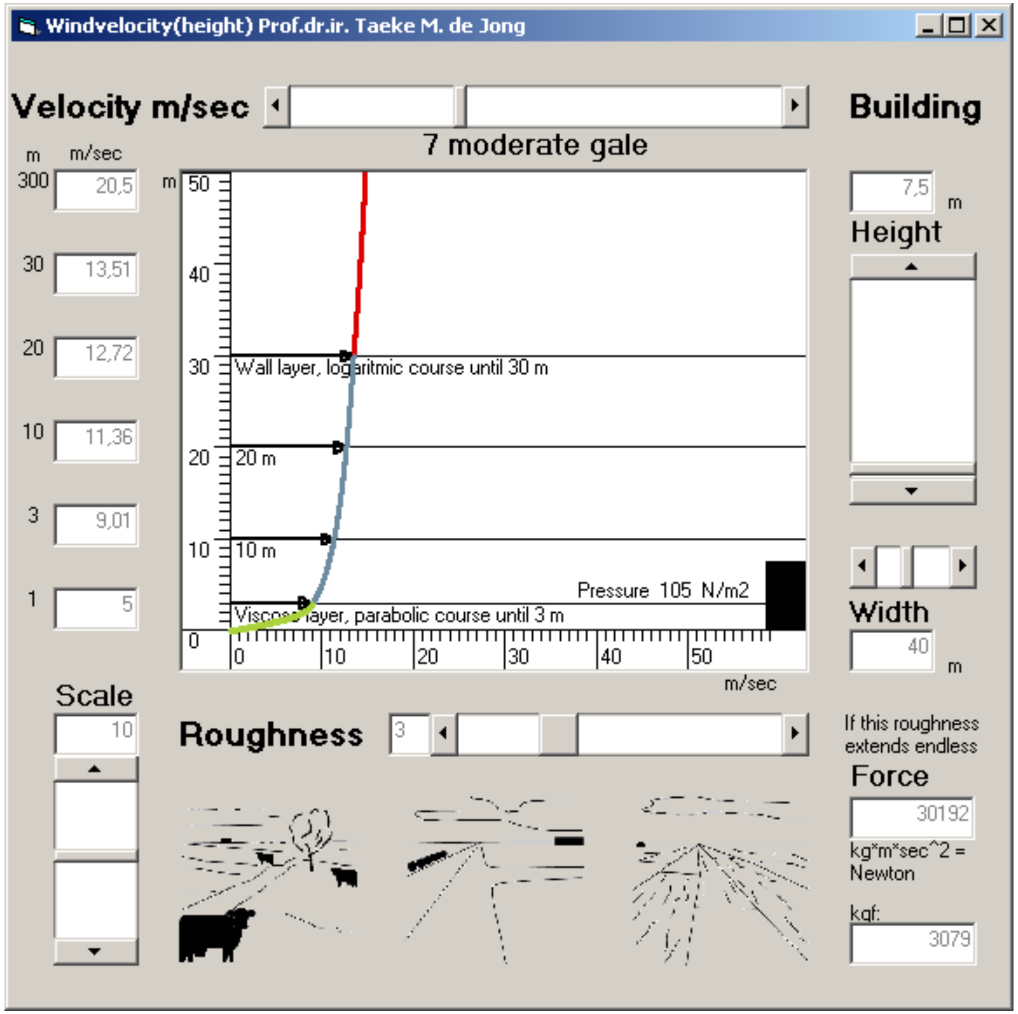


And, roughness class per direction

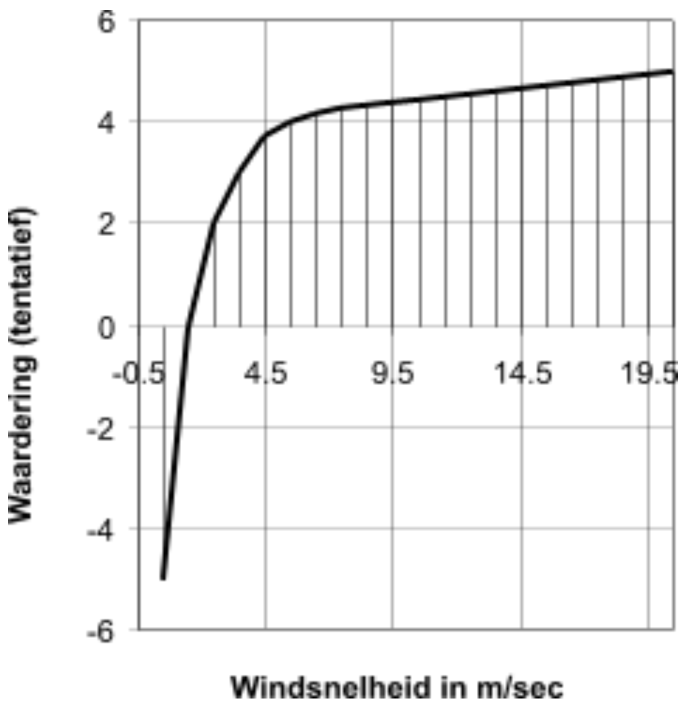


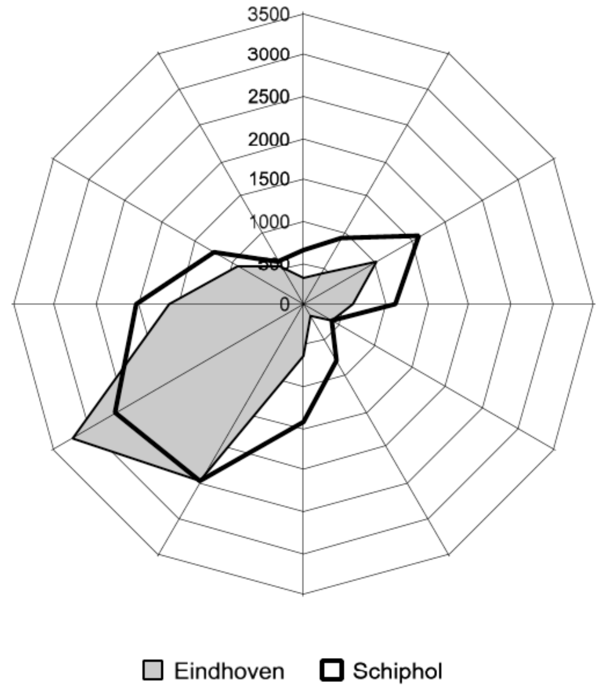
And, rougness effects wind velocity…

…until
high
altitudes.



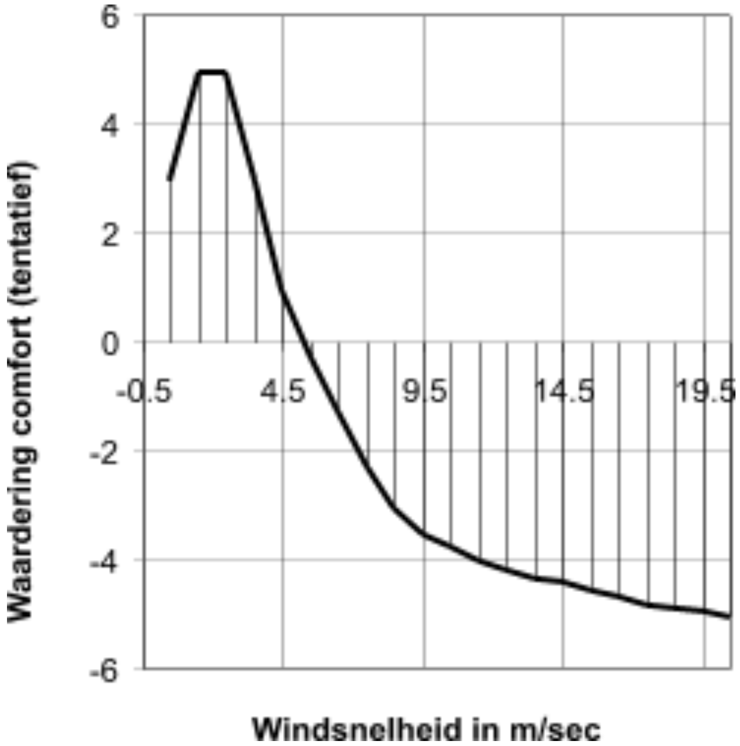
Dispersion of air pollution

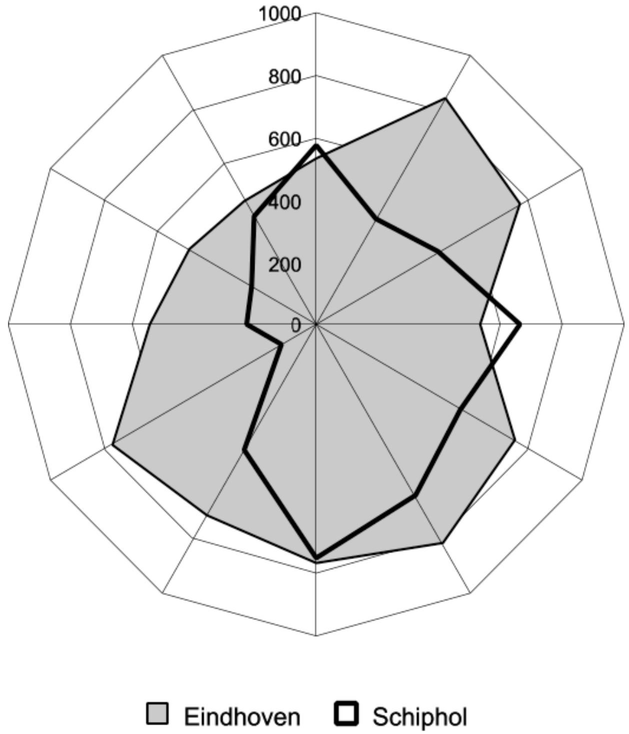




also dependent upon direction and roughness per direction.

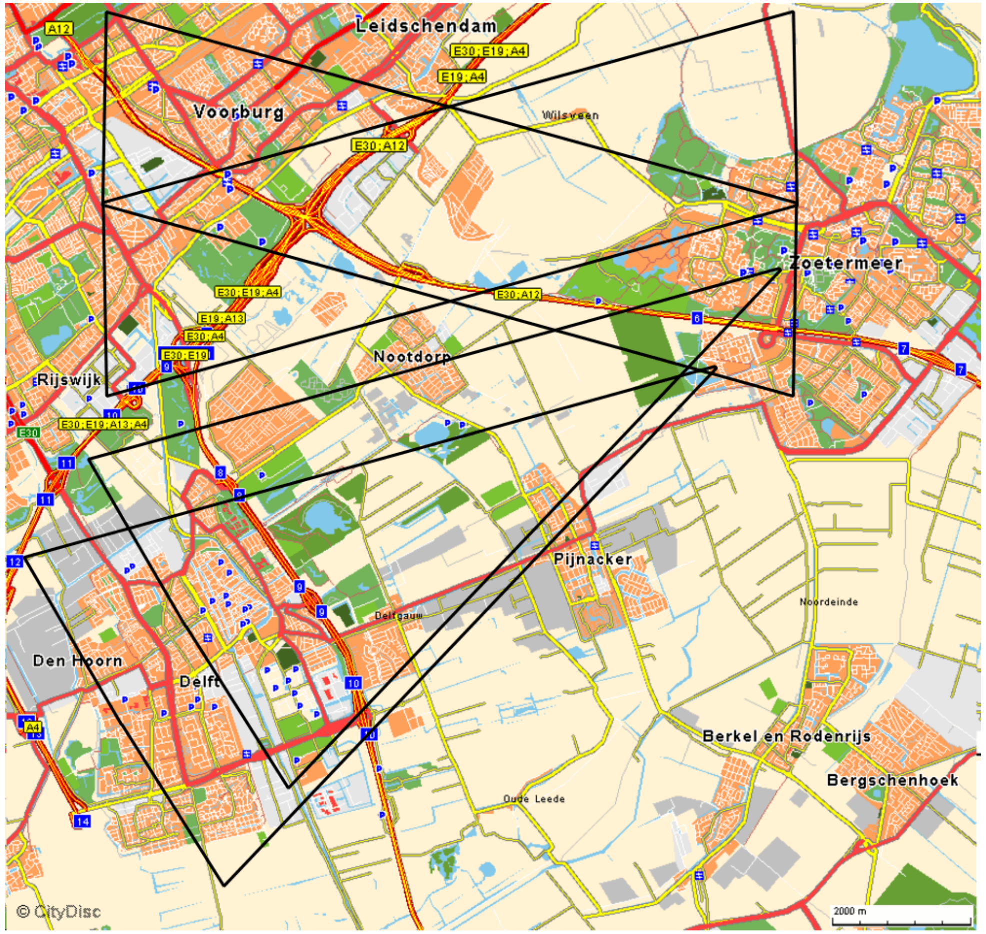
Comfort



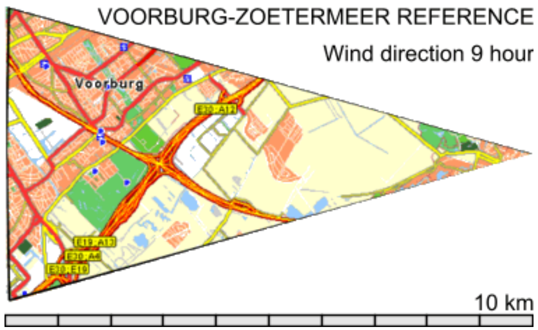


also dependent upon direction and roughness per direction.

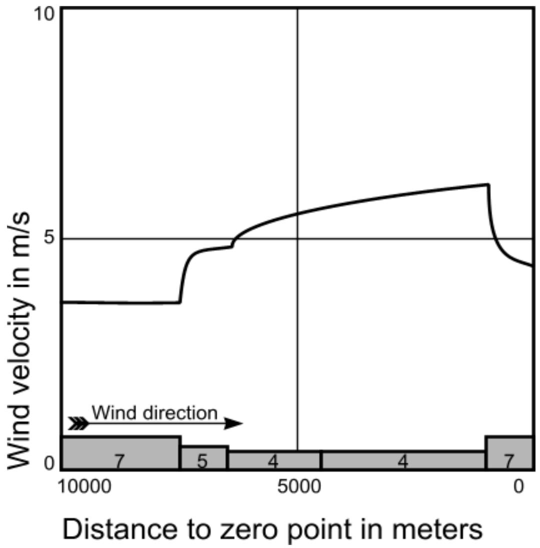
Regional behaviour

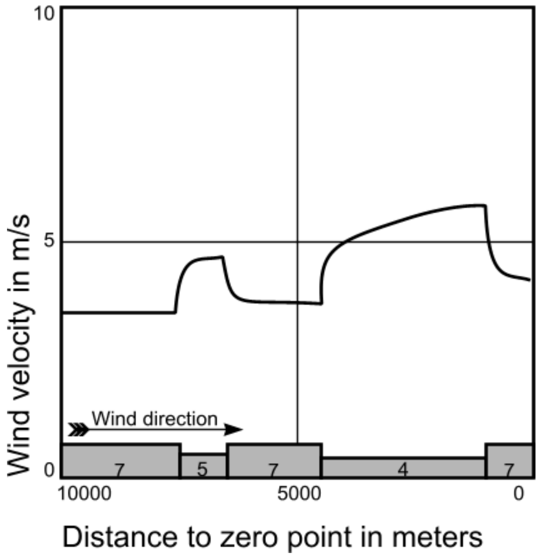


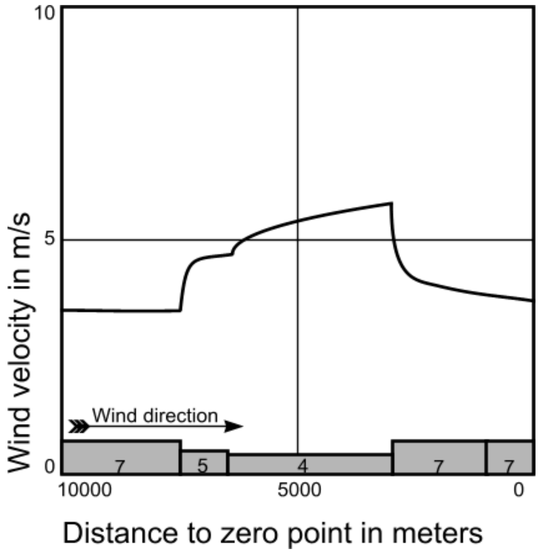
Windvelocity at 20m altitude



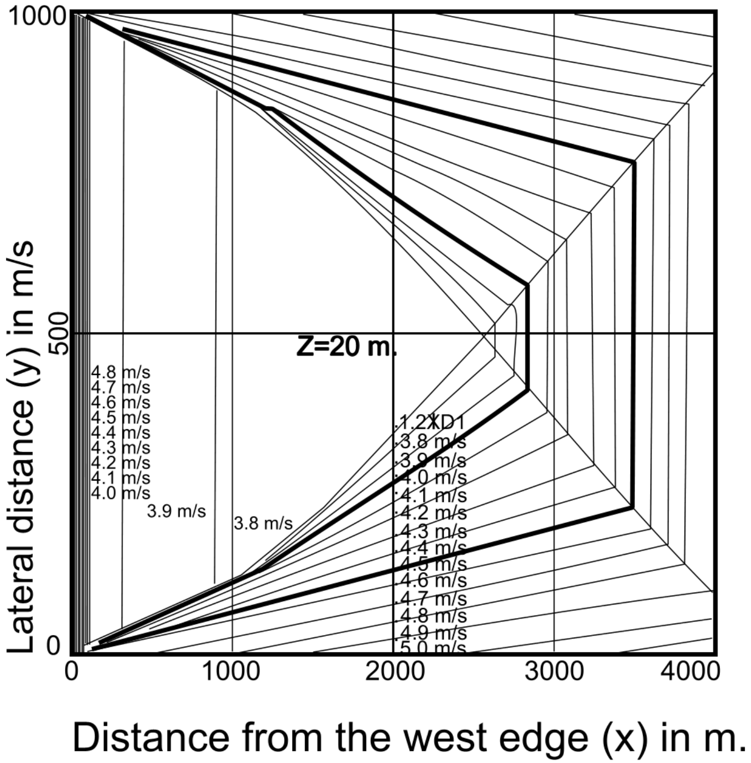
Where to locate Leidschenveen?

