

SOLENERGIREVOLUSJONEN OG OLJELANDET



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27 MAI 2021. NORSK KLIMASTIFTELSE OG UNIVERSITETET I STAVANGER

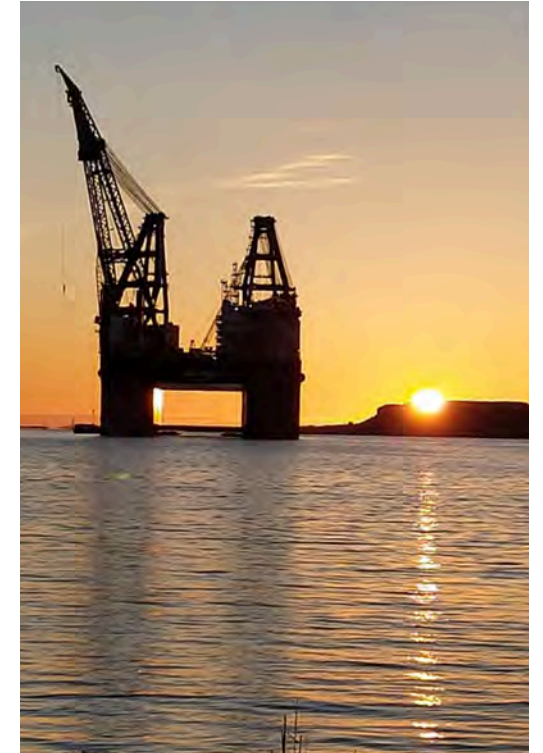
«THE TIMES THEY ARE E CHANGIN'»

Bob Dylan



Soloppgangssymbolet.
Soldrevet kirke, Strand.

- 1 DET STORE KLIMABILDET. HVA VIRKER ?
- 2 HVA ER SOLENERGIPOTENSIALET ?
- 3 HVORFOR BYGNINGSINTEGRASJON ?
- 4 EGNE PROSJEKTER HER OG DER OG
- 5 PÅ UNIVERSITETET I STAVANGER.
- 6 HASSAN GHOLAMI, PhD RESEARCHER.



Solnedgangsindustri ?

1 DET STORE BILDET

IPCC :

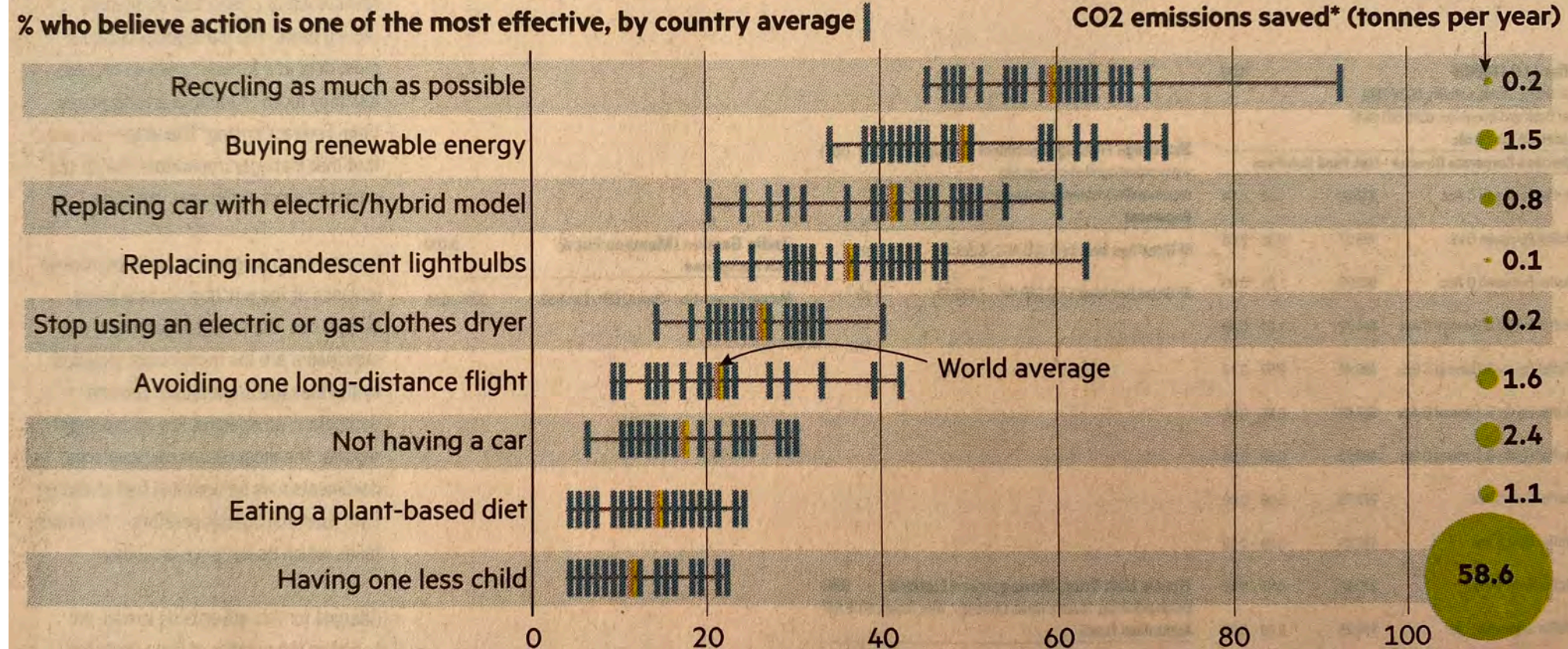
**FAR-REACHING
AND UNPRECEDENTED CHANGES
IN ALL ASPECTS OF SOCIETY
WILL BE REQUIRED.**

