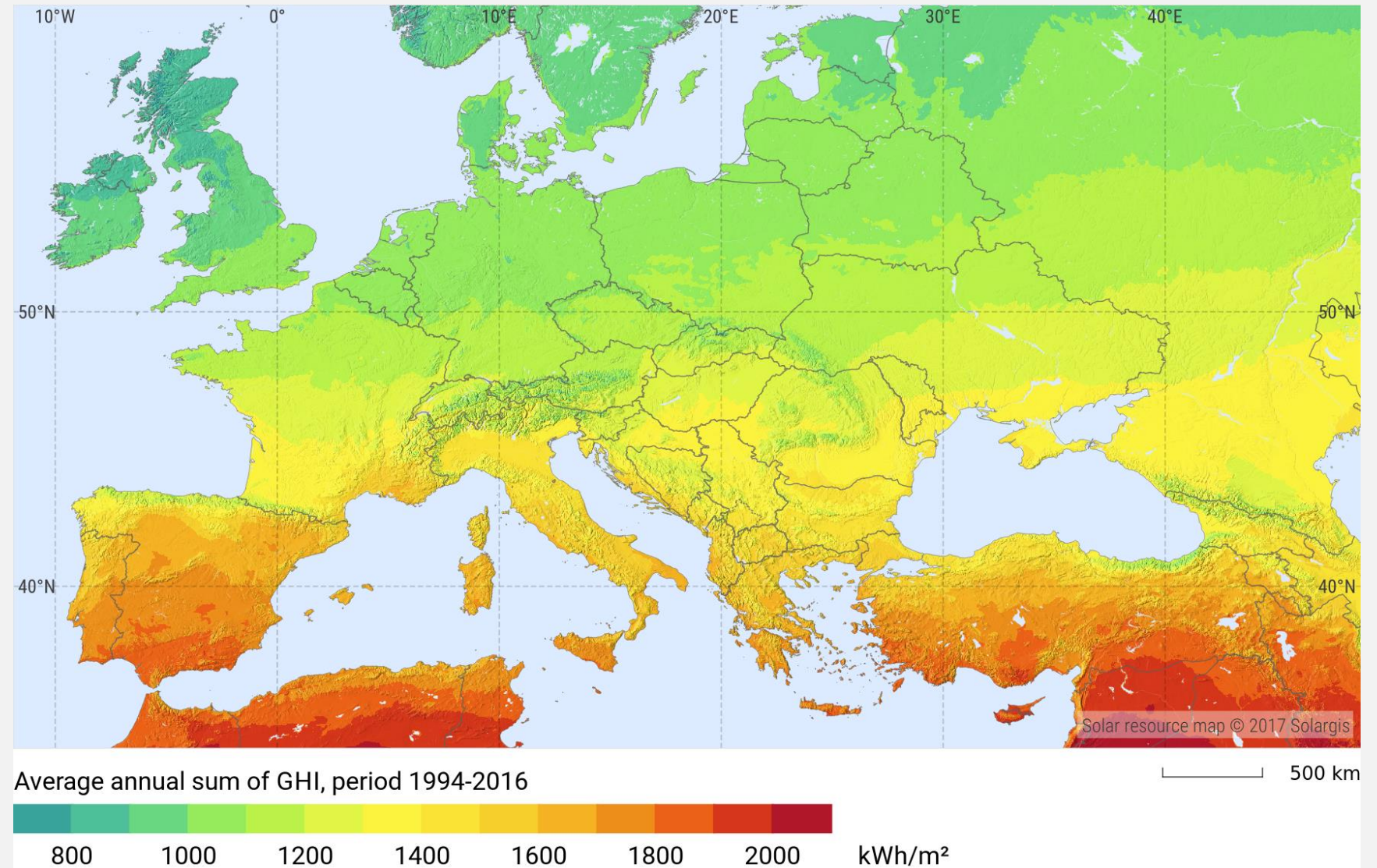


Solar energy



Finding the best buildings to start the rollout!

Multiconsult

Stephan Niderehe – solar energy + facade technology



Solar energy - agenda

- Solar energy – the big picture
- Solar energy – using GIS to get all geometric information
- Solar energy – using spreadsheets to do the number crunching
- Solar energy – present the results and start building!

Solar energy – the big picture

Solar energy is going to be the dominant energy source in the future.

Michael Liebreich, founder of Bloomberg New Energy Finance (BNEF), about the expected development towards 2030 in the global energy system (quote from 2020):

