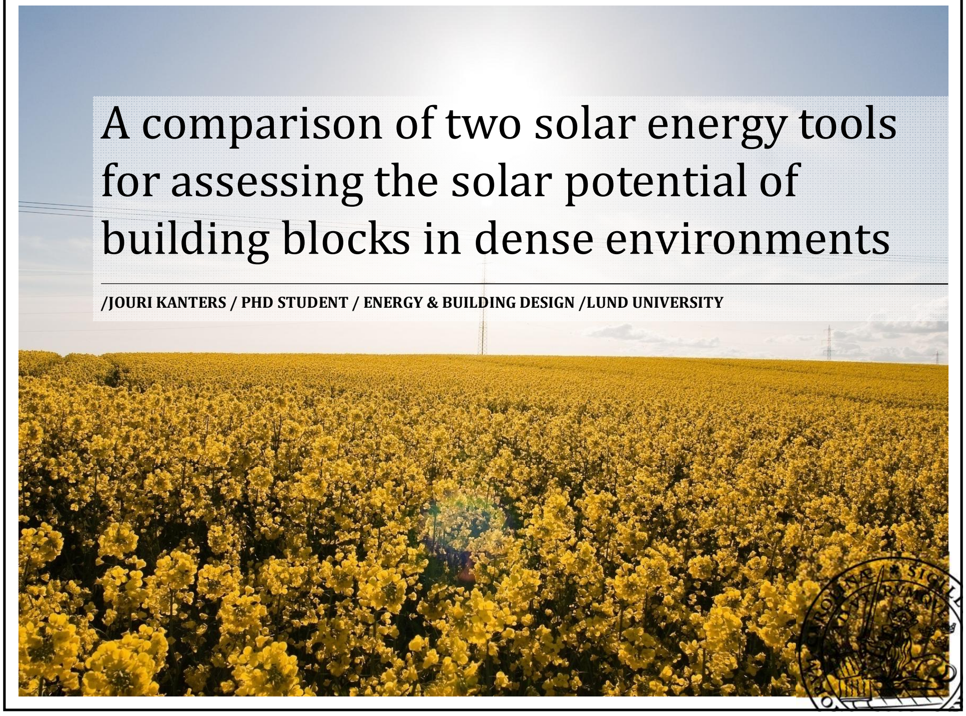

A comparison of two solar energy tools for assessing the solar potential of building blocks in dense environments

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[Introduction]

» EPBD: net zero energy buildings

» Biggest challenge will be building such NZEB in densely built urban environments, where access to daylight and solar irradiation might be limited

» All involved actors need to take informed decisions based on reasonable estimates of the solar potential.

[Introduction]

» BPS tools -> decisions regarding solar energy based on quantification rather than intuition.

» Two solar energy tools are compared to achieve future solar studies with an intention to yield a greater understanding of the limitations in the assumptions and results as well as of the key input parameters to control.

[Introduction]

» BPS for assessing solar

Tool	Described in literature by author
RADIANCE	Compagnon (2004)
Solar energy planning (SEP) system	Gadsden *et al.* (2003)
PPF (RADIANCE)	Cheng *et al.* (2006)
LT model	Ratti *et al.* (2005)
r.sun	Hofierka and Kanuk (2009)
EnergyPlus	Hachem *et al.* (2011)
Ecotect (+ GECO)	Ibara and Reinhart (2011)
Townscope	Teller and Azar (2001)
IES VE	Kim *et al.* (2012)
PVSyst	Chikh *et al.* (2011)
DIVA-for-Rhino	Ibara and Reinhart (2011)
RETScreen	Lee *et al.* (2012)

[DIVA4Rhino / Ecotect]