(.....FOR Å NÅ 1,5 C GRADERS MÅLET – 1860 - 2100)

VI HAR JO ALLEREDE NÅDD + 1,1 GRADER C.
ER VI PÅ VEI MOT 3,4 ELLER 5 GRADER ?
ELLER FIKSER VI DETTE SEG SELV ?

Most people fail to identify the best ways to reduce their carbon footprint

More than 21,000 people from nearly 30 countries were asked: from this list of options, which three do you think would most reduce the greenhouse gas emissions of an individual living in one of the world's richer countries?



* Based on data for developed countries

Visual journalism: Chelsea Bruce-Lockhart and Steven Bernard

Source: Ipsos; IOPScience Follow @ftclimate on Instagram

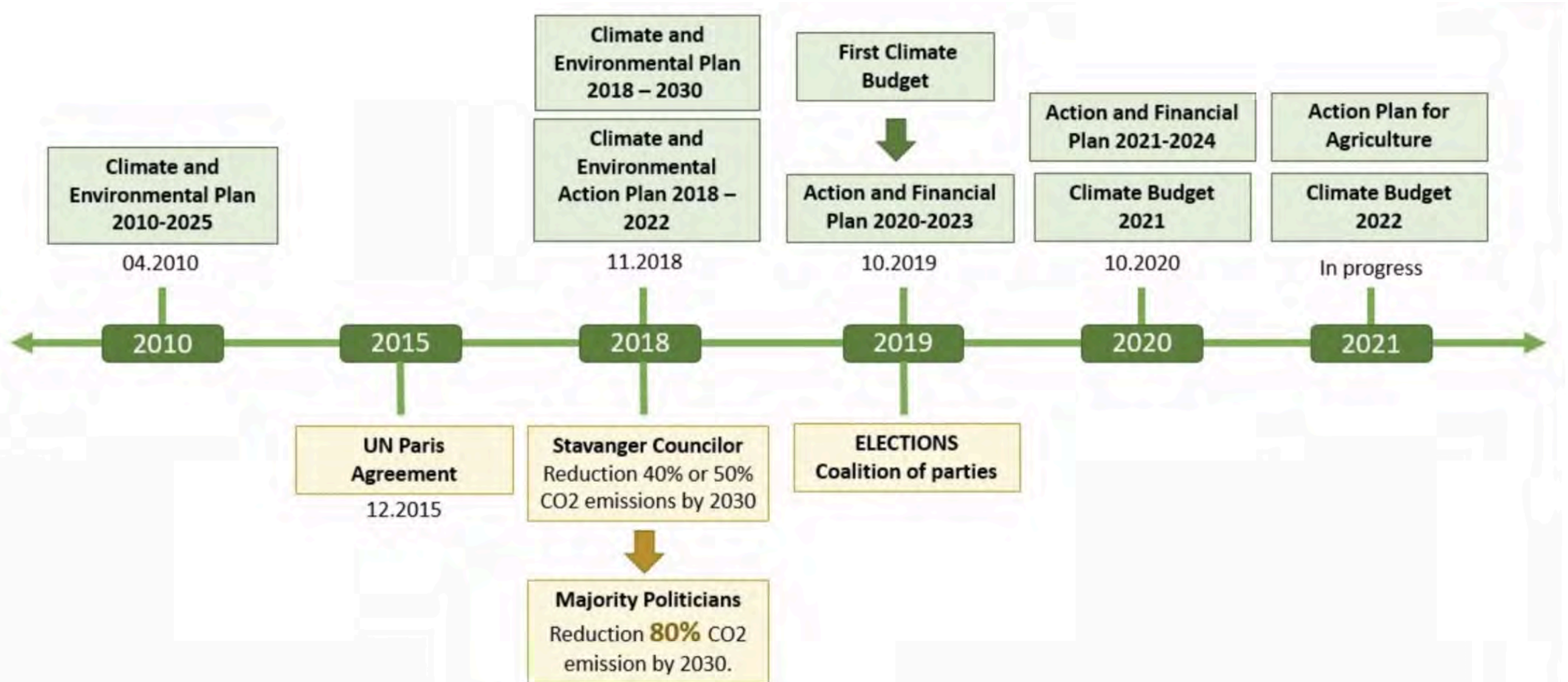
For the FT's latest climate change stories
[ft.com/climate](https://www.ft.com/climate)