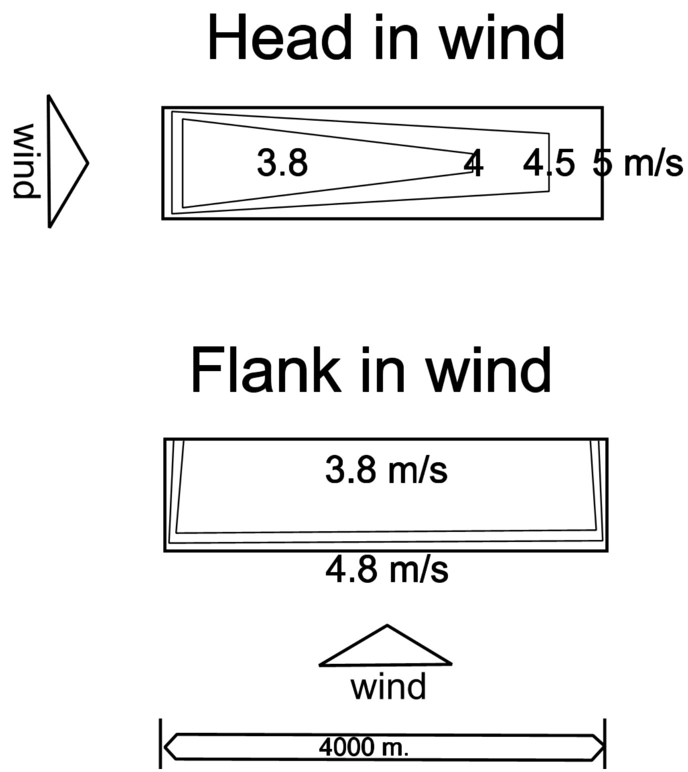




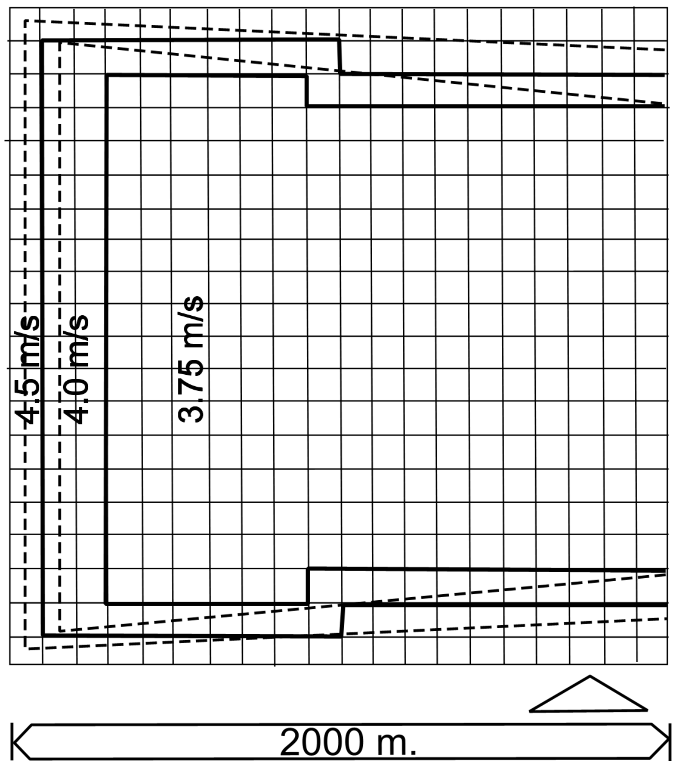


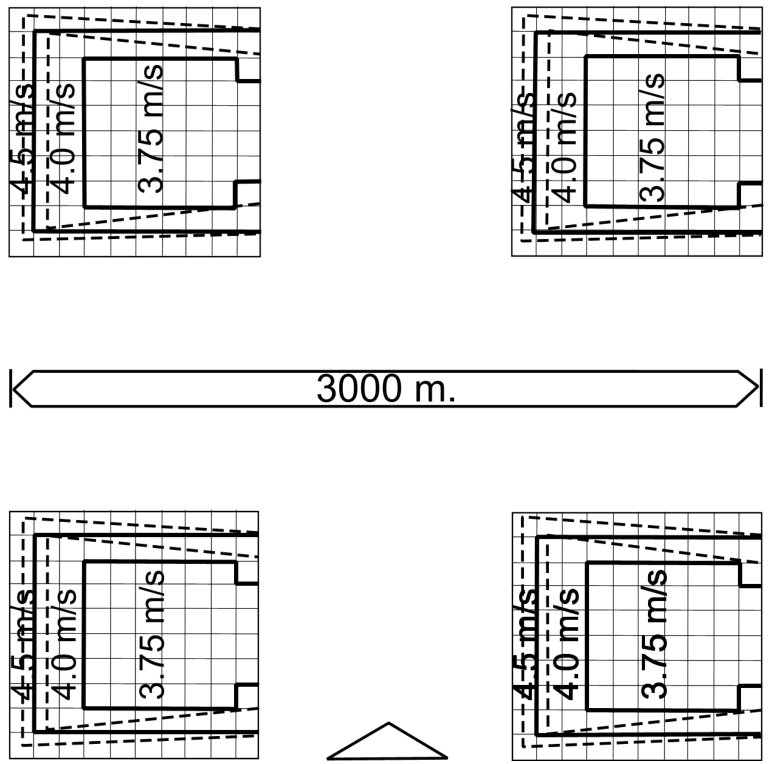
Lateral impacts



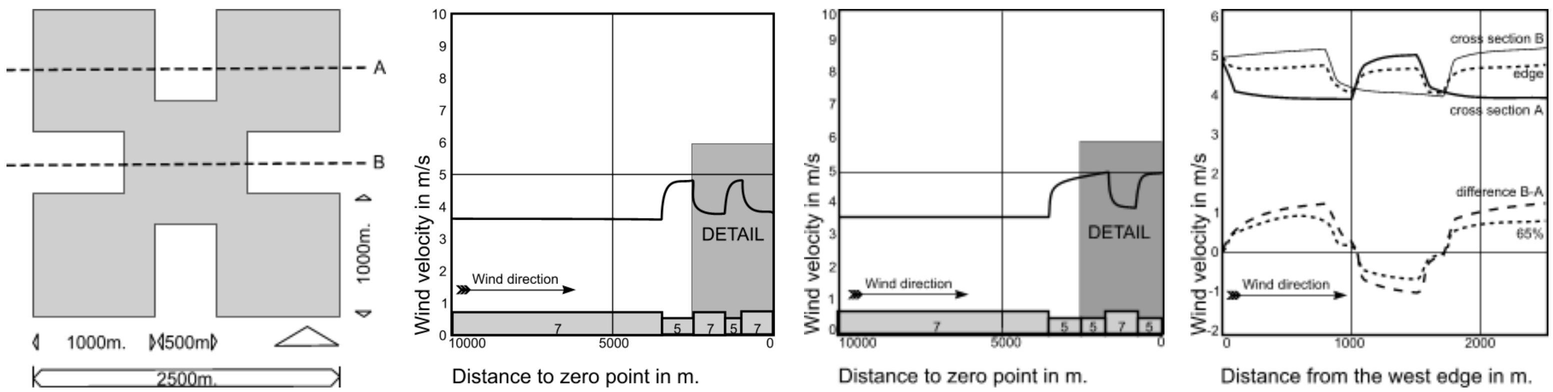


Lateral impacts

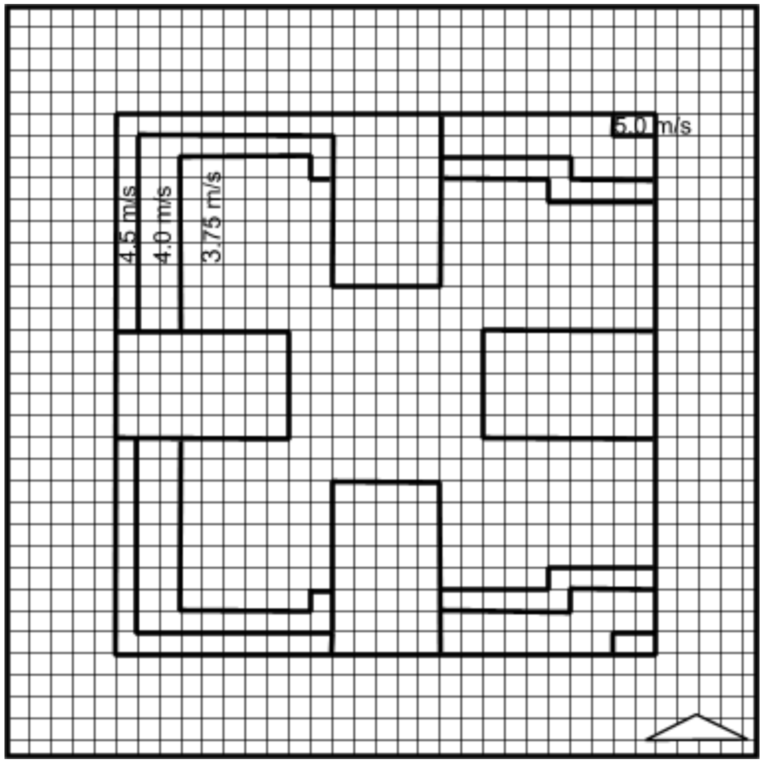


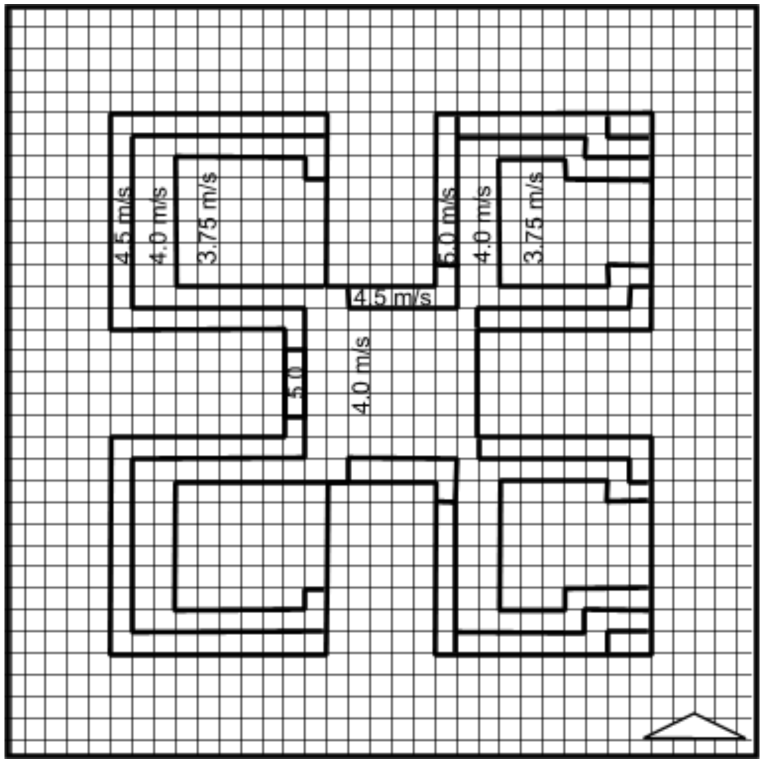


Lobe city

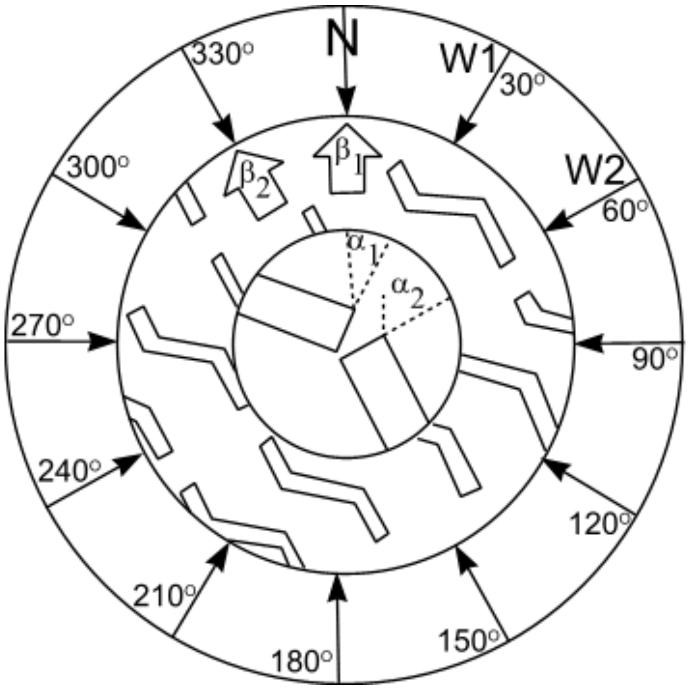

A
B
1000m.
1000m.
500m
2500m.
Wind velocity in m/s
DETAIL
Wind direction
Distance to zero point in m.
Wind velocity in m/s
DETAIL
Wind direction
Distance to zero point in m.
cross section B
edge
cross section A
difference B-A
65%
Wind velocity in m/s
Wind direction
Distance from the west edge in m.