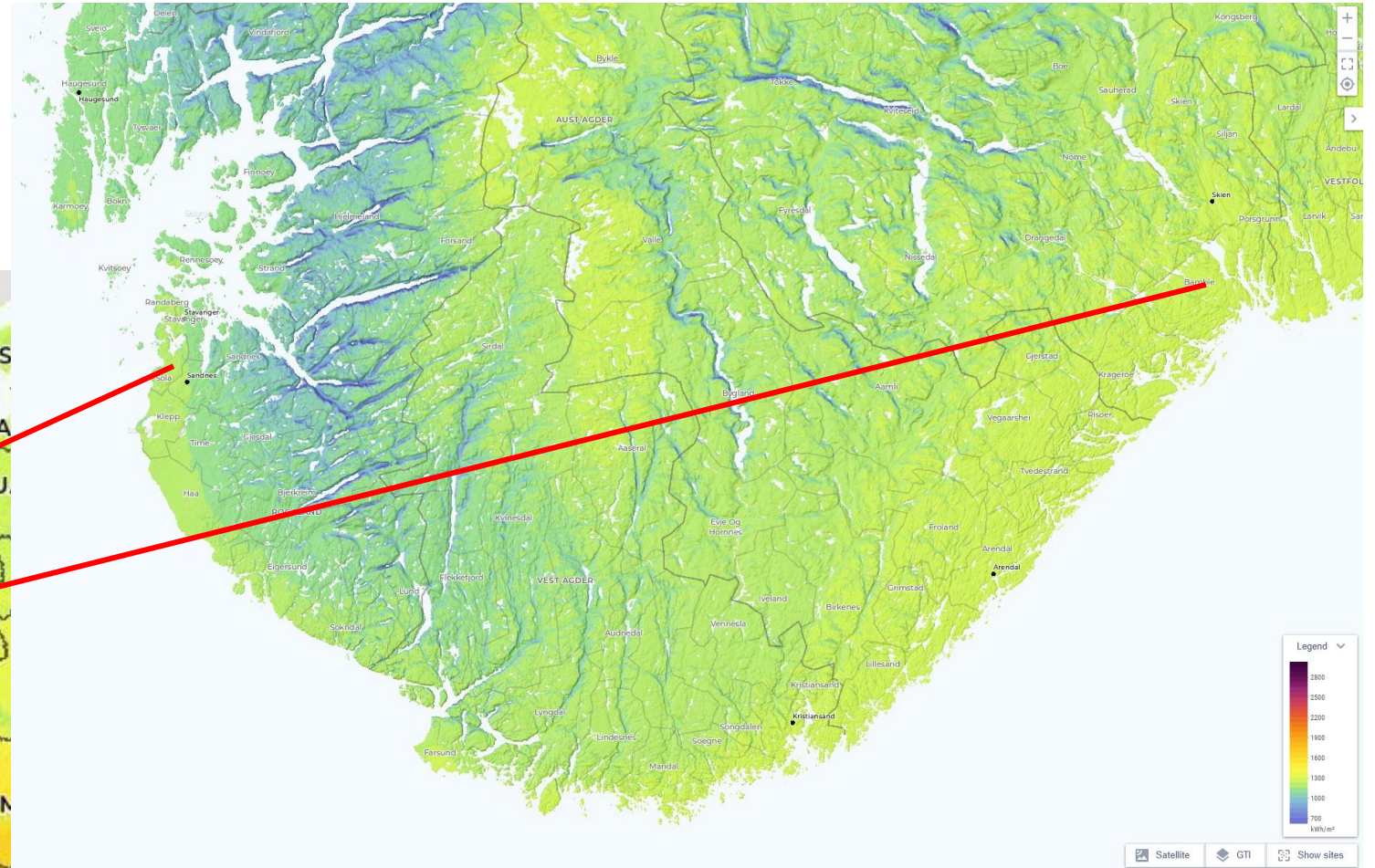
By 2030, erecting a new building without integrating solar power, without equipping it with a battery and a heat pump, without capturing rainwater, will be an act of deliberate economic self-harm.

<https://list.solar/news/peak-emissions/>



Solar energy – potential for solar energy i Norway

Yearly sum of global irradiation on optimal inclined, south oriented solar energy modules