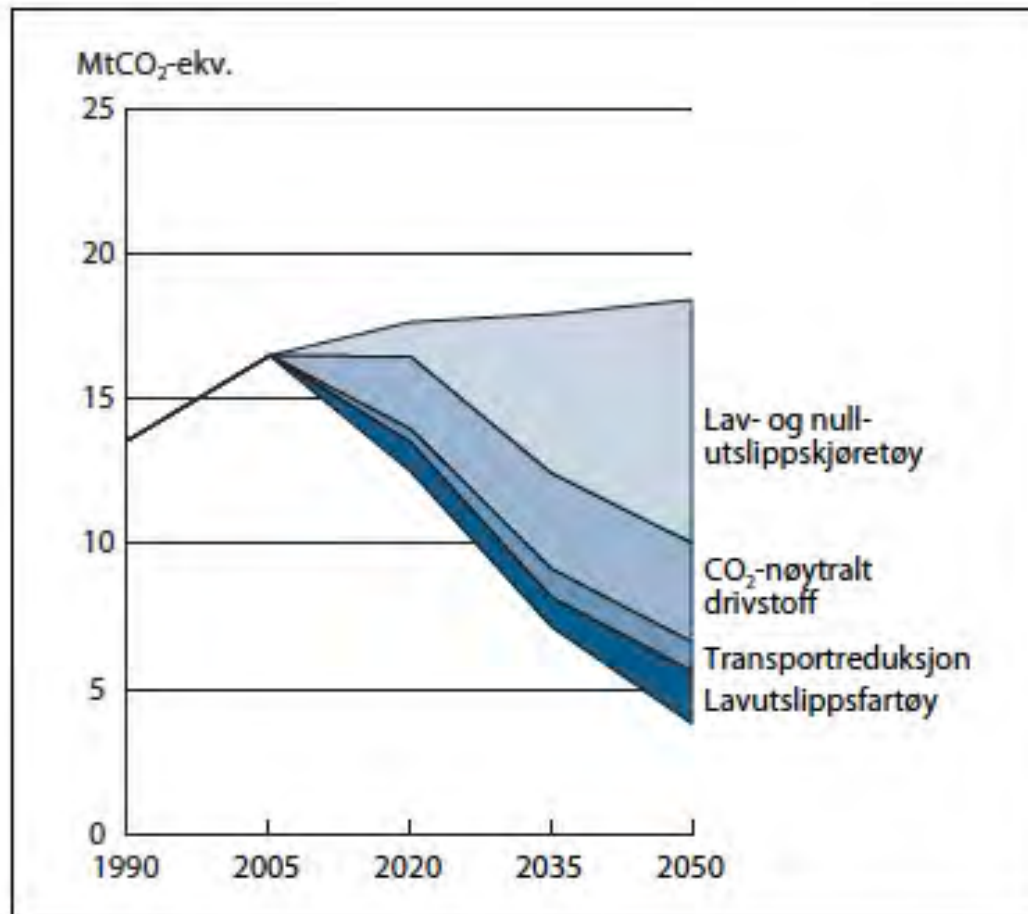
HOW TO FIX IT ?

1. POLITIKK
2. ADFERDSENDRING
3. TEKNOLOGY

POLITIKK FIKSER DET SJELDEN



ADFERDSENDRING PRE-COVID TAR FOR LANG TID



ADFERDSENDRING
er viktig men
tar lang tid!

Teknologiskifte
går raskere.

Figur 6.5 Illustrasjon av tiltak og reduksjoner i årlige utslipp fra transport.

Kilde: Lavutslippsutvalget.