» Close connection to CAD environment, graphical output

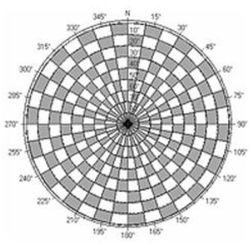
	DIVA-for-Rhino	Ecotect
Model editor	In Rhinoceros	Own modeller and options to import
Compatibility for 3D geometry import	3DM, 3DS, DWG/DXF, FBX, IGES, KML, LWO, PLY Points, SLC, SolidWorks, STEP, VRML	3DM, 3DS, ASC, TXT, BIN, BMP, DEM, DXF, IFF, IOB, LP, LWO, RTG, IV, RBS, RWX, LAND, SCENE, SBP, XSI, STL, COB, DDF, GEO, WRL, OBJ
Documentation (both calculation methods and user manuals)	Very detailed, both in literature and online. Most information on http://diva4rhino.com/ and http://radsite.lbl.gov	Very limited, both in literature and online. Most information on: http://wiki.naturalfrequency.com/

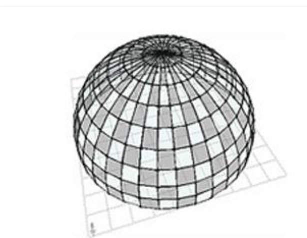
Important features of D4R and Ecotect

[Sky model: Ecotect]

» Ecotect :equal-angle method for its sky model instead of the equal patches model.

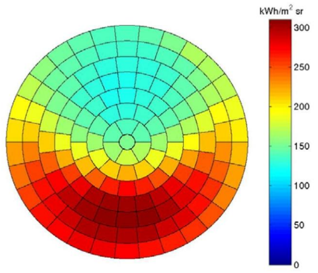
» Ecotect will create a bias in accuracy towards the zenith of the sky dome when compared to the horizon as each segment is much smaller in the zenith area.





[Sky model: DIVA4Rhino]

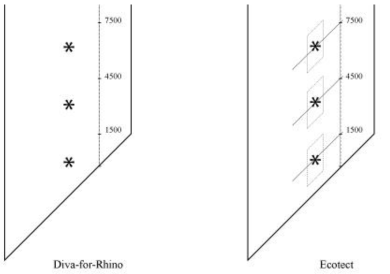
» DIVA4Rhino: GenCumulativeSky (Robinson and Stone (2004)): a cumulative sky - using the Perez all weather distribution model divided in 145 patches- is generated based on a weather file and aggregates values at discrete points within the sky vault.



[Simulation settings]

Parameters	D4R	Ecotect (medium setup)
Ambient bounces	5	N/A
Ambient divisions	1000	N/A
Ambient super-samples	20	N/A
Ambient resolution	300	N/A
Ambient accuracy	0.1	N/A
Start date	01 01	01 01
End date	12 31	12 31
Hour range	00 24	00 24
Geometric density	100	N/A
Surface sampling	N/A	5 * 5
Sky subdivision	N/A	5° *5°
Reflectance of surfaces	35%	35%
Weather data	Copenhagen ASHRAE	Copenhagen ASHRAE

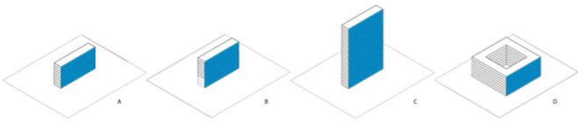
[Simulation settings]



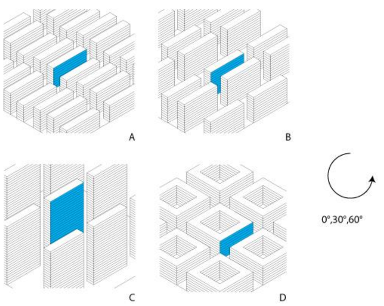
Sensor points in D4R and surfaces modelled in Ecotect

[5 cases]