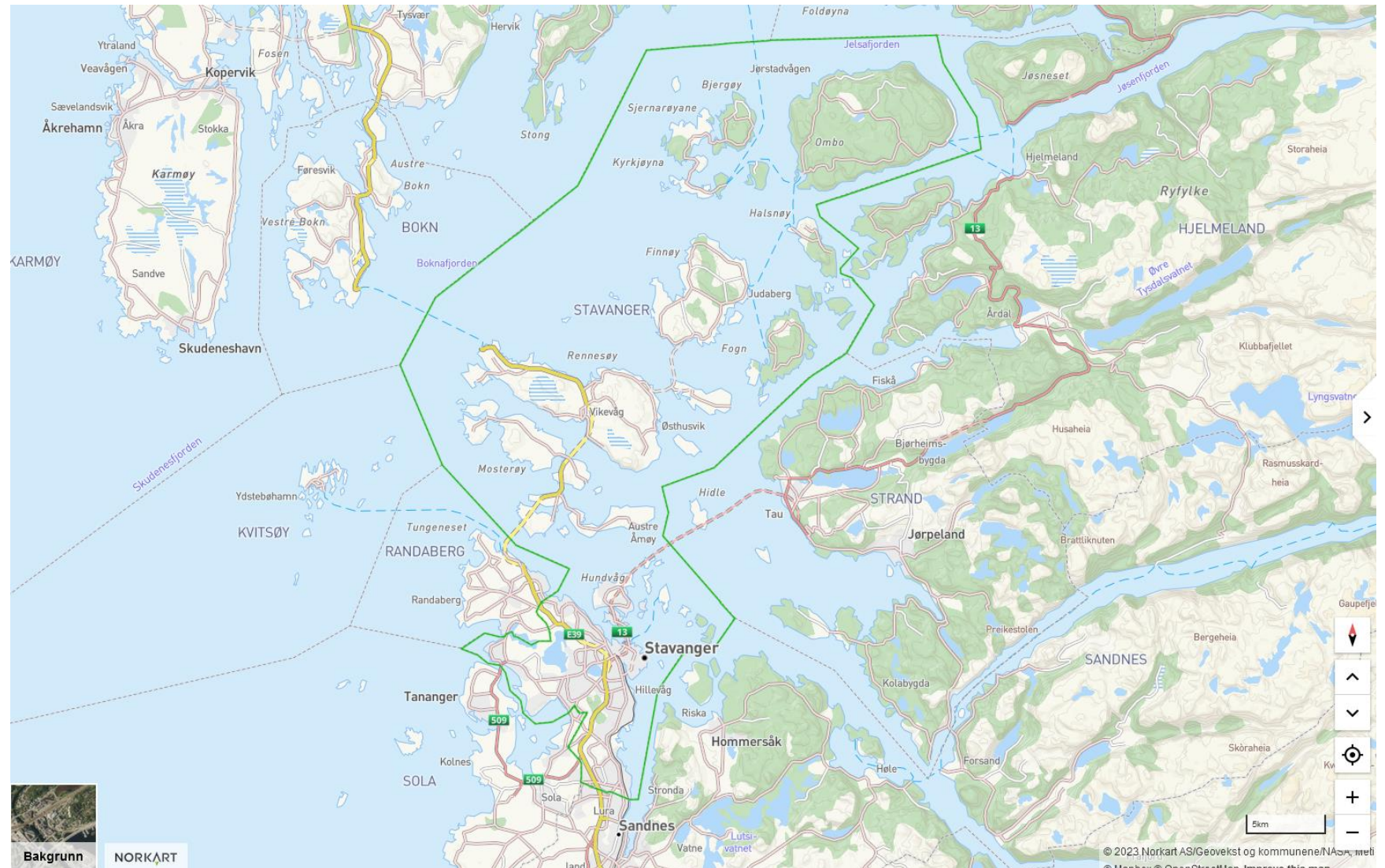


Bilder: Global Solar Atlas (Worldbank)

Solar energy - evaluation of major building portfolios

Stavanger kommune

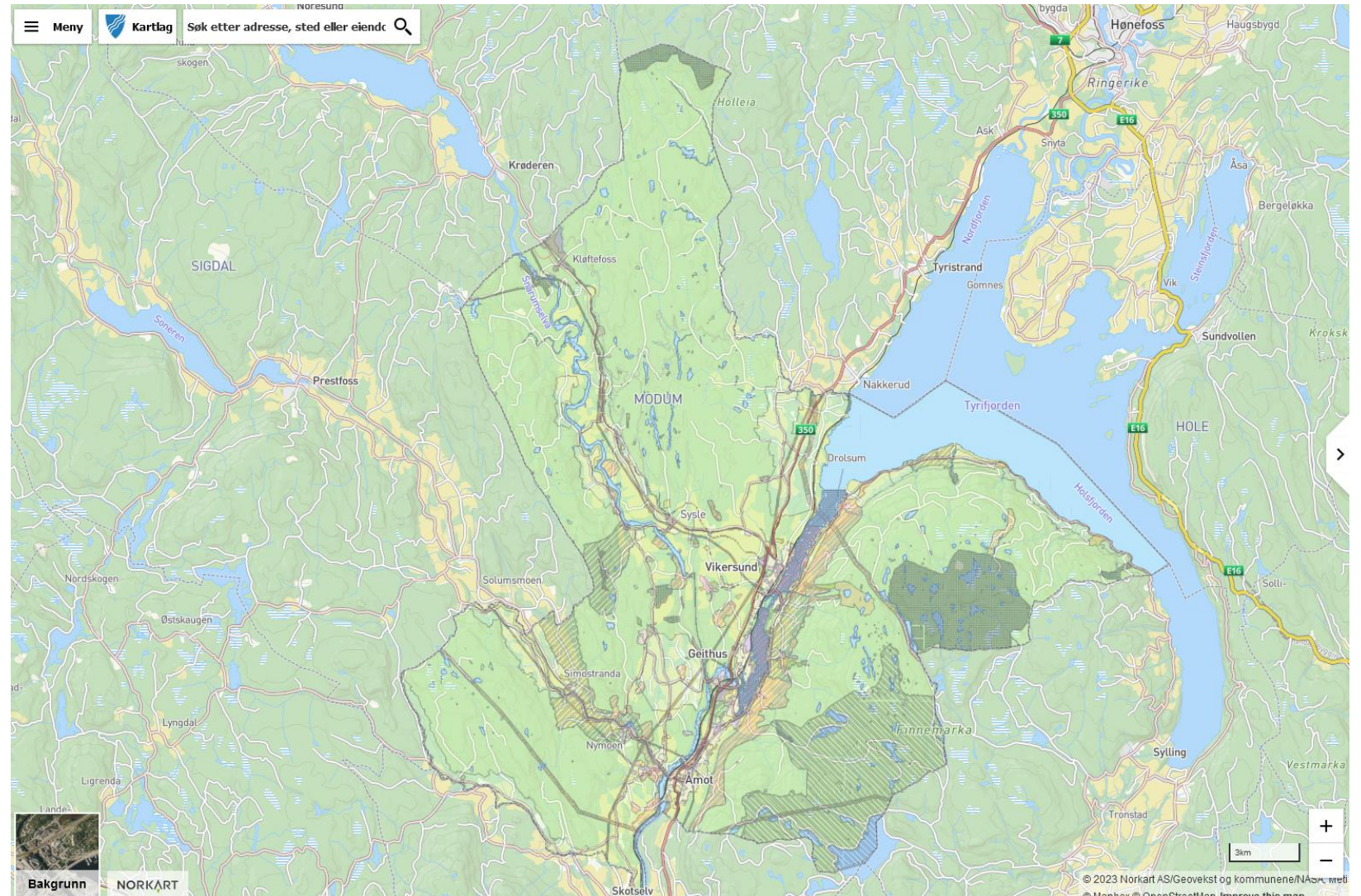
- About 700 buildings owned by municipality
- About 400 should be evaluated
- Spread over 241km² (with 145.000 inhabitants)