2005

TEKNOLOGI FIKSER DET

FOSSIL ENERGI ER:

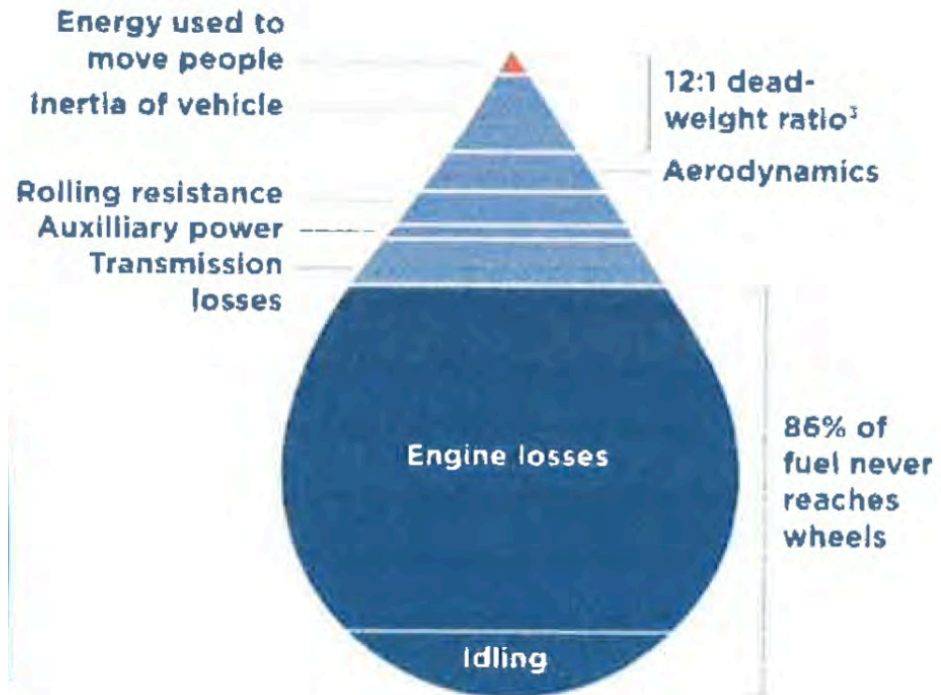
LITE EFFEKTIVT.

86% NÅR ALDRI HJULENE OG BLØIR TIL FREMDRIFT.

I TILLEGG PRODUSERES DRIVHUSGASSER.

STORSKALA CCS (Carbon Catching and Storage)
ER ENNÅ EN DRØM MED MANGE USIKRE FAKTORER.

TANK-TO-WHEEL ENERGY FLOW - PETROL



DET ER HER DE FREMTIDSRETTEDE ARBEIDSPLASSENE SKAPES



BØLGEBLIKKTAK ERSTATTET MED SOLSTRØMTAK
FJØSET PÅ KULTURMINNEGÅRDEN SYGARD GRYTTHING I OPPLAND.

PROFESSOR HARALD N. RØSTVIK, UNIVERSITETET I STAVANGER



SOL ÅS – KINA



Fra venstre Agrienergi, Reunion island. Solar loop, skisse for 10 000 MWh italiensk prosjekt.
Til høyre for denne, kombinert solfangerfarm over dyrkbar jord hvor landbruksmaskiner kan kjøre under.
Helt til høyre: Skog av solfangere til belysning i Frognerparken og til a-has gratis jubileumskonsert.

HOW TO FIX IT ?

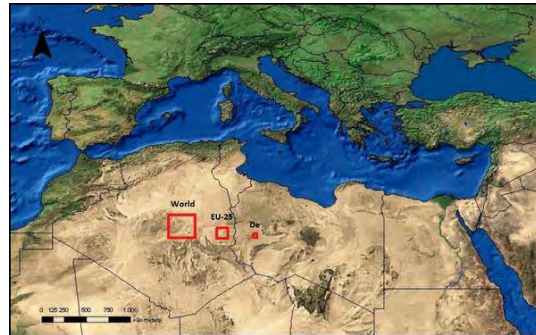
1. POLITIKK
2. ADFERDSENDRING
3. TEKNOLOGY

HOW TO FIX IT ?