Lobe city


5.0 m/s
4.5 m/s
4.0 m/s
3.75 m/s


4.5 m/s
4.0 m/s
3.75 m/s
5.0 m/s
4.0 m/s
3.75 m/s
4.5 m/s
5.0
4.0 m/s

Lower levels of scale



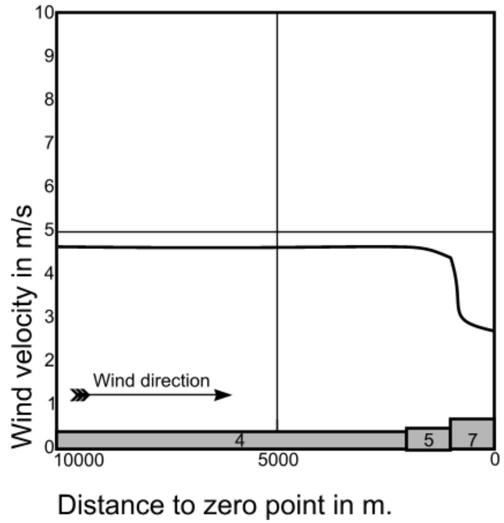
Wind directions

Orientation parcelling

Orientation façades

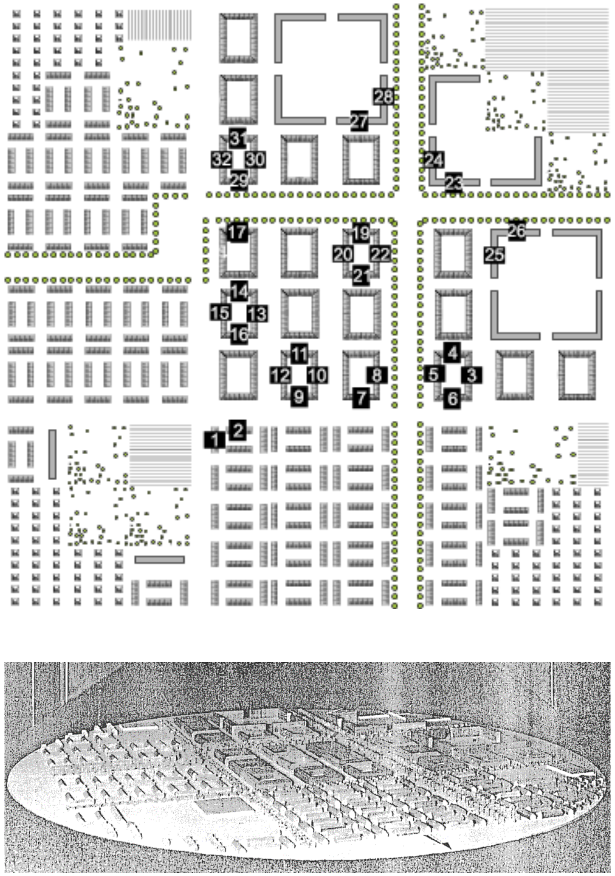
within parcelling

within wind directions

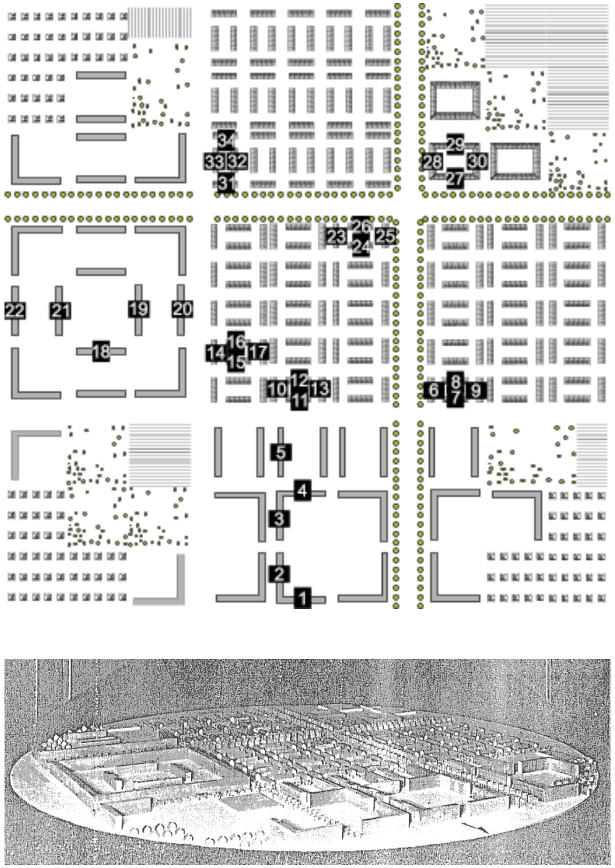


Districts R=1km

High rise peripheral or central

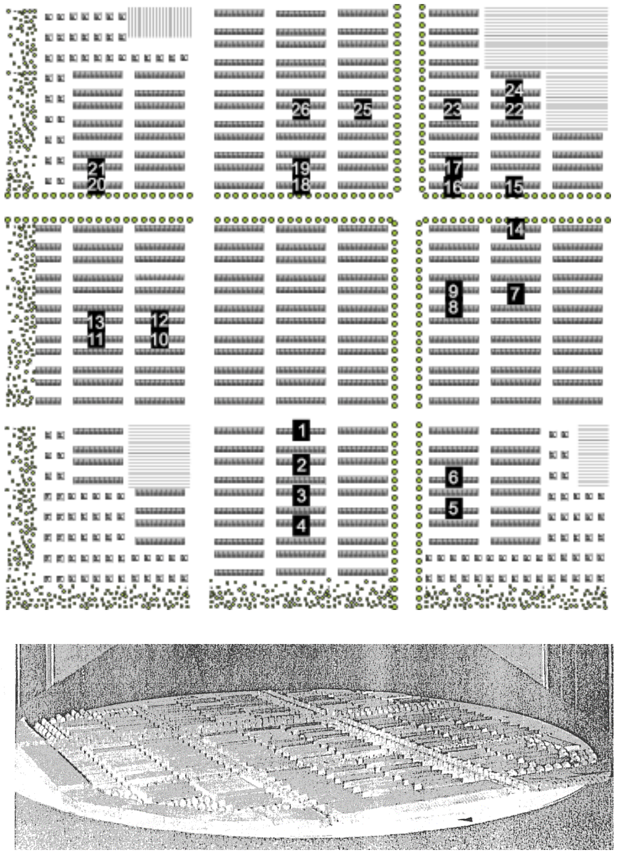


'Low rise at the edge'

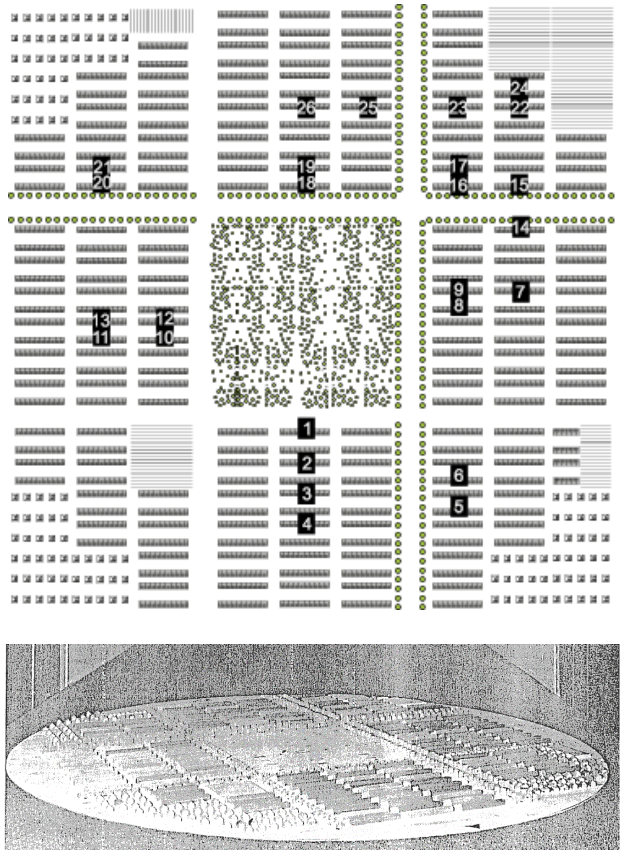


'High rise at the edge'

Green perpheral or central

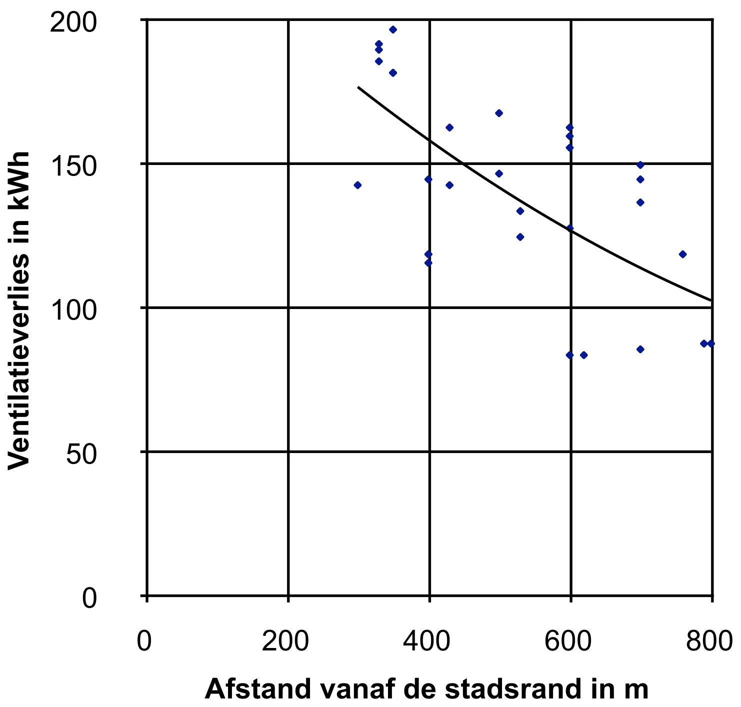


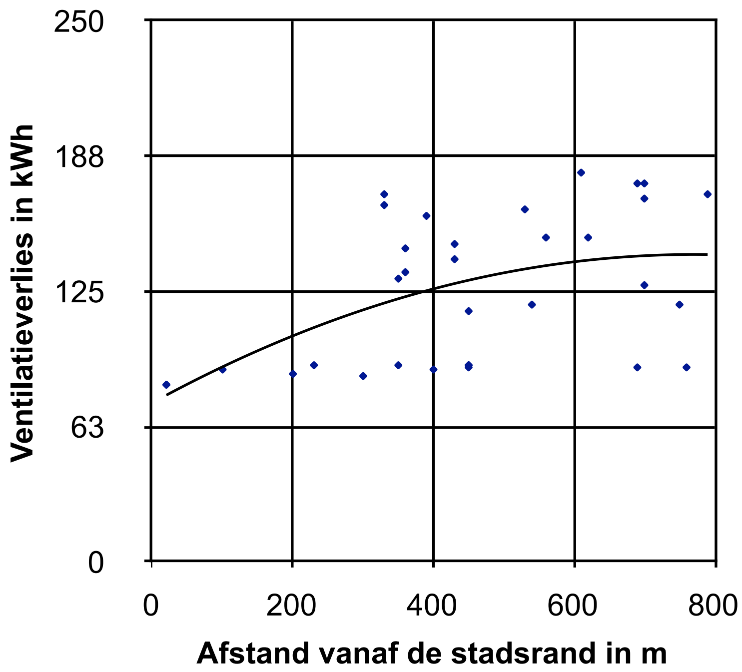
'Peripheral green'



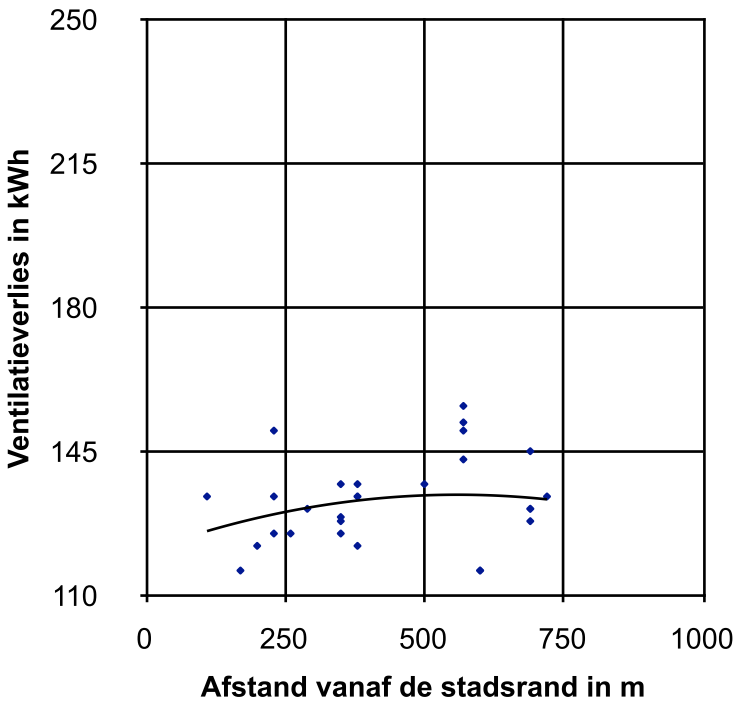
'Central green'

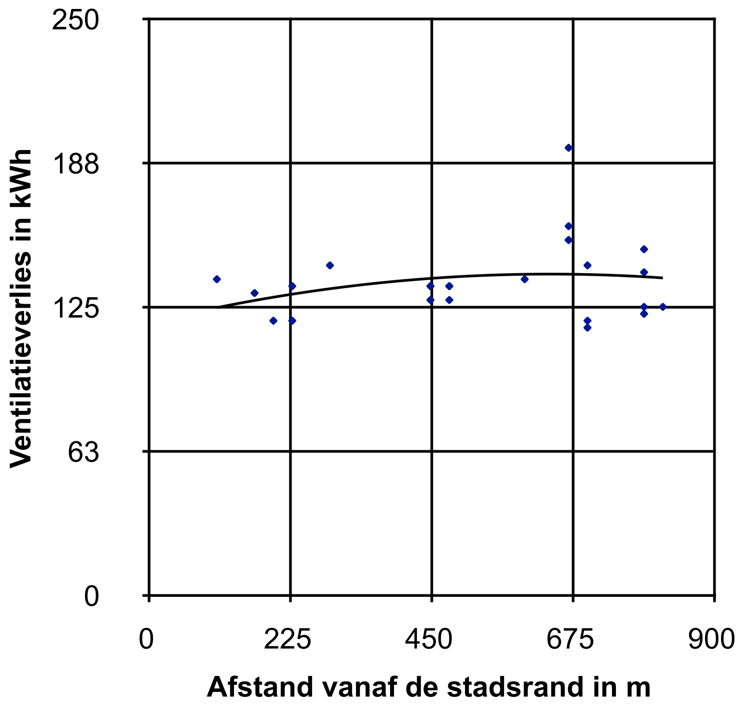
Low and high rise on the edge





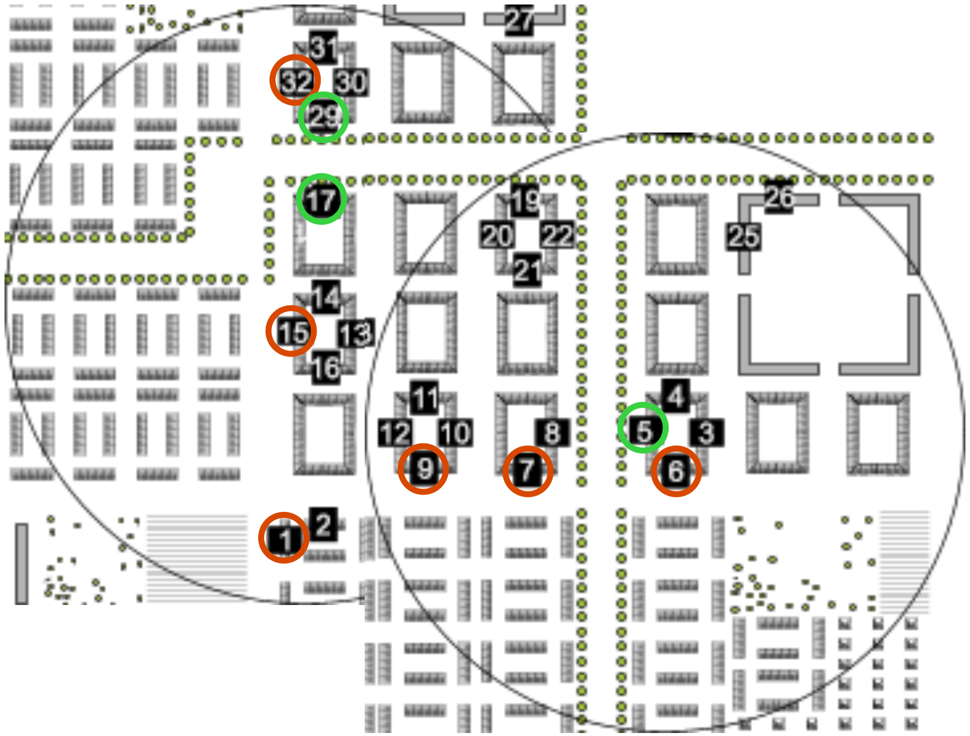
Green peripheral or central





Neighbourhoods R=300m

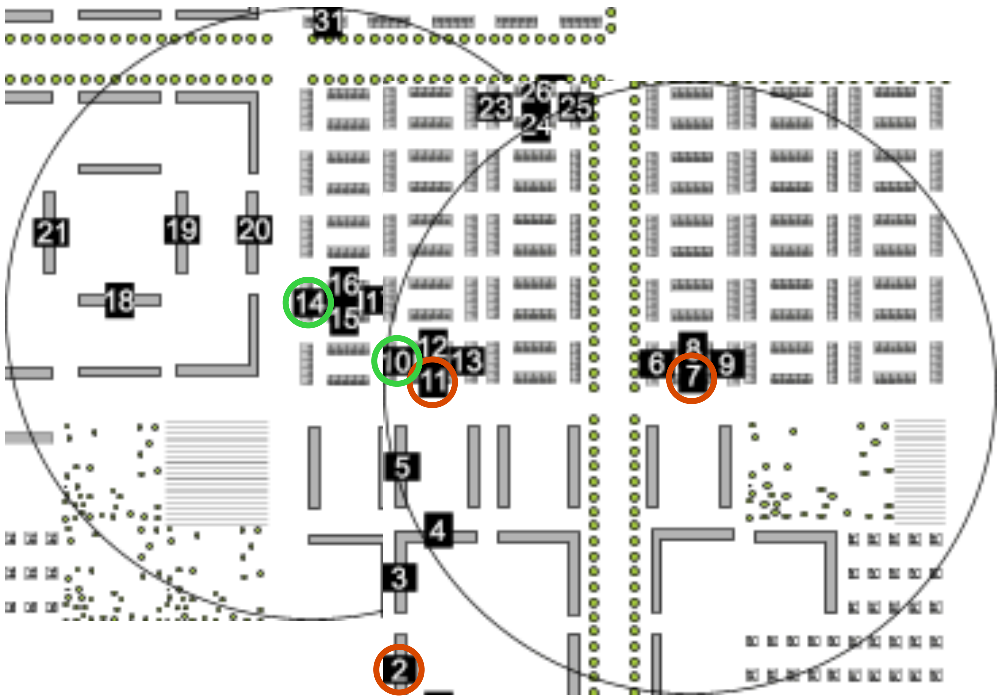
Neighbourhoods and trees



Measure points 1, 6, 7, 9, 15 and 32 score high by wind over a 40m neighbourhood road without trees.

Measure points 5, 17 and 29 get wind over a much wider district road (80 to 100m) with 6m heigh trees score lower.

Neighbourhoods and trees

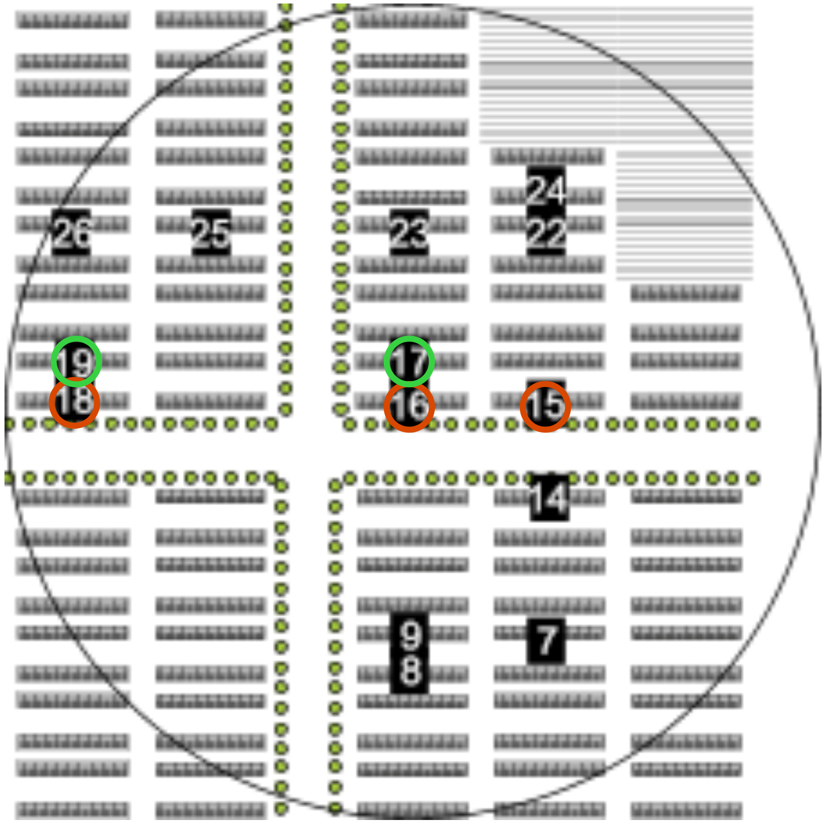


Measure points 2, 7 and 11 score high: these lie on a 40m wide neighbourhood road without trees.