Solar energy - evaluation of major building portfolios

Modum kommune

- About 100 buildings owned by municipality
- About 80 should be evaluated
- Spread over 517km² (with 14.200 inhabitants)



Solar energy – identifying portfolio with GIS system (1)

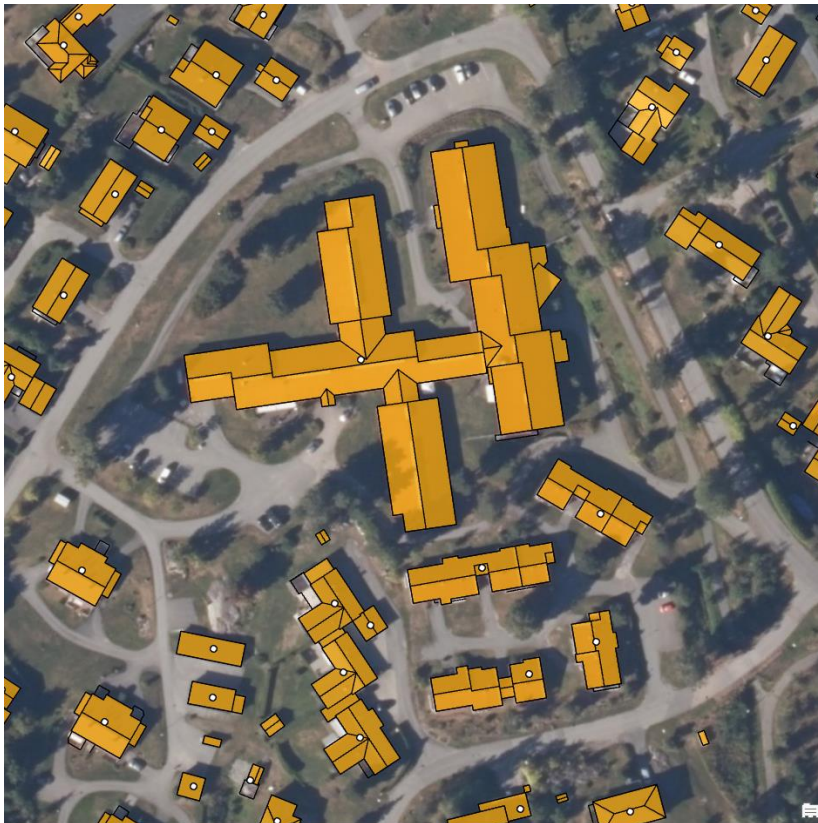
- List from municipality with address and national building number
- National building number identifiable in database in GIS system (geographical information system), which also provides 3D geometric data from aerial surveys – but no distinction between buildings and terrain

SSB Byggnings	Byggnavn	Besøksadresse	Post	Poststed
7968183	Enger skole	Eikerveien 52	3340	ÅMOT
7988818	Avlastningshjem barn	Ekornveien 2	3370	VIKERSUND
160475625	Gamle servicebygg heggen kirke?	Gamle Kirkevei 160	3370	VIKERSUND
7983484	Søndre Modum Ungdomsskole - Rockeverksted	Jellumveien 3	3340	ÅMOT
160424648	Søndre Modum Ungdomsskole	Jellumveien 3	3340	ÅMOT
160424648	Søndre Modum Ungdomsskole	Jellumveien 3	3340	ÅMOT
300389145	Elvika renseanlegg	Katfossveien 1	3360	GEITHUS
21872288	Åmot høydebasseng	Melumveien 95	3340	ÅMOT
160524057	Sysle kloakkrenseanlegg	Røstebakken 1	3370	VIKERSUND
160523891	Sysle skole SFO	Røsteveien 87	3370	VIKERSUND
7979762	Sysle skole	Røsteveien 85	3370	VIKERSUND
7979762	Sysle skole	Røsteveien 85	3370	VIKERSUND
160524332	Rådhuset, gamelgården og kulturhuset	Rådhusveien 1	3370	VIKERSUND
160514434	Rådhuset, gamelgården og kulturhuset	Rådhusveien 1	3370	VIKERSUND
160524332	Rådhuset, gamelgården og kulturhuset	Rådhusveien 1	3370	VIKERSUND
160524332	Rådhuset, gamelgården og kulturhuset	Rådhusveien 1	3370	VIKERSUND
160465336	Nordre Modum Ungdomsskole	Skolegata 11	3370	VIKERSUND
160465336	Nordre Modum Ungdomsskole	Skolegata 11	3370	VIKERSUND
7976771	Vikersund barneskole	Skolegata 22	3370	VIKERSUND
160425151	Stalhorn barneskole	Stalhornveien 24	3360	GEITHUS