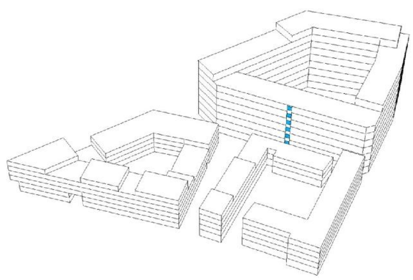
» Five cases for comparing D4R, Ecotect



Case 2

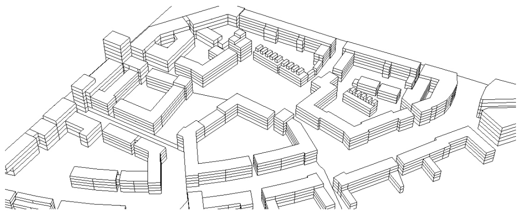


Case 1

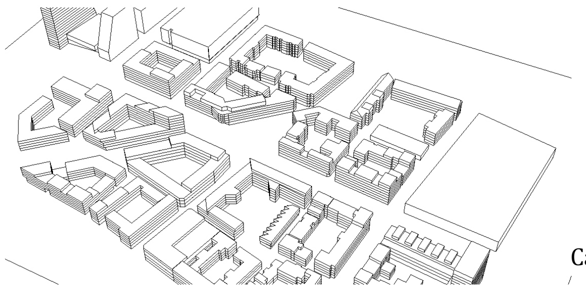


Case 3

[5 cases]

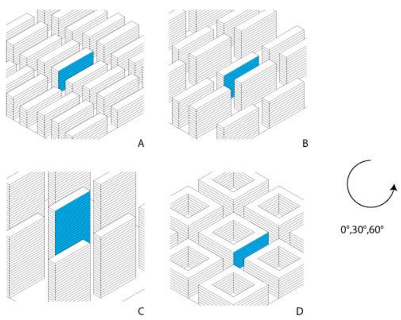


Case 4



Case 5

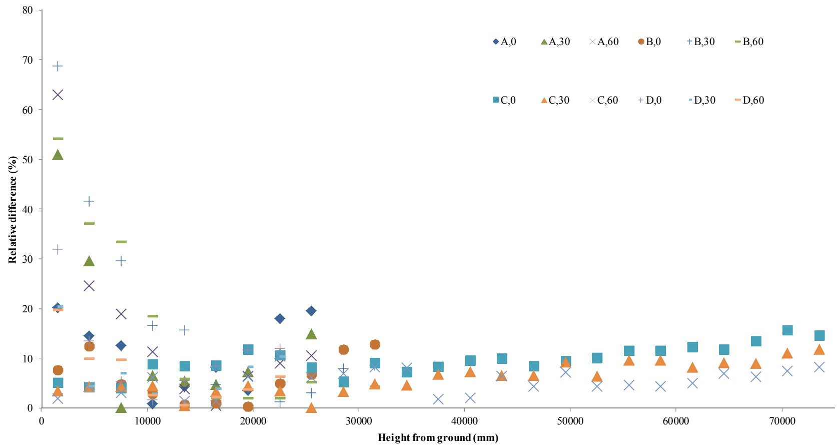
[Results: case 1]



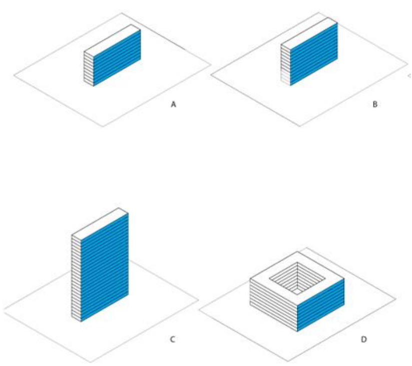
Annual irradiation values (kWh/m^{2}a) for Design A, B, C,D, rotation 30°