Measure point 14 scores low because it is sheltered by 22m high high rise buildings on the other side of the road.

The low rise minimum measure point 10 lies on 10m wide ensemble streets.

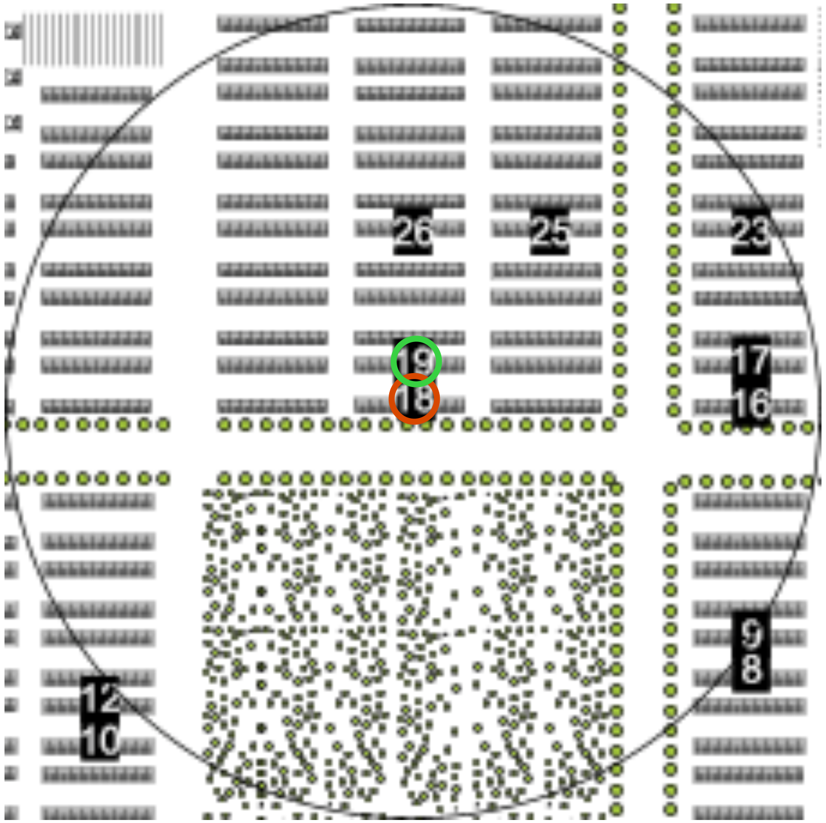
Neighbourhoods and trees



Measure points 18, 15 and 16 score high lying on a 70m wide district road with trees.

Minima 17 and 19 get wind from a backyard lying on 10m wide ensemble roads.

Neighbourhoods and trees

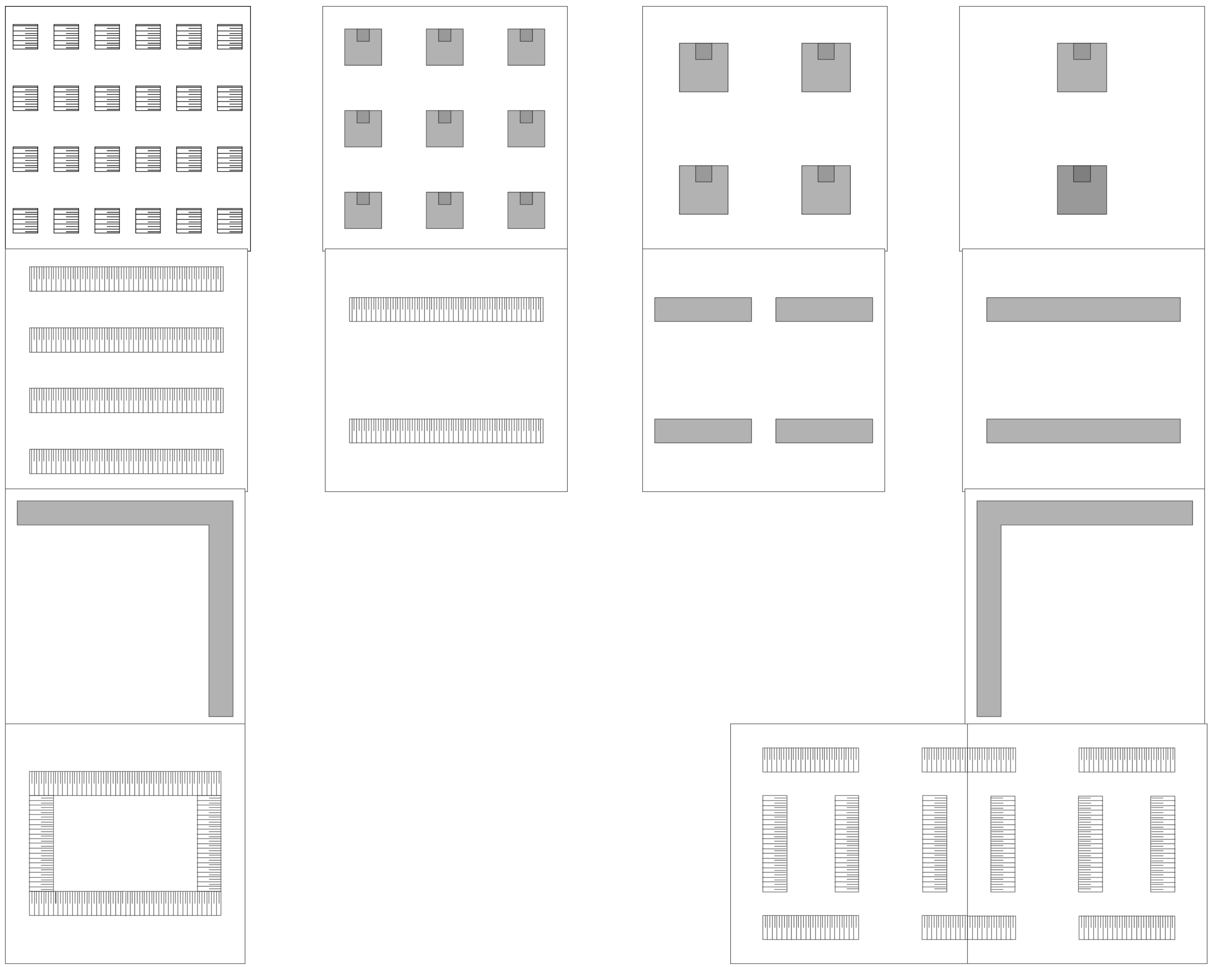


Measure point 18 scores extremely high. It gets wind from 300m wide open green area in the centre of district quarter. Even district road trees do not help much on this location.

Measure point 19 lies on a small street, but that is the first street behind the green behind measure point 18, and that is still apparent there.

Allotments R=100m

Repeating hectare allotments



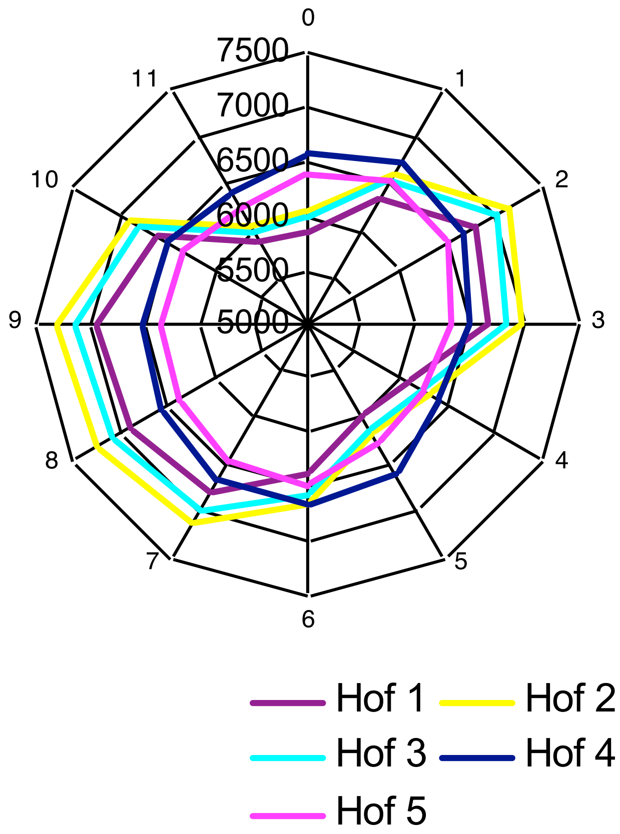
point

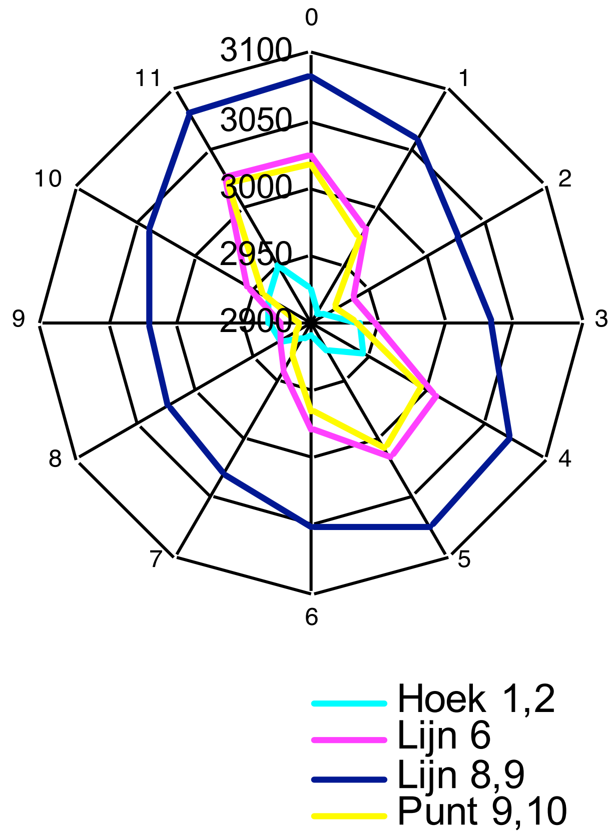
line

angle

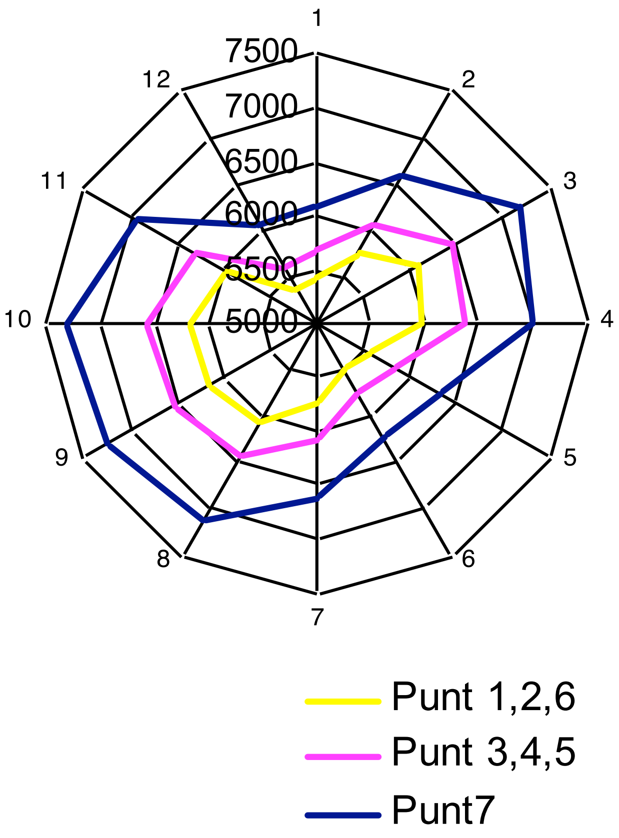
court

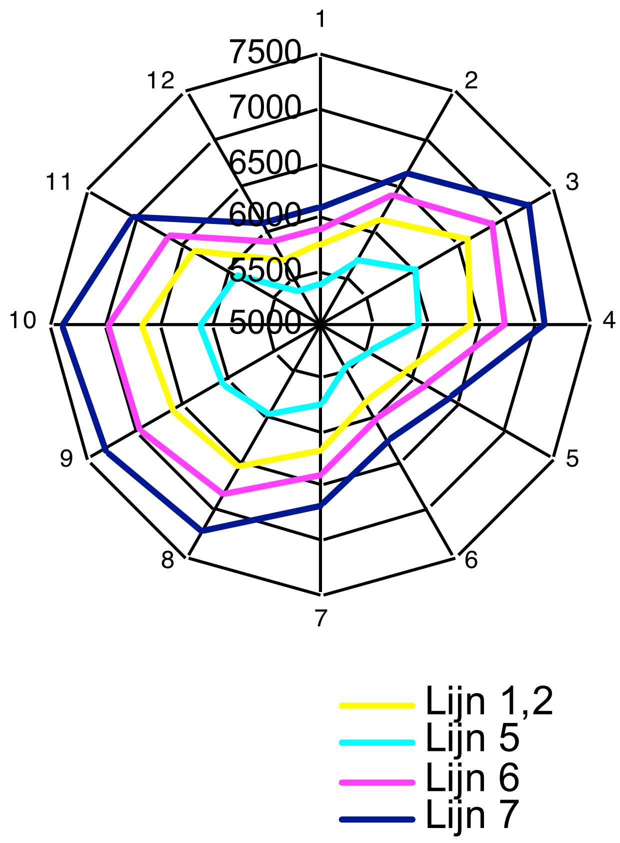
Court and high rise allotments



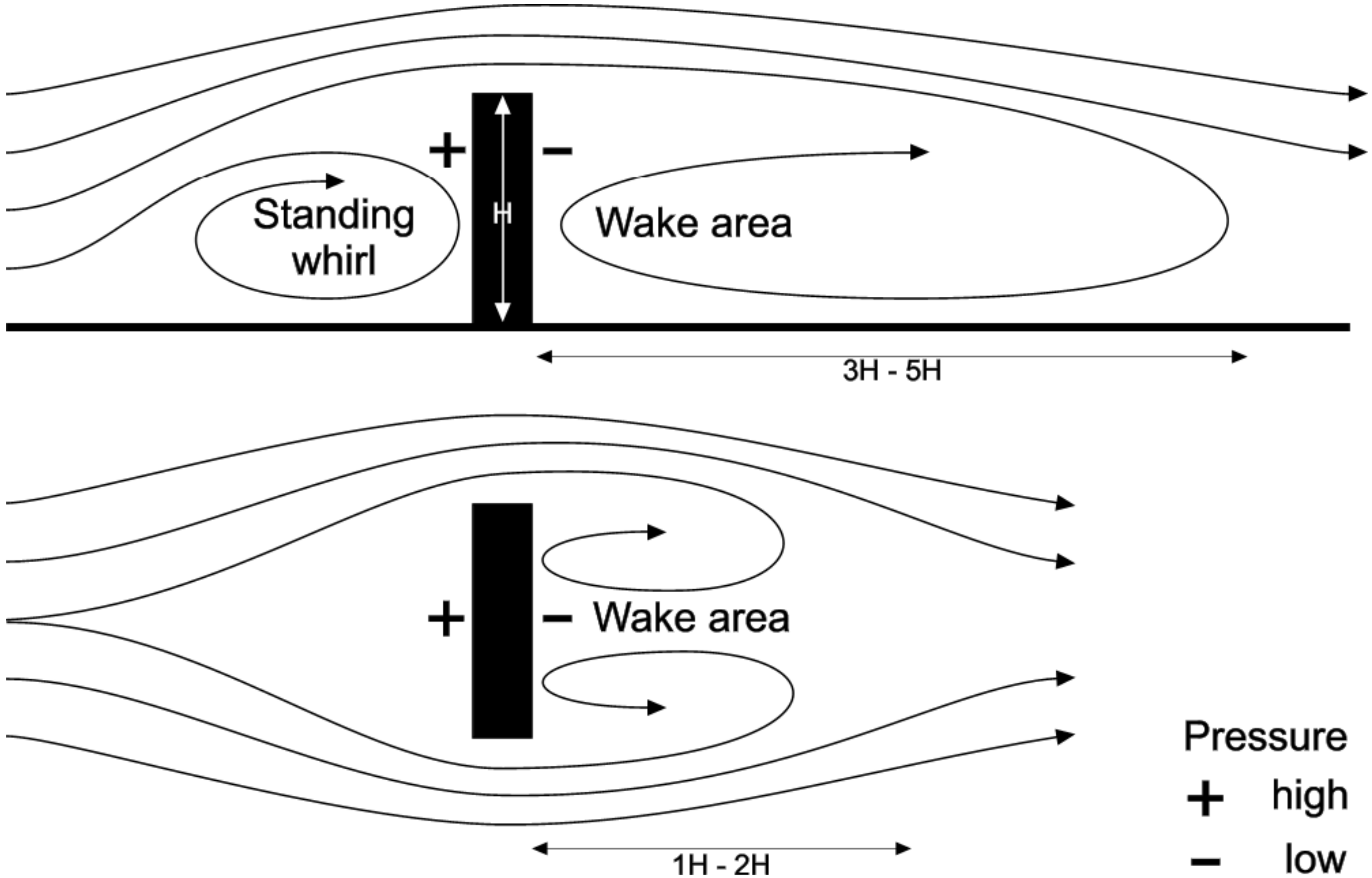


Point and line allotments





Building level



Vibration in the air

If air is moving into one direction longer than 5 seconds it is measured as ‘wind’.