Solar energy – identifying portfolio with GIS system (2)

- National database provides outer limits and roof lines of buildings, but no slope angle or direction of slope
- Pixelated grid (1m*1m) established for identification of slope and azimuth of all roof surfaces

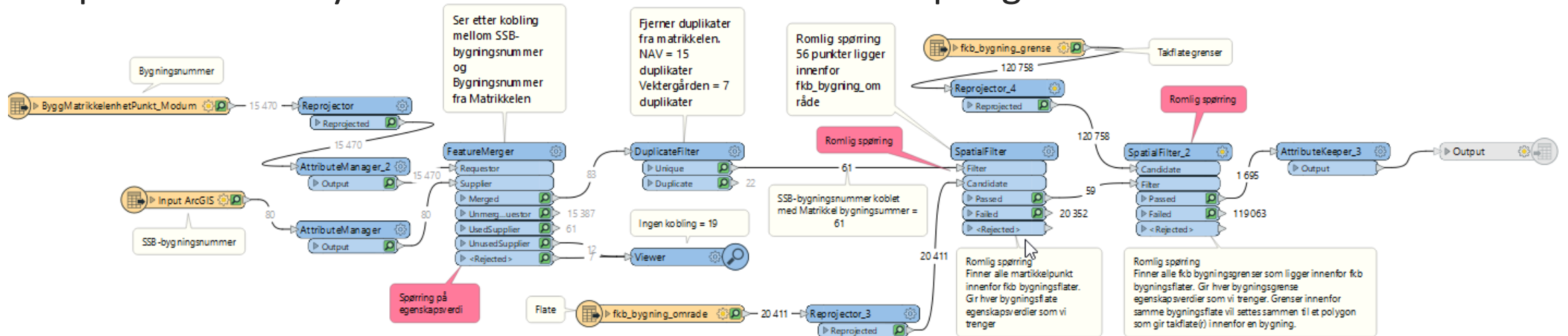


Solar energy – identifying portfolio with GIS system (3)

And then magic happens... 😊

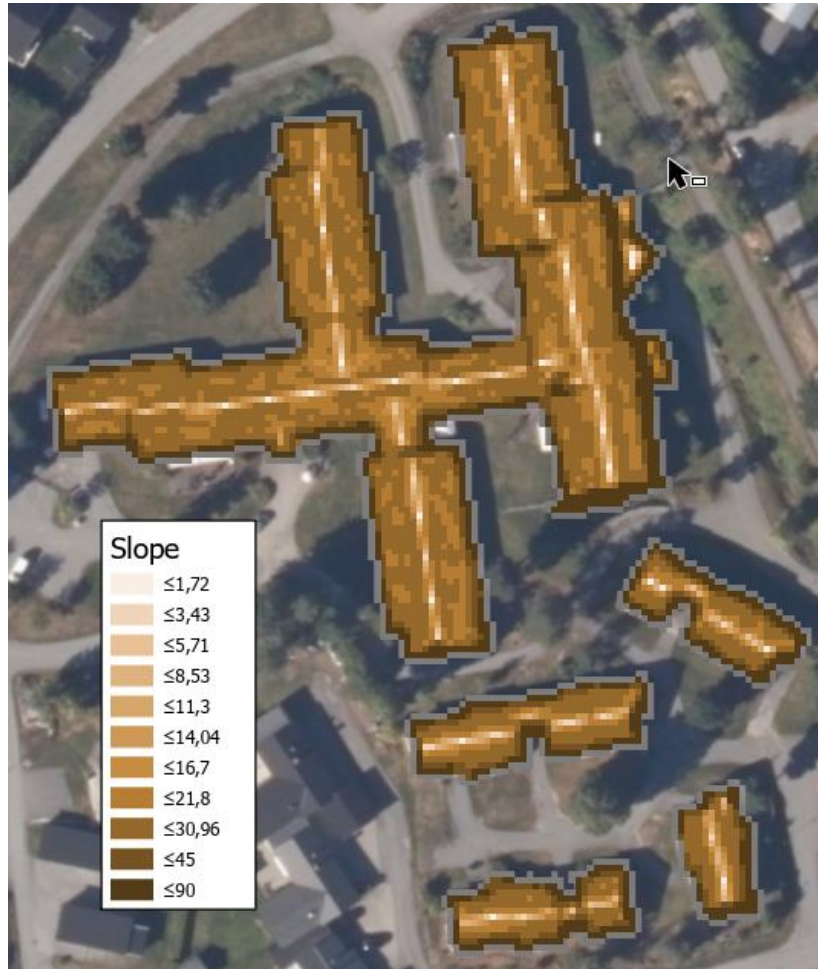
Basically:

- Each building is identified with its national building number and outline in GIS
- Within each identified roof surface the height of each centre point of each 1m*1m pixel is taken from the 3D image, and compared to its neighbours. With this, the slope and azimuth for each roof surface can be determined.
- Repeat with every roof surface until finished. 😊 Scripting rulez!