	Design A, 30°			Design B, 30°			Design C, 30°			Design D, 30°		
Height	D4R	Ecotect	Diff.	D4R	Ecotect	Diff.	D4R	Ecotect	Diff.	D4R	Ecotect	Diff.
1500	78.34	118.37	51.1	64.36	108.62	68.8	269.96	260.59	3.5	137.05	165.23	20.6
4500	112.38	145.77	29.7	81.60	115.57	41.6	281.92	269.31	4.5	181.49	189.84	4.6
7500	172.51	172.91	0.2	96.39	125.02	29.7	301.68	288.30	4.4	247.75	265.48	7.2
10500	255.39	272.45	6.7	122.92	143.43	16.7	314.82	300.51	4.5	317.56	327.16	3.0
13500	359.89	379.62	5.5	142.80	165.24	15.7	322.44	324.05	0.5	396.22	399.33	0.8
16500	527.13	501.51	4.9	199.54	189.99	4.8	345.25	333.69	3.3	499.06	479.16	4.0
19500	653.25	604.68	7.4	255.91	265.42	3.7	366.66	349.74	4.6	615.17	563.50	8.4
22500	712.71	633.97	11.0	322.71	326.82	1.3	376.30	362.82	3.6	712.22	637.76	10.5
25500	761.95	647.92	15.0	412.43	399.29	3.2	385.84	385.40	0.1			
28500				521.13	479.14	8.1	408.89	395.26	3.3			
31500				616.95	563.54	8.7	426.48	405.44	4.9			
34500							448.17	427.03	4.7			
37500							472.93	440.50	6.9			
40500							494.80	458.36	7.4			
43500							504.99	471.45	6.6			
46500							532.58	497.58	6.6			
49500							560.38	508.08	9.3			
52500							575.63	538.25	6.5			
55500							612.65	552.90	9.8			
58500							639.56	577.21	9.7			
61500							652.14	598.47	8.2			
64500							676.54	614.30	9.2			
67500							698.88	635.72	9.0			
70500							719.67	639.70	11.1			
73500							739.05	651.25	11.9			

[Results: case 1]



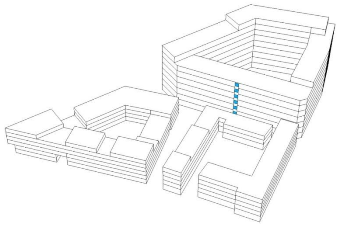
[Results: case 2]



	A			B			C			D		
	D4R	Ecotect	Diff.	D4R	Ecotect	Diff.	D4R	Ecotect	Diff.	D4R	Ecotect	Diff.
1500	891	649.24	27.1	895	649.24	27.5	899	649.24	27.8	900	649.24	27.9
4500	889	649.24	27.0	895	649.24	27.5	895	649.24	27.5	891	649.24	27.1
7500	882	649.24	26.4	880	649.24	26.2	891	649.24	27.1	880	649.24	26.2
10500	873	649.24	25.6	889	649.24	27.0	887	649.24	26.8	871	649.24	25.5
13500	866	649.24	25.0	866	649.24	25.0	880	649.24	26.2	869	649.24	25.3
16500	858	649.24	24.3	869	649.24	25.3	872	649.24	25.5	861	649.24	24.6
19500	859	649.24	24.4	855	649.24	24.1	865	649.24	24.9	876	649.24	25.9
22500	851	649.24	23.7	864	649.24	24.9	862	649.24	24.7	869	649.24	25.3
25500	835	649.24	22.2	845	649.24	23.2	856	649.24	24.2			
28500				847	649.24	23.3	846	649.24	23.3			
31500				844	649.24	23.1	840	649.24	22.7			
34500							834	649.24	22.2			
37500							828	649.24	21.6			
40500							832	649.24	22.0			
43500							827	649.24	21.5			
46500							811	649.24	19.9			
49500							806	649.24	19.4			
52500							803	649.24	19.1			
55500							800	649.24	18.8			
58500							802	649.24	19.0			
61500							799	649.24	18.7			
64500							789	649.24	17.7			
67500							786	649.24	17.4			
70500							795	649.24	18.3			
73500							793	649.24	18.1			

Annual irradiation values (kWh/m^{2}a) for Case 2

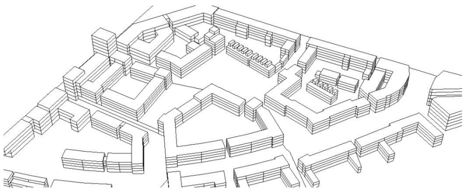
[Results: case 3]