- If it is flowing back in the next 5 seconds it is not counted in wind statistics.
- It has a frequency f = 1/5 = 0.2 vibrations per second or ‘0.2Hz’ (hertz): ‘wind’ nor ‘sound’.
- Sound starts at 16Hz.

Sound

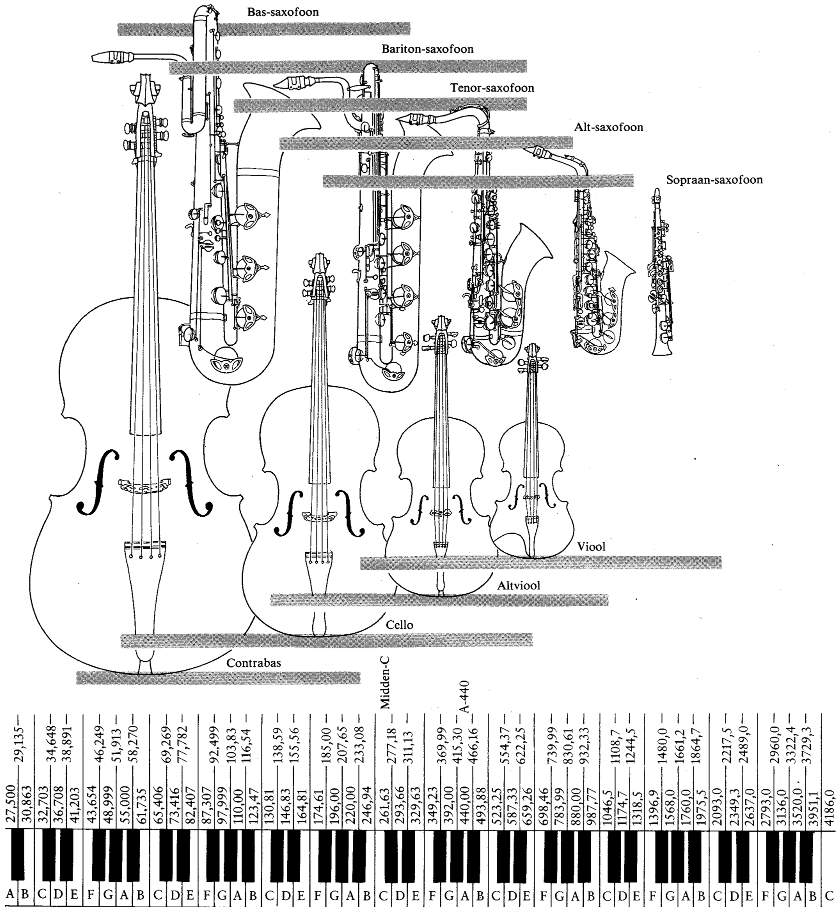
Vibrations from 16 Hz until 20 000 Hz are accepted as ‘sound’ by our eardrums.

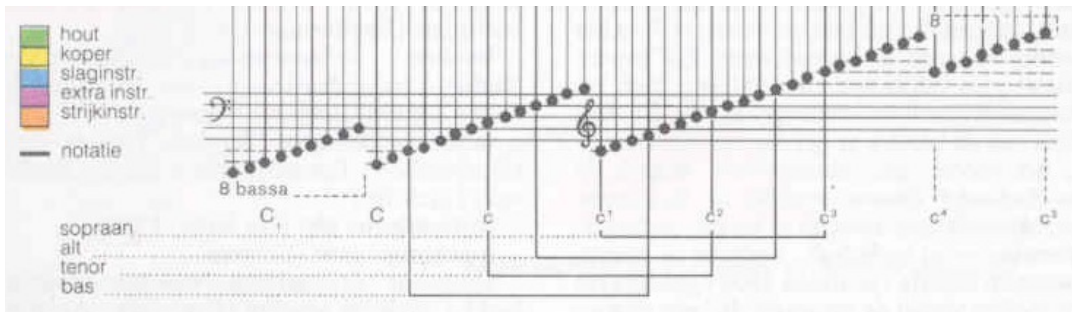
Vibrations slower then 16Hz are called infrasonic, faster then 20 000Hz ultrasonic.

A piano starts at 27.5, ending at 4186Hz.

Span of music

Frequences starting at 27.5Hz:





Notes

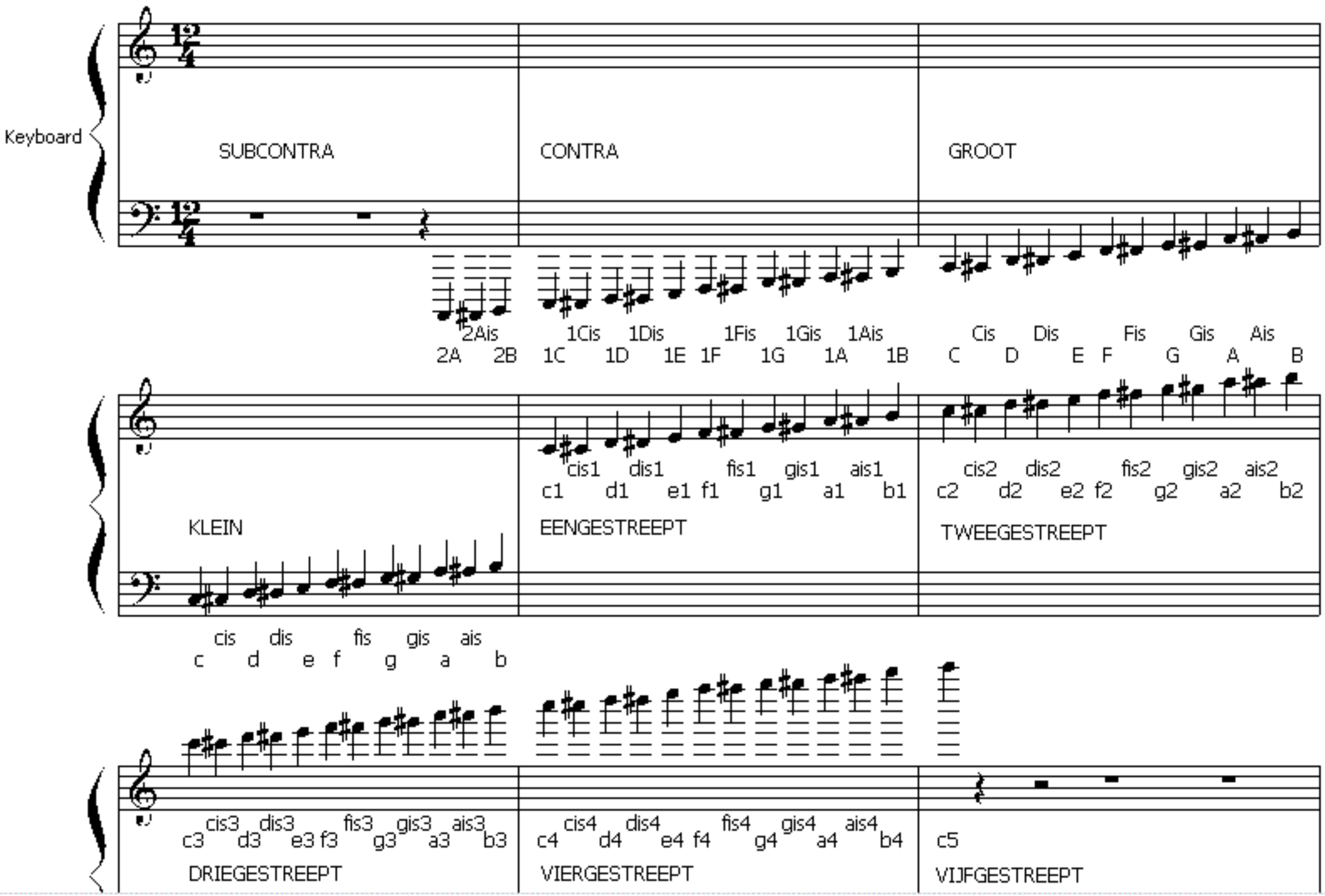
Any next octave doubles the frequency.

An octave is subdivided in 12 notes (named a, ais or bes, b, c, cis or des, d, dis or es, e, f, fis or ges, g, gis).

Because $2^{1/12} = 1.0594630944$, the frequency of any next key is a factor 1.0594630944 higher than the previous one.

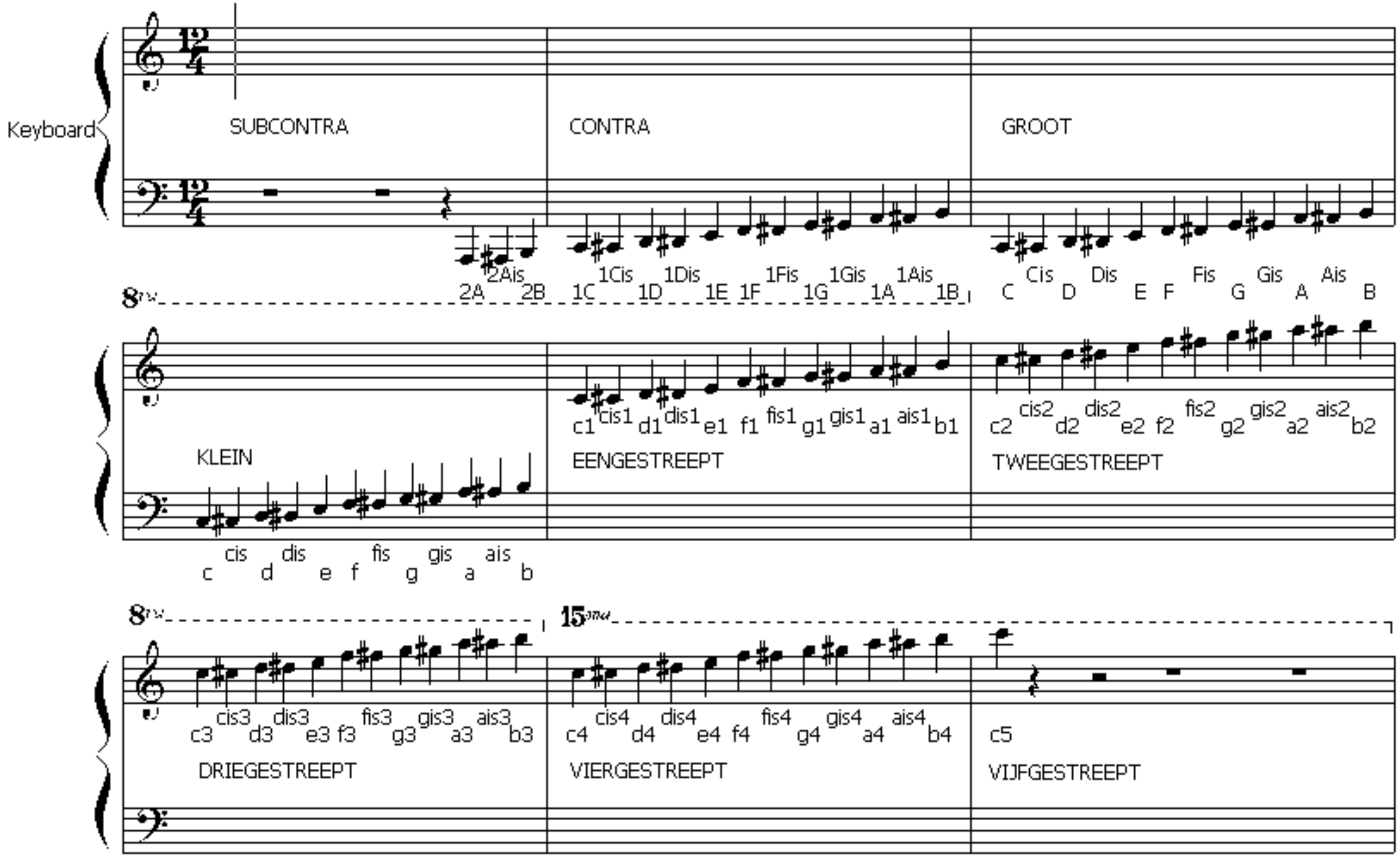
So you can calculate the frequency of any note (n=0…87) by $f(n)=27.5 \times 1.0594630944^n$.