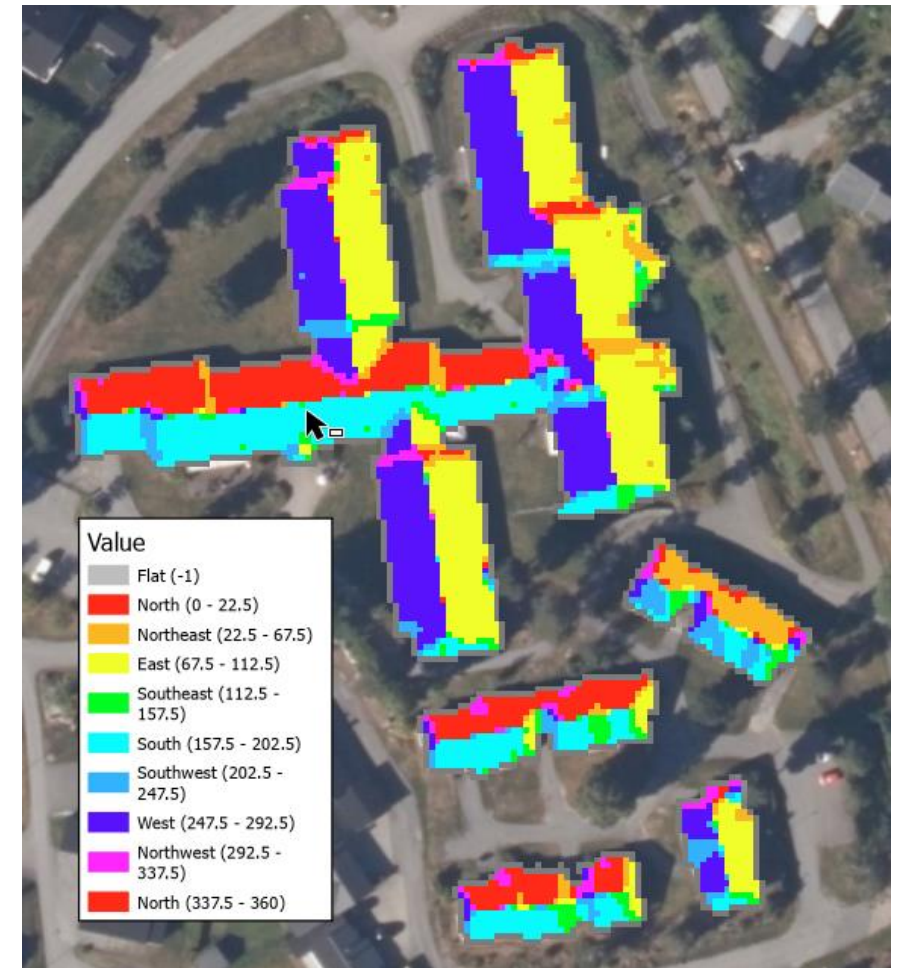


Solar energy – identifying portfolio with GIS system (4)

- Slope



- Azimuth



Solar energy – spreadsheets for techno-economical analysis (1)

Input variables for analysis:

- Size of system, derived from GIS information (roof and building)
- Economical assumptions (cost of system depending on size, internal discount value, degrading of panels, inverter cost, learning rates for inverter replacement cost, development of power prices, own consumption, etc.)
- Technical assumptions (efficiency of solar modules, efficiency of inverter, production potential kWh/kWp, etc.)
- Exclusion parameters (roof surfaces with area under threshold, slope angles over threshold, production potential under threshold)

The image shows a screenshot of the 'Multiconsult' spreadsheet. The interface is divided into several sections:

- Market parameters:** Includes fields for 'Market electricity price' and 'Market electricity price development'.
- Technical parameters:** Includes fields for 'Module efficiency', 'Inverter efficiency', 'Production potential kWh/kWp', and 'Degrading of panels'.
- Economical parameters:** Includes fields for 'Internal discount value', 'Inverter replacement cost', and 'Development of power prices'.
- Exclusion parameters:** Includes fields for 'Roof surfaces with area under threshold', 'Slope angles over threshold', and 'Production potential under threshold'.
- Data Tables:** Several tables are visible, including a table with columns for 'Year', 'Production potential', 'Inverter replacement cost', and 'Development of power prices'. There are also tables for 'Production potential under threshold' and 'Production potential over threshold'.