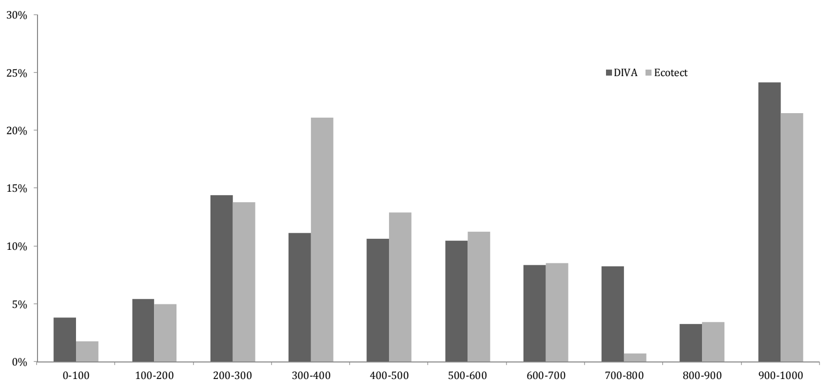


	refl.0%			Refl.20%			Refl. 50%			Refl. 80%		
height	D4R	Ecotect	rel.dif	D4R	Ecotect	rel.dif	D4R	Ecotect	rel.dif	D4R	Ecotect	rel.dif
2000	89	152	70.8	98	152	35.7	166	152	8.2	359	152	57.6
6000	301	358	18.9	325	358	9.3	402	358	10.8	584	358	38.6
10000	660	608	7.9	689	608	13.3	742	608	18	887	608	31.4
14000	713	631	11.5	750	631	18.9	850	631	25.8	1006	631	37.3
180000	735	636	13.5	789	636	24	875	636	27.3	1014	636	37.2
22000	733	636	13.2	807	636	26.8	874	636	27.2	995	636	36
26000	734	636	13.4	775	636	21.8	872	636	27	978	636	34.9

Annual irradiation values (kWh/m^2a) for Case 3

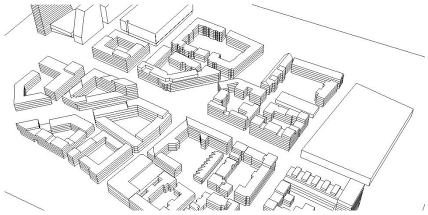
[Results: case 4]

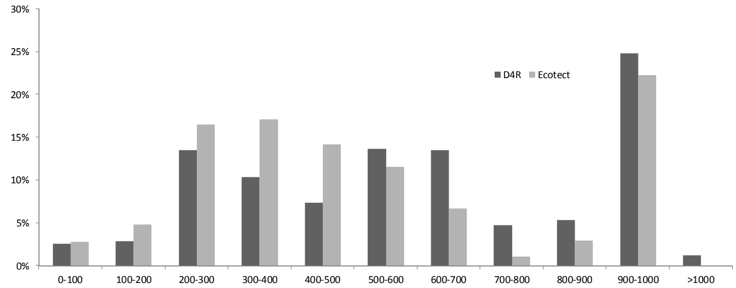




Percentage of area per category of irradiation in Brunnshög

[Results: case 5]





Percentage of area per category of irradiation in Hyllie

[Discussion]

» Relative difference: 0-30%

» Shaded environments: Ecotect higher irradiation levels at the bottom of the facade, while D4R returned higher irradiation levels at on higher facade portions.

» Annual solar energy potential analyses of large scale urban districts, differences between the programs were also around 0-30%.

» In this study: the irradiation values are not validated against measured data.

» The question that needs to be discussed is: **which error margin is acceptable?**

[Discussion]

» Another important aspect is the running time of the two programs

» For simple and small scale models, the running time is short. In cases 4 and 5, there is a big difference in running times for the same model. A long running time might prevent users to analyse several design alternatives.