Notes and Octaves

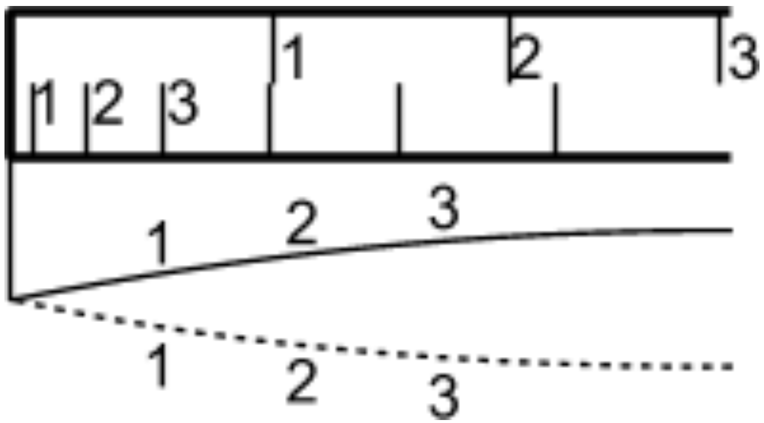


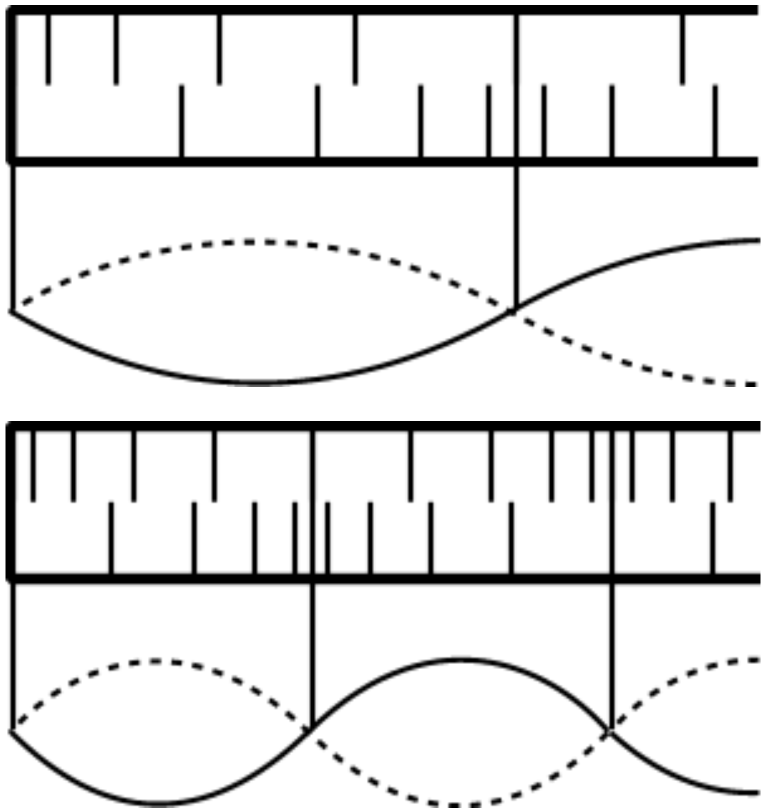
Notes and Octaves

Package

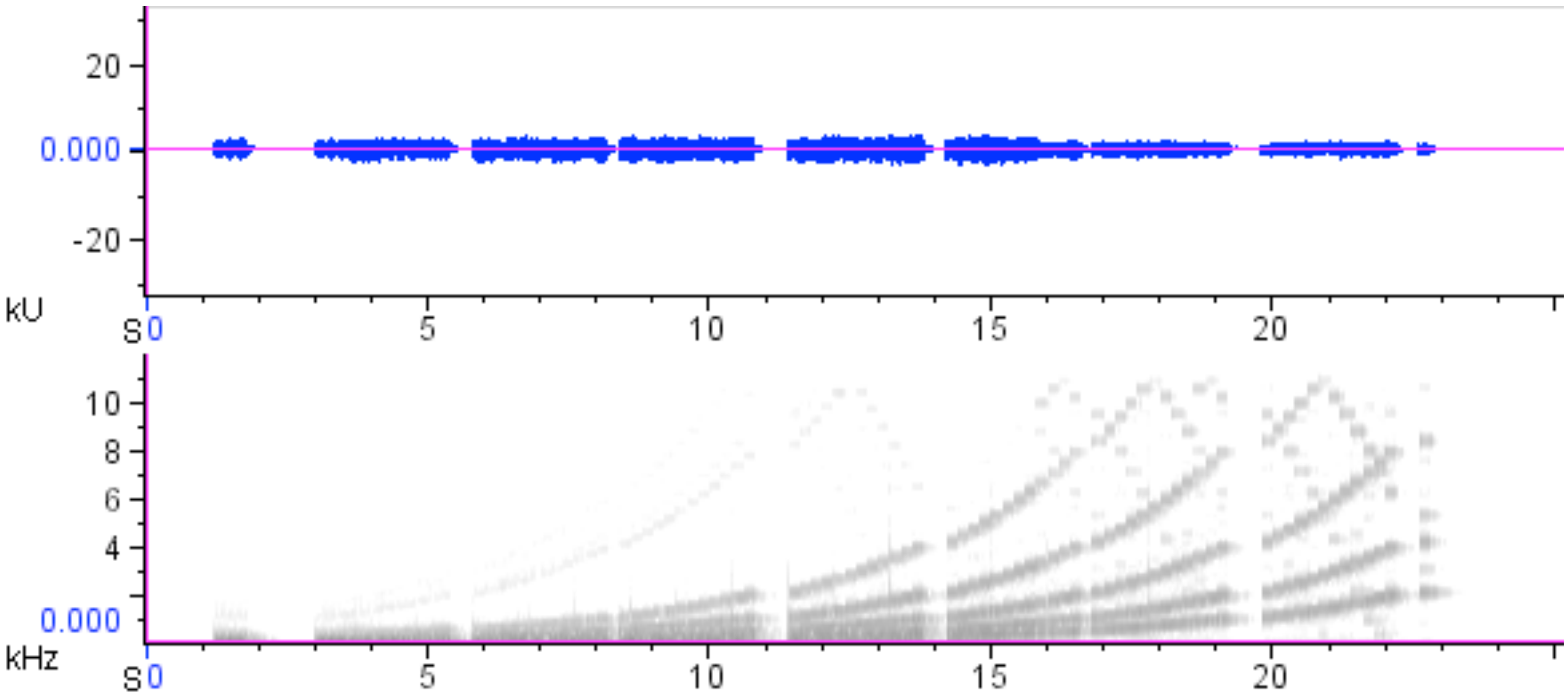


Overtones





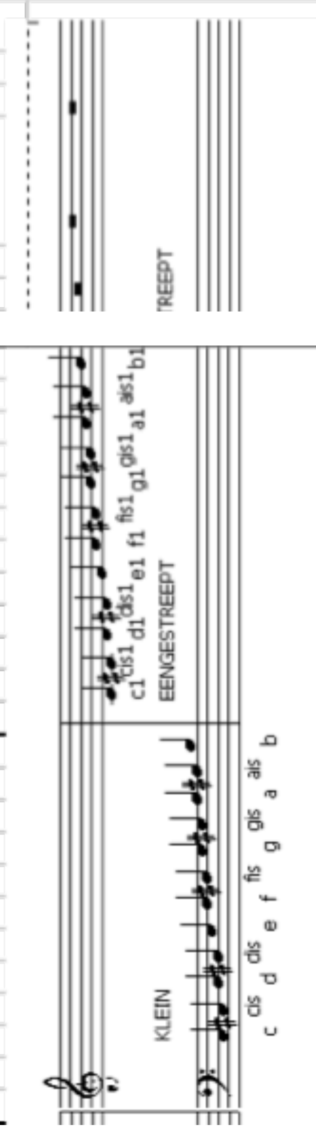
Notes amplitude and frequency



Music notes, intervals

Music notes

m/sec velocity v	factor	keybord		
340	1,0594630944			
0,688	493,883	50	b1	b1
0,729	466,164	49	bes1	ais1
0,773	440,000	48	a1	a1
0,819	415,305	47	as1	gis1
0,867	391,995	46	g1	g1
0,919	369,994	45	ges1	fis1
0,974	349,228	44	f1	f1
1,031	329,628	43	e1	e1
1,093	311,127	42	es1	dis1
1,158	293,665	41	d1	d1
1,227	277,183	40	des1	cis1
1,300	261,626	39	c1	c1
1,377	246,942	38	b	b
1,459	233,082	37	bes	ais
1,545	220,000	36	a	a
1,637	207,652	35	as	gis
1,735	195,998	34	g	g
1,838	184,997	33	ges	fis
1,947	174,614	32	f	f
2,063	164,814	31	e	e
2,186	155,563	30	es	dis
2,316	146,832	29	d	d
2,453	138,591	28	des	cis
2,599	130,813	27	c	c



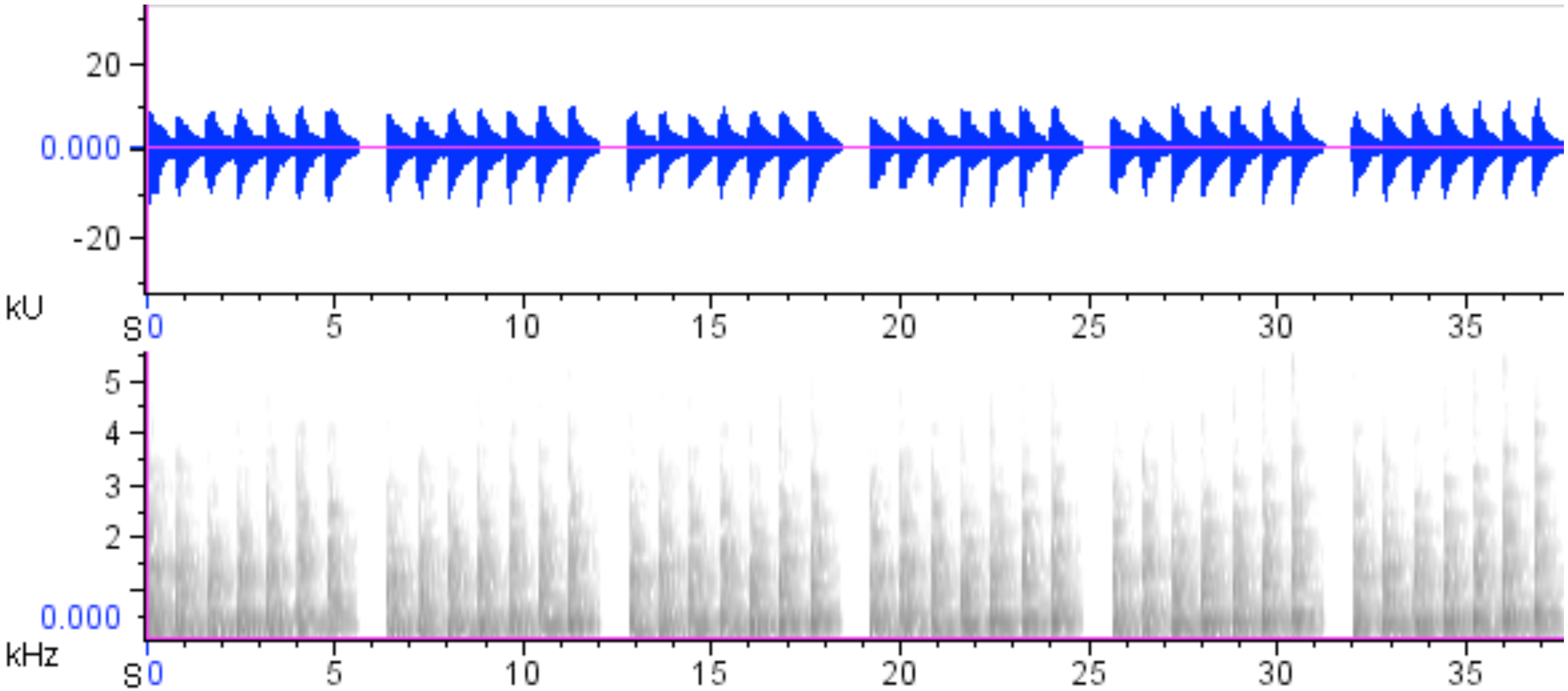
Harmonic intervals

stamtonen	seconds	thirds	fourths	fifths	sixths
	secundes	tertsen	kwarten	kwinten	sexten
b1					
a1	stemtoon	klein^	rein^	rein^	
g1					
f1		groot^			groot^
e1			rein^		
d1		klein^		rein^	
c1	centrale c				
b	secundes	tertsen	kwarten	kwinten	sexten
a	groot^				klein^
g	groot^	groot^		rein^	
f	groot^		overmatig^		
e	klein^	klein^			
d	groot^				
c	groot^	groot^	rein^	rein^	groot^

HARMONIC INTERVALS

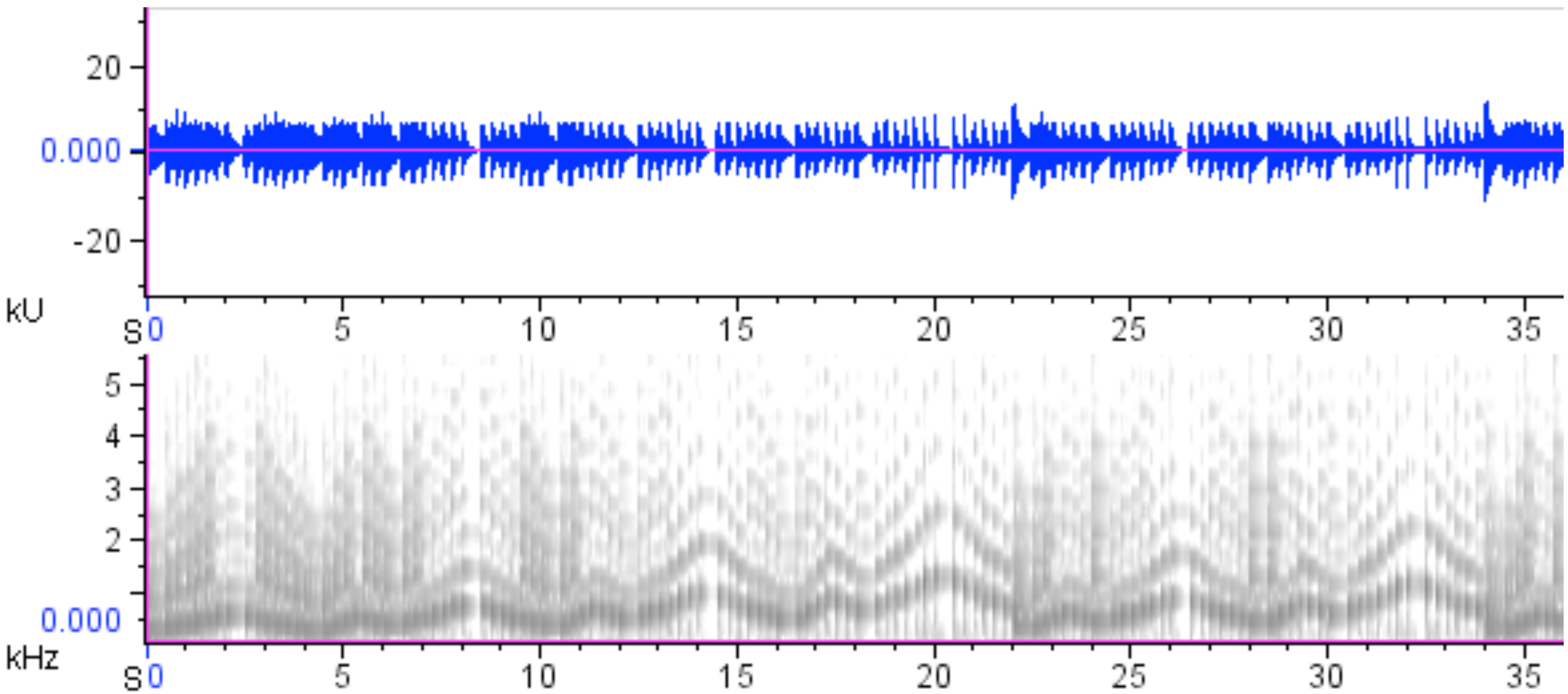
Package

Intervals amplitude and frequency



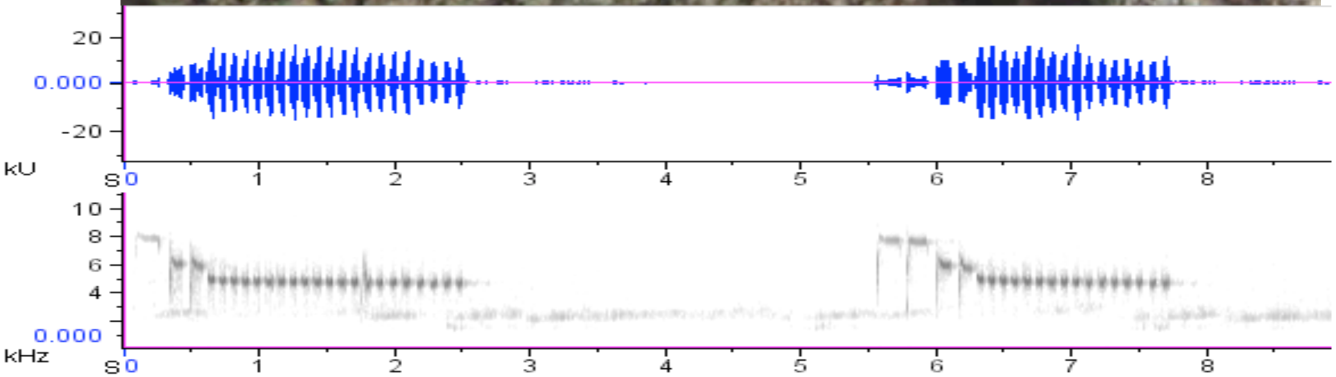
Scales

Scales amplitude and frequency



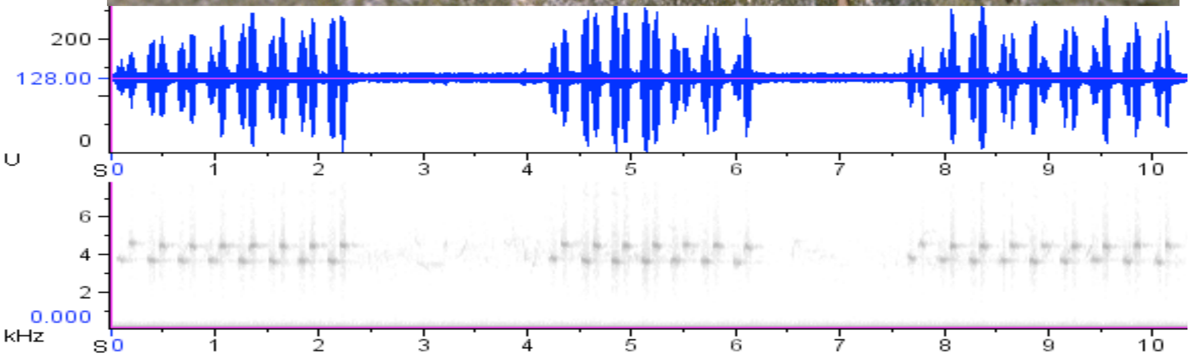
Package

Bluetit (pimpelmees)

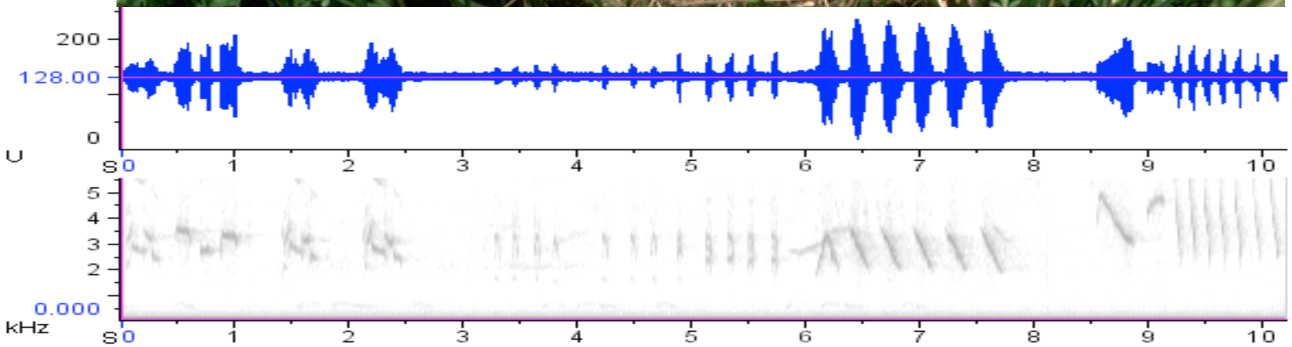


Great tit (koolmees)