Solar energy – spreadsheets for techno-economical analysis (2)

- 400 buildings and 8000 (!) roof surfaces were analyzed for Stavanger

The image shows a detailed spreadsheet used for techno-economical analysis of solar energy potential. The spreadsheet is organized into several main sections:

- Header Section:** Contains the 'Multiconsult' logo and various project parameters and settings.
- Main Data Table:** A large table with numerous columns, likely representing different buildings and their roof surfaces. Columns include identifiers, building names, roof area, orientation, and various calculated values.
- Summary/Calculation Section:** Contains formulas and results for the overall analysis, including totals and averages.
- Visual Elements:** Includes a color-coded legend for roof orientations and a small bar chart showing data distribution.

Solar energy – spreadsheets for techno-economical analysis (3)

Present the client with the results – and start contracting the most profitable buildings!

Multiconsult		Oppdragsnummer		Oppdragsnavn		Oppdragsleder		Prosjekt		Dato		Revisjon	
Multiconsult		Stavanger Kommune		Utredning solenergi potensial		16.03.2022		0					

Grenseverdi	Antall bygg	Andel av bygg (%)	Installert effekt (kWp)	Energiproduksjon (kWh/år)	Mengde spart CO2 (tonn CO2-ekv.år)	Investeringskostnad (kr)	Spesifikk kostnad gj. snitt (kr/Wp)
IRR < 2,5%	133	36%	4 935	3 433 006	-	389	68 726 751
2,5% ≤ IRR < 4,0%	142	39%	16 721	11 902 050	-	1325	152 952 444
IRR ≥ 4,0%	91	25%	23 807	17 334 609	-	1930	170 648 658
Total	366	100%	45 464	32 729 665	-	3 644	392 327 854

	Installert effekt (kWp)	Energiproduksjon (kWh/år)	CO2 (tonn CO2-ekv.år)	Investeringskostnad (kr)	kostnad gj. snitt (kr/Wp)
Sum Topp 10	5 366	3 988 883	-	444	34 315 022
Sum Topp 20	7 862	5 833 021	-	649	51 441 072

Antall bygg	IRR < 2,5%	2,5% ≤ IRR < 4,0%	IRR ≥ 4,0%
91	25%		
142		39%	

Installert effekt (kWp)	IRR < 2,5%	2,5% ≤ IRR < 4,0%	IRR ≥ 4,0%
23 807	52%		
16 721		37%	