1. TEKNOLOGI
2. ADFERDSENDRING
3. POLITIKK

2 SOLENERGIPOTENSIALET

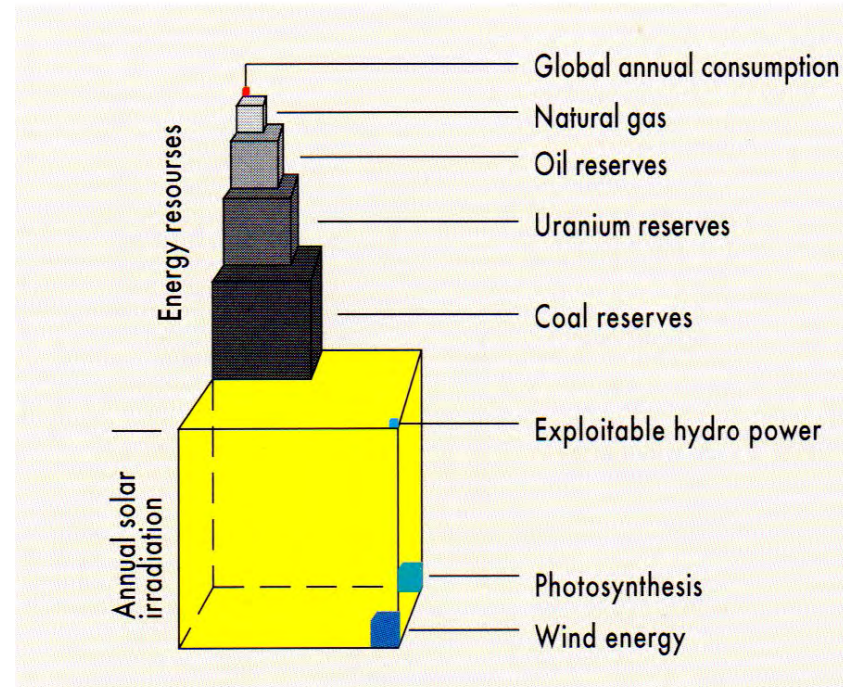
GLOBALT SOLENERGI POTENSIALE



Sanyo's Genesis

Global Energy Network Equipped with Solar cells and International Superconductor Grids

A GAME CHANGER



Annual irradiation versus energy reserved and global energy consumption.

IEA OG ANDRE ANALYTIKERE HAR KONSEKVENT BOMMET.

STATUS ER:

TRE TEKNOLOGIER UTKONKURRERER NÅ ANDRE TEKNOLOGIER

ELBILER, SOLCELLER, BATTERIER.

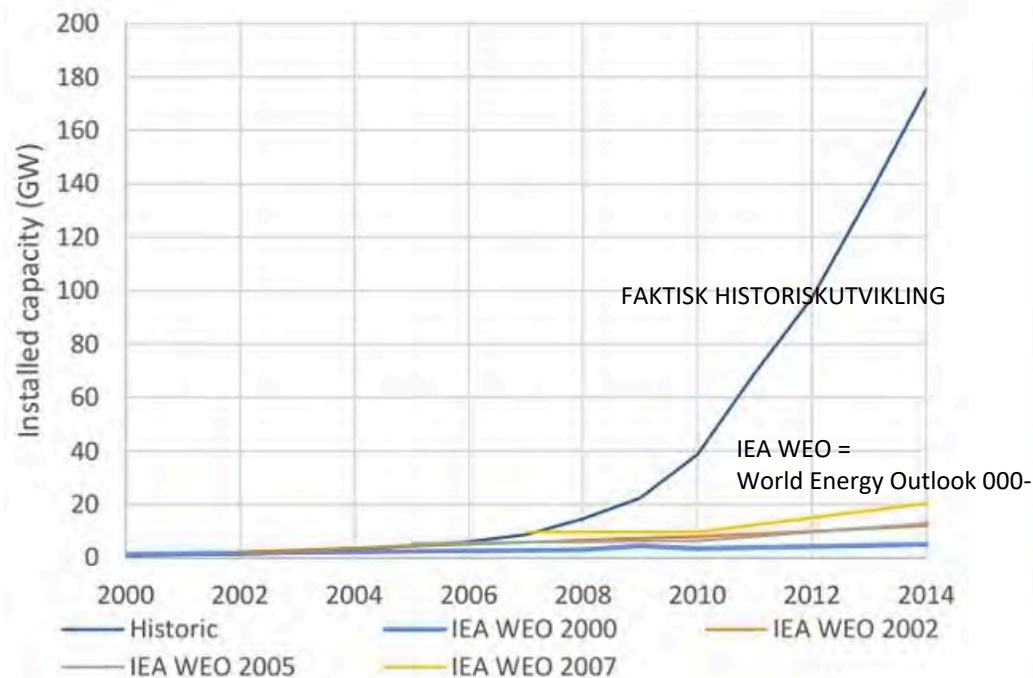
**PERSPEKTIVMELDINGEN
VARSLER