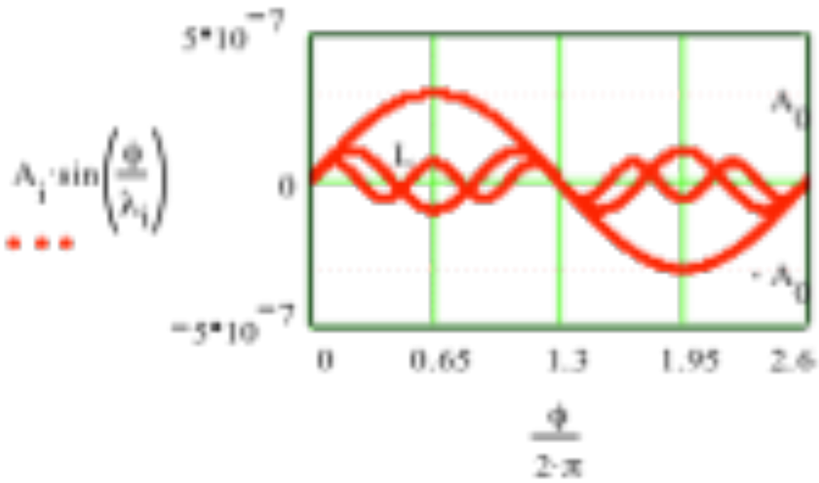
Package

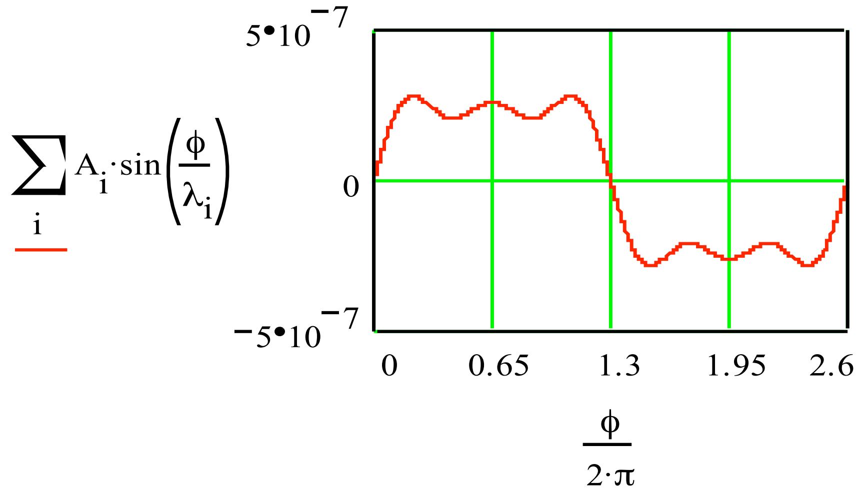


Song thrush (zanglijster)

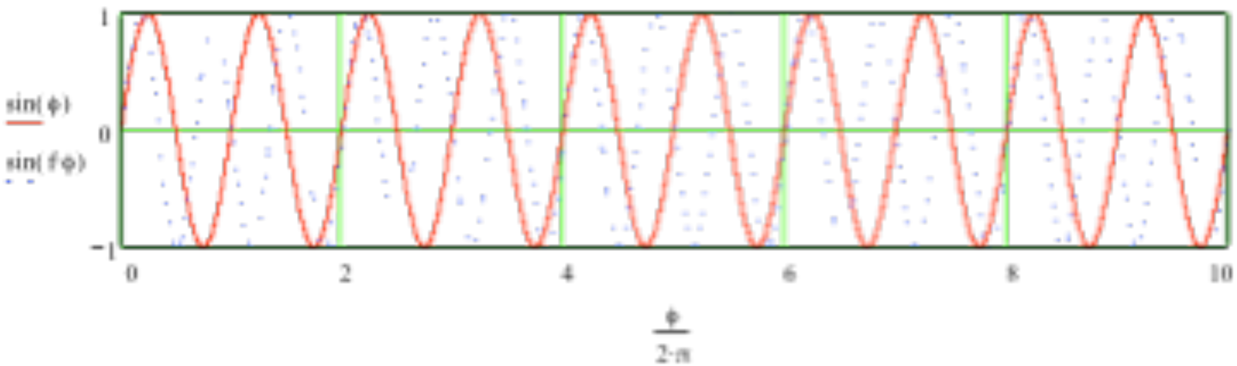


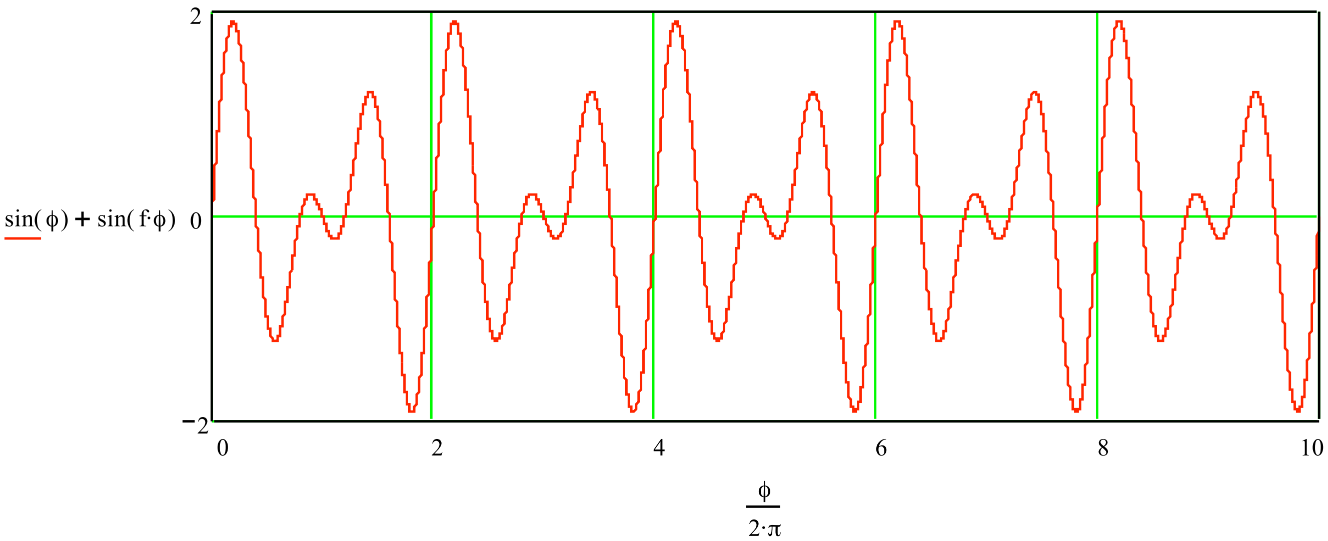
Added amplitudes



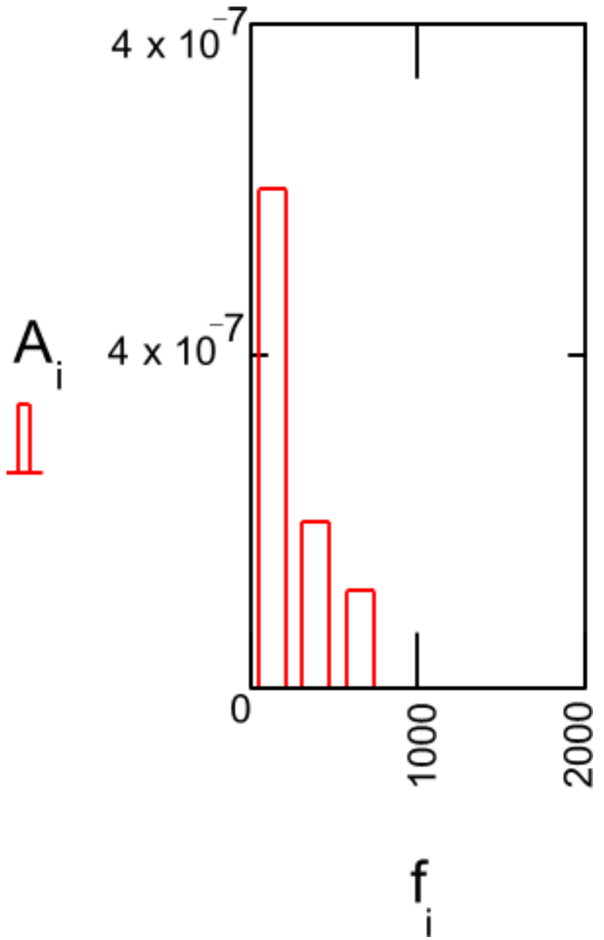


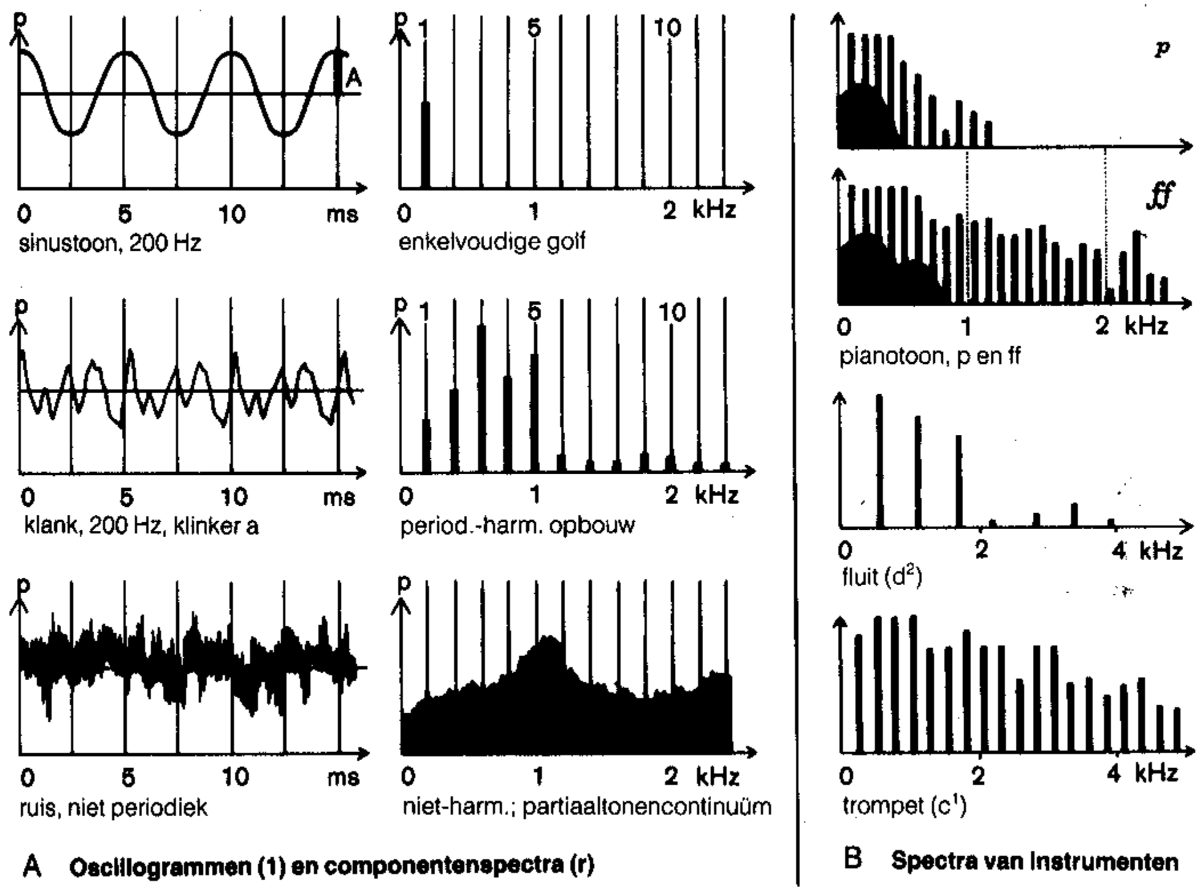
Supposition of tones





From sound to noise





Power/m^2

The power/m^2 of a sound wave (called intensity ‘I’, expressed in W/m^2) depends on

frequency f (tone),

amplitude A (loudness),

air density ρ (normally $1.290 kg/m^3$), and

travel speed c (normally 340m/sec)

according to $I = \rho \times (2 \times \pi \times f \times A)^2 \times c/2$.

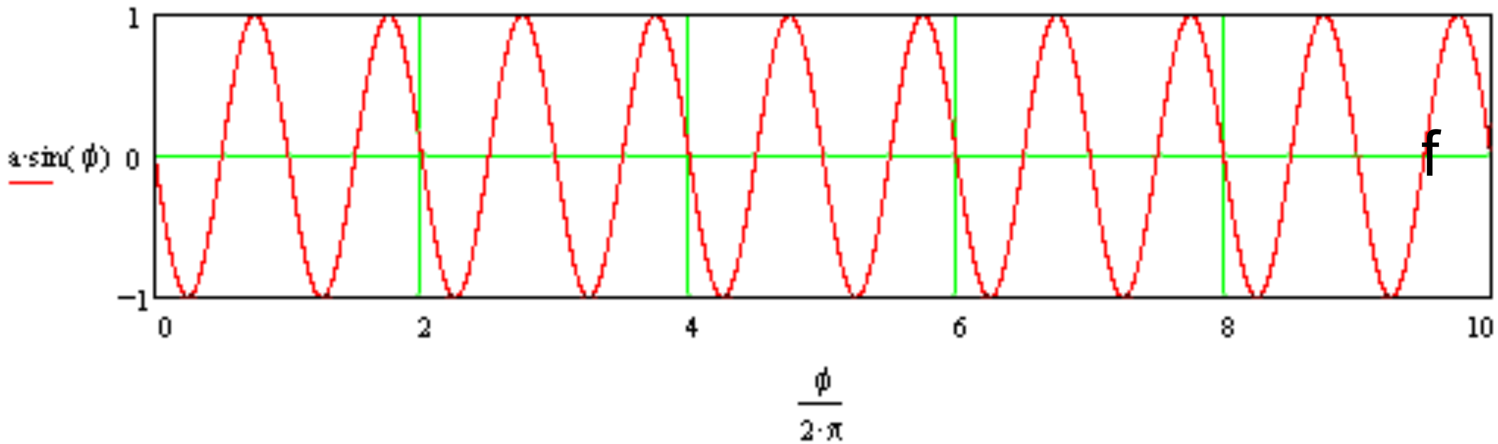
So, in normal ρ and c conditions power depends on frequency f and amplitude A according to

$I = 8658 \times (f \times A)^2$.

Power of sound (f,A)

Power = 8658 x (frequency x Amplitude)^2

a = −1



f A

Distance

A globe with 28cm radius has a surface of $1m^2$.

At 28cm a voice has a power of 10^{-5} W/m^2.

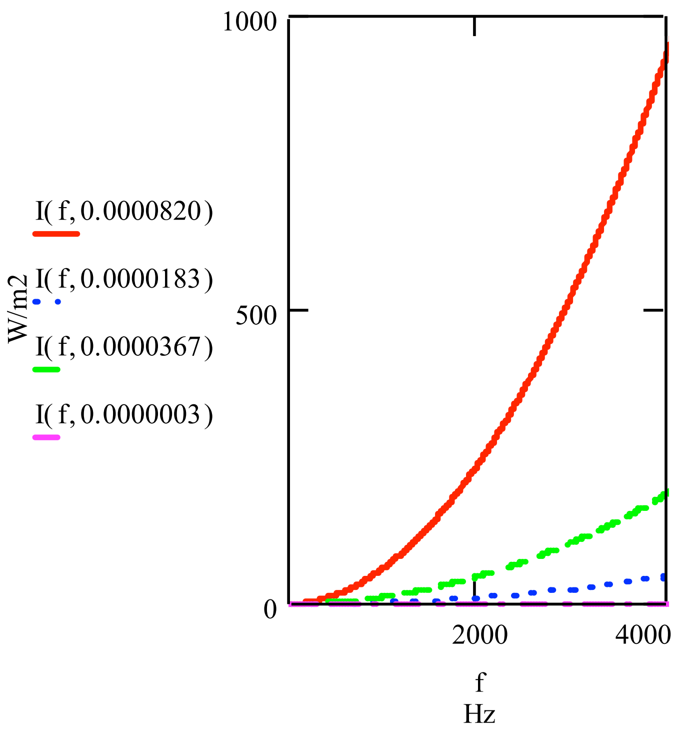
Composed by adding $8658*(f \times A)^2$ for every frequency and its Amplitude.

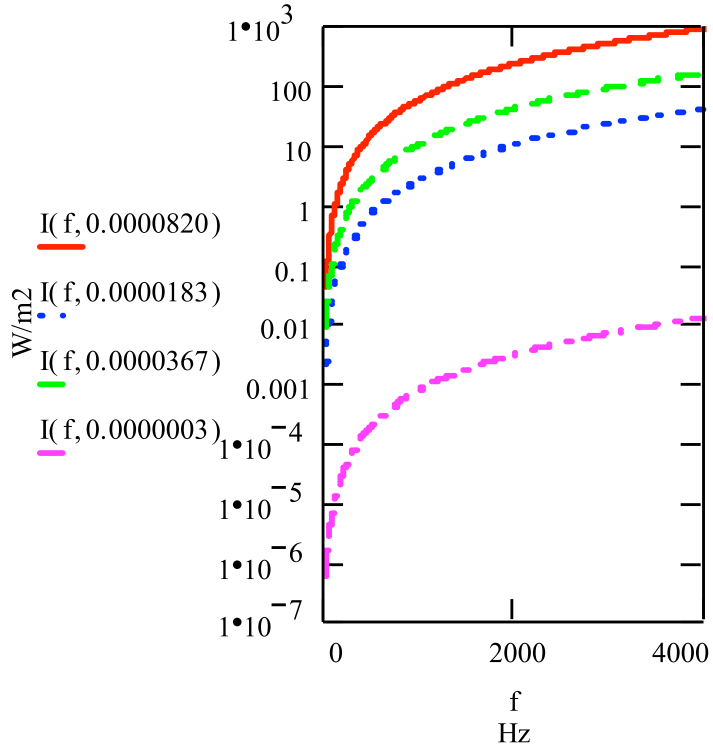
Piano <$0.2W/m^2$.

Orchestra <$5W/m^2$.

Loudspeaker <$100W/m^2$.