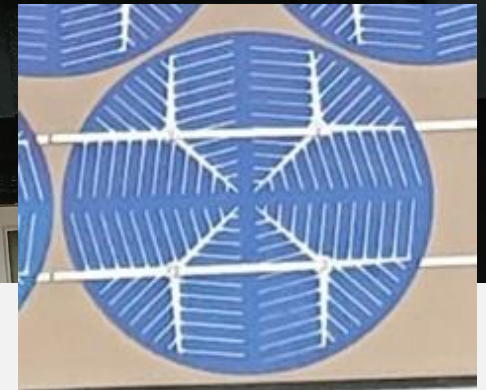
Rangering	Status (utført/prosjekt/ikke utført)	Byggnr./inter.	IRR	SSB b.nr. redigert	Byggnavn	Bygggruppe	Besøkspost sted	Komment	Fasade (delvis) akteut (fajneilikke vurdert enc)	Faktor: Prosent aktuell etter visuell inspeksjon	Installert effekt (kWp)	Energiproduksjon (kWh/år)	Mengde spart CO2 (tonn CO2-ekv.år)	Investeringskostnad eks. MVA (kr)	LCOE (kr/kWh)	IRR [%]	NPV (kr)	Rekkfølge vurdering mtp takrehabilitering	Spesifikk kostnad (kr/Wp)	Spesifikk ytelse (kWh/kWp)
1	kartlagt	1 4238993/	7,96%	4 298 993	Hetlandshallen - Hovedbygg	Kommunale idrettsbygg	STAVANGER		ja	100%	1042	783 782	-87,3	6 340 192	0,50	7,96%	3 296 435	1	6	752
2	kartlagt	1 4564634/	7,85%	4 564 634	Auglend skole - Bygg A-D Hovedbygg	Skolelokaler	STAVANGER		ja	100%	650	487 372	-54,3	3 328 965	0,50	7,85%	1 869 675	4	6	750
3	kartlagt	1 4660722/	7,49%	4 660 722	Lassahagen BF - Lassaveien 2 a, 2 b, 2 c	Omsorgsboliger	STAVANGER		nei	100%	376	286 174	-31,9	2 548 623	0,56	7,49%	1 157 761	3	7	761
4	kartlagt	1 4329821/	7,46%	4 329 821	Stavanger Idrettsshall - Stavanger idrettsshall	Kommunale idrettsbygg	STAVANGER		nei	100%	1126	799 653	-89,0	6 777 165	0,52	7,46%	3 044 672	1	6	710
5	kartlagt	1 4324668/	7,42%	4 324 668	Tjensvollsentret - Tjensvolltorget 6 Snr 2	Institusjonslokaler	STAVANGER		nei	100%	366	278 934	-30,8	2 483 059	0,56	7,42%	1 100 658	4	7	757
6	kartlagt	1 4342577/	7,34%	4 342 577	Stokka Sykehjem - Hovedbygg	Institusjonslokaler	STAVANGER		ja	100%	349	267 080	-29,7	2 410 729	0,57	7,34%	1 042 646	1	7	766
7	kartlagt	1 4324609/	7,19%	4 324 609	Tjensvollsentret - Tjensvolltorget 2 Snr 3	Institusjonslokaler	STAVANGER		nei	100%	241	163 625	-20,4	1 664 312	0,58	7,19%	665 744	4	7	763
8	kartlagt	1 3002117/	7,19%	3 002 117	Husabryggen Bofellesskap - Sagafjords vei 1	Omsorgsboliger	HUNDVÅG		nei	100%	234	178 750	-19,9	1 619 091	0,58	7,19%	666 591	1	7	764
9	kartlagt	1 4310330/	7,16%	4 310 330	Bergåstjern Sykehjem - Hovedbygg	Institusjonslokaler	STAVANGER		nei	100%	464	336 102	-37,4	3 039 029	0,58	7,16%	1 263 447	1	7	725
10	kartlagt	1 4829468/	7,07%	4 829 468	Tastarustå skole - Hovedbygg	Skolelokaler	STAVANGER		ja	100%	520	389 411	-43,4	3 443 858	0,55	7,07%	1 364 151	5	7	749
11	kartlagt	1 4530465/	7,04%	4 530 465	Løkveien 51	Administrasjonsbygg	STAVANGER		nei	100%	225	172 823	-19,2	1 585 739	0,59	7,04%	621 202	5	7	768
12	kartlagt	1 4655087/	6,92%	4 655 087	Blidensol Sykehjem - Fløy	Institusjonslokaler	STAVANGER		ja	100%	228	170 393	-19,0	1 580 956	0,59	6,92%	593 033	5	7	747
13	kartlagt	1 4627881/	6,89%	4 627 881	Tastahallen - Tastahallen	Kommunale idrettsbygg	STAVANGER		ja	100%	374	283 478	-31,6	2 536 755	0,56	6,89%	942 000	1	7	757
14	kartlagt	1 9329846/	6,86%	9 329 846	Vestre Åmøy Bærehage	Førskolelokaler	VESTRE ÅMØY		nei	85%	183	137 880	-15,4	1 276 450	0,60	6,86%	468 232	5	7	754
15	kartlagt	1 4680960/	6,85%	4 680 960	Svanholmen 3 - Verksted/Lager/Kontor	Diverse bygg	STAVANGER		ja	100%	507	353 980	-39,4	3 363 449	0,59	6,85%	1 231 537	3	7	699
16	kartlagt	1 3000420/	6,85%	3 000 420	Auglendsdalen 85/87 - Verksted/kontor	Kommunale idrettsbygg	STAVANGER		nei	100%	146	111 367	-12,4	1 022 069	0,60	6,85%	372 708	5	7	764
17	kartlagt	1 4875990/	6,79%	4 875 990	Auglend skole - Bygg F (b. hage og skole)	Skolelokaler	STAVANGER		ja	100%	179	134 559	-15,0	1 252 501	0,60	6,79%	448 094	5	7	750
18	kartlagt	1 3003390/	6,79%	3 003 390	Sera bråde bofellesskap - Sera Bråde bofellesskap	Omsorgsboliger	HAFRSFJORD		nei	100%	161	121 810	-13,6	1 129 534	0,60	6,79%	402 830	1	7	755
19	kartlagt	1 4861051/	6,77%	4 861 051	Vassøy Barnehage	Førskolelokaler	VASSØY		nei	100%	140	106 339	-11,8	980 781	0,61	6,77%	347 400	5	7	761
20	kartlagt	1 4680979/	6,75%	4 680 979	Svanholmen 3 - Lager	Diverse bygg	STAVANGER		ja	100%	353	251 508	-28,0	2 397 816	0,60	6,75%	845 095	3	7	713
21	kartlagt	1 4837304/	6,75%	4 837 304	Boganes Sykehjem - Hovedbygg	Institusjonslokaler	STAVANGER		nei	100%	468	326 433	-36,3	3 128 413	0,60	6,75%	1 102 353	5	7	697
22	kartlagt	1 4711068/	6,74%	4 711 068	Sølvberget kulturhus - Kulturhuset	Kommunale kulturbygg	STAVANGER		nei	60%	187	141 943	-15,8	1 331 623	0,61	6,74%	466 194	5	7	757
23	kartlagt	1 3003365/	6,72%	3 003 365	Kristianslyst skole - Hovedbygg	Skolelokaler	STAVANGER		nei	90%	551	413 446	-46,0	3 635 412	0,55	6,72%	1 265 041	1	7	750
24	kartlagt	1 4655079/	6,70%	4 655 079	Blidensol Sykehjem - Hovedbygg	Institusjonslokaler	STAVANGER		ja	100%	174	129 823	-14,5	1 217 640	0,61	6,70%	420 101	2	7	745



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Solar panels from around 1982, still going strong and producing all necessary energy for a cabin in Telemark region, Norway



Bilder: Stephan Niderehe

Thanks for your attention! **Questions?**

Multiconsult