Intensity(frequency, amplitude)





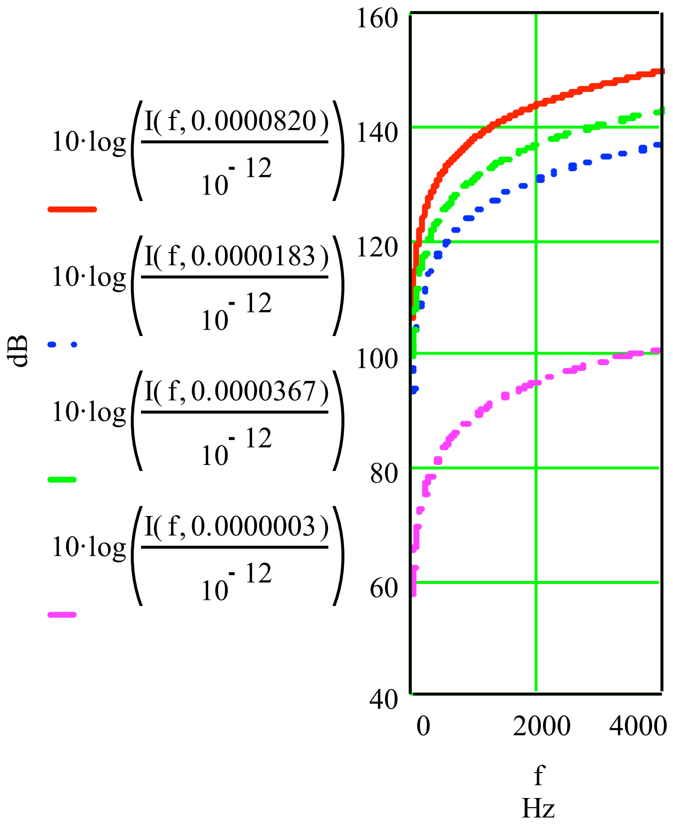
Intensity (W/m^2) and dB

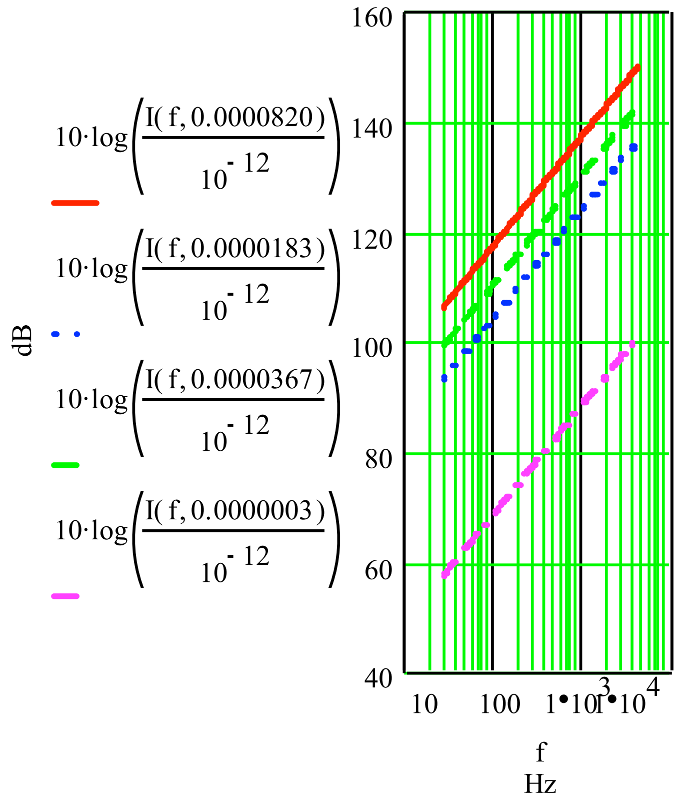
A logarithmic representation shows the range from soft to loud better.

Dividing the intensity by a standard of 10^{-12} W/ m^2 (comparing it with that standard) we get positive logarithms from 0 to 14, starting with what is just audible.

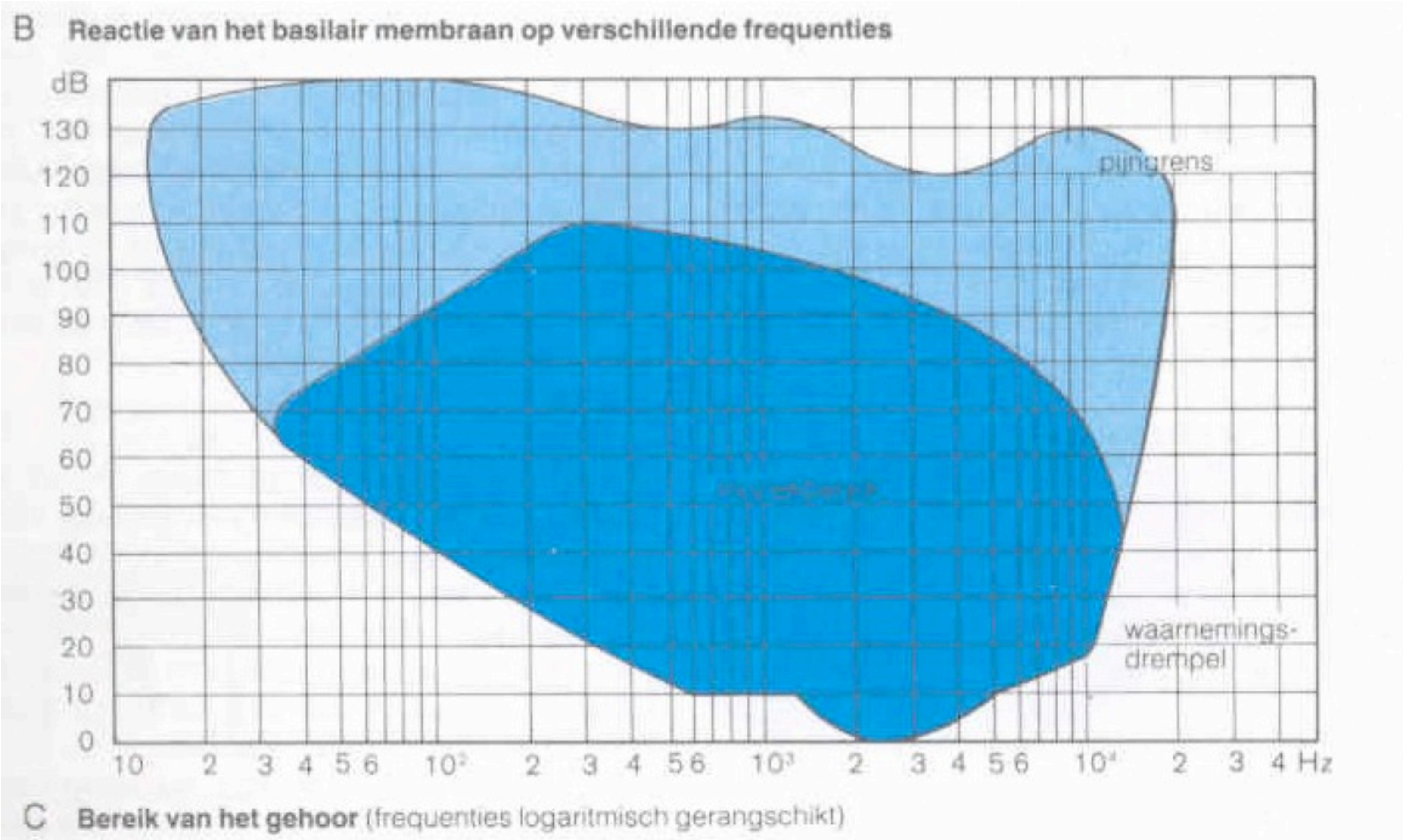
Multipying it by 10 we get a useful range of decibells (dB) from 0 to 150.

From intensity to dB

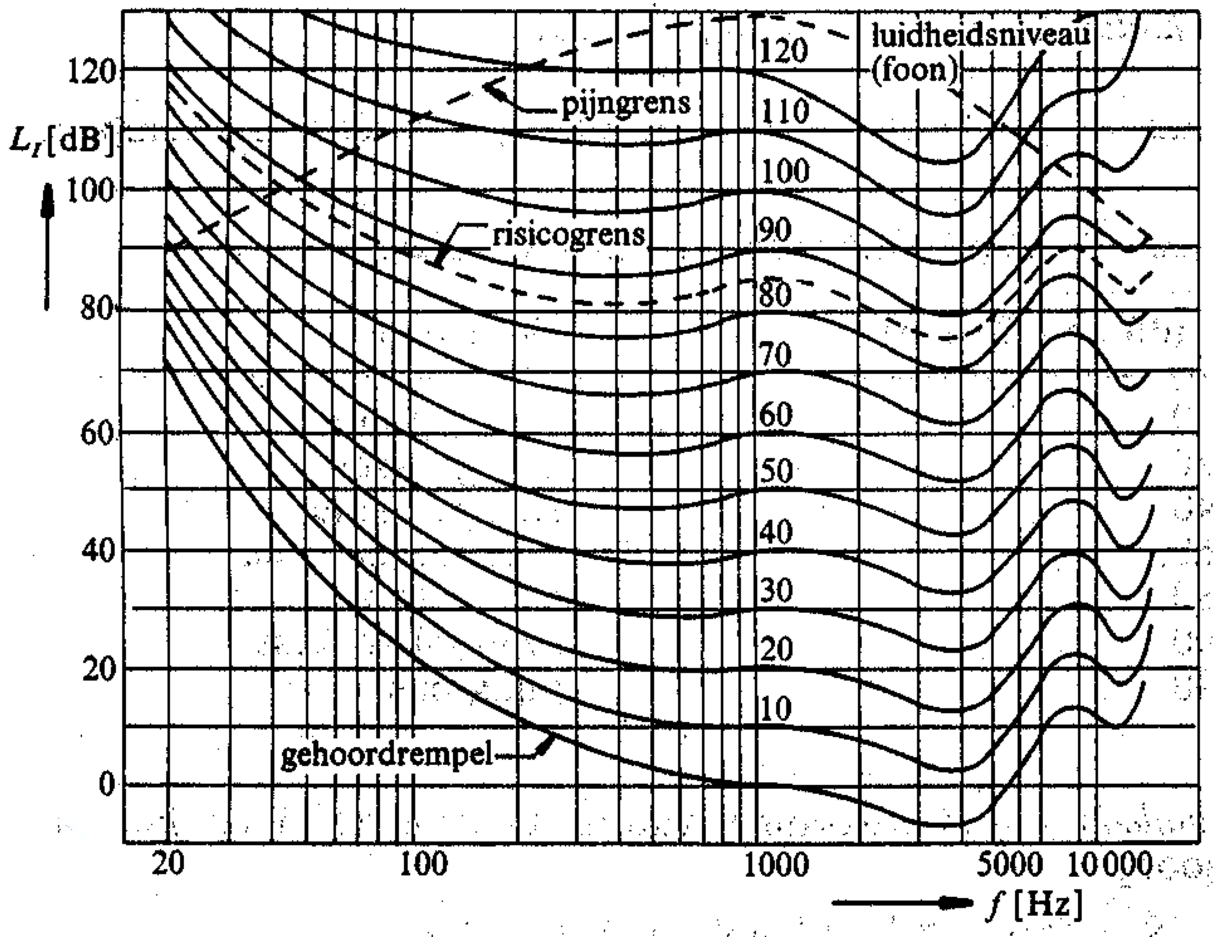




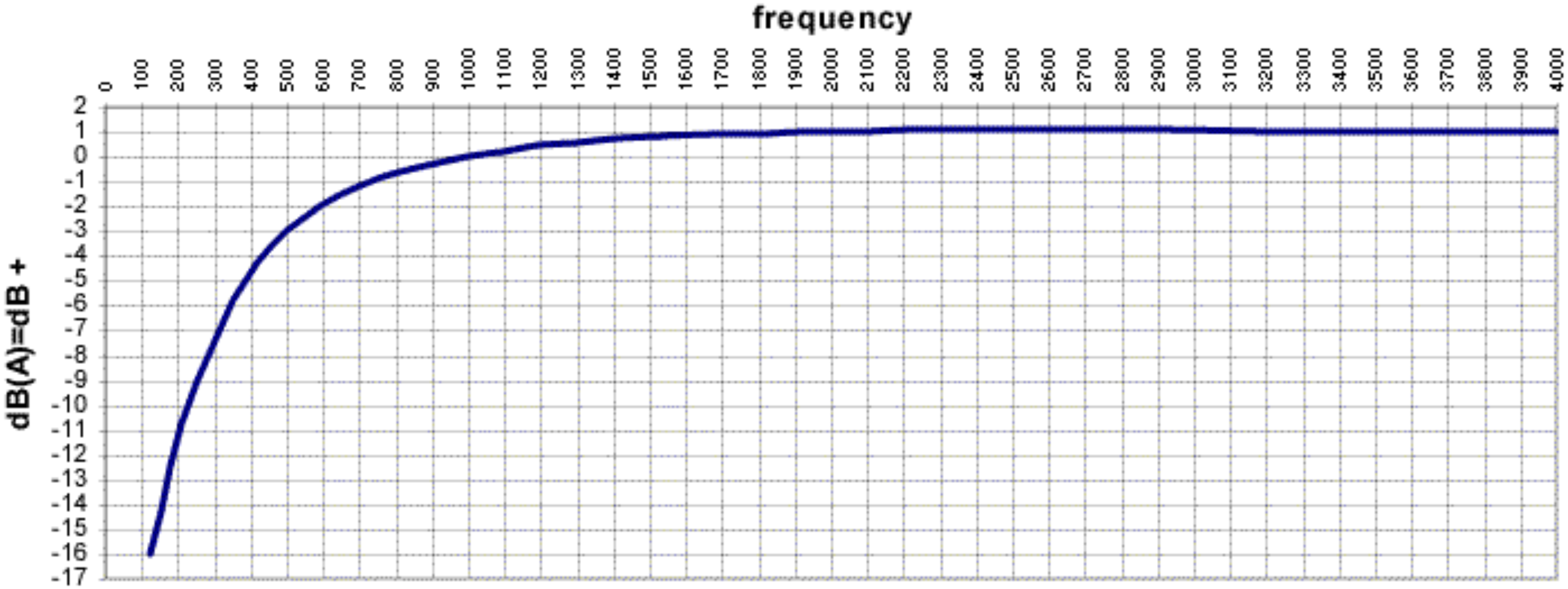
Audibility


B Reactie van het basilair membraan op verschillende frequenties
dB
130
120
110
100
90
80
70
60
50
40
30
20
10
0
10
2
3
4
5
6
10²
2
3
4
5
6
10³
2
3
4
5
6
10⁴
2
3
4 Hz
pijngrens
waarnemings-
drempel
C Bereik van het gehoor (frequenties logaritmisch gerangschikt)

dB(A): what we think to hear



From dB to dB(A)



Traffic noise

Traffic noise

http://www.stillerverkeer.nl/index.php?section=rmv&subject=RMW02&page=download

Db(A) Noise Nuisance according to SRM1	L_{Aeq}	**61,0 Db(A)**		
m Altitude Observer (O)	h_w	20,0		
m Altitude Road	h_{weg}	0,0		
m Altitude Traffic line		0,8		
m Horizontal Distance O to Traffic line	d_w	40,0		
m Relevant Area along the Road	$4d_w$	160,0		
m Shortest Distance O to Traffic line	r	44,4		max
km/hr Velocity Light Vehicles	v_{lv}	50		70
km/hr Velocity Medium Vehicles	v_{mv}	50		
km/hr Velocity Heavy Vehicles	v_{hv}	50		
m width of lanes		2,75		
# Light Vehicles/hr	Q_{lv}	1972		
# Medium Vehicles/hr	Q_{mv}	50		
# Heavy Vehicles/hr	Q_{hv}	30		
number of lanes		2	for example district road	→
% Light Vehicles		96%		
% Medium Vehicles		2%		
% Heavy Vehicles		1%		max
Db(A) Correction Road Surface Light Vehicles	$C_{wegdek,\ lv}$	-0,98		-5,42
Db(A) Correction Road Surface Medium Vehicles	$C_{wegdek,\ mv}$	0		
Db(A) Correction Road Surface Heavy Vehicles	$C_{wegdek,\ hv}$	0		-5,25
Db(A) Light Vehicles	E_{lv}	78,7		
Db(A) Medium Vehicles	E_{mv}	63,8		
Db(A) Heavy Vehicles	E_{hv}	61,5		
m Distance to Nearest Crossing	a_1	150		
Db(A) Correction Crossing	$C_{kruispunt}$	-0,1		
m Distance to Nearest Obstacle	a_2	50		
Db(A) Correction Obstacle	$C_{obstakel}$	0,3		
Db(A) Correction Acceleration	C_{optrek}	0,3		
m Distance of Opposite Reflecting Surface to Traffic line	d_r	40		
m Altitude of Opposite Reflecting Surface		40		
m Width of Opposite Reflecting Surface		150		
% Fraction of Opposite Reflecting Surface		47%		
Db(A) Correction Reflecting Surface	$C_{reflectie}$	0,7		
Db(A) Reduction by Distance	$D_{afstand}$	16,5		
Db(A) Reduction by Air	D_{lucht}	0,3		
m2 Relevant Soil Surface between O and Traffic line		3198		
m2 Non-reflecting Soil Surface between O and Traffic line		2500		
% Soil factor	B	78%		
Db(A) Reduction by Soil	D_{bodem}	1,9		
Db(A) Reduction Meteo	D_{meteo}	0,3		
Db(A) Emission	E	79,0		
Db(A) Total Emission	L_{Aeq}	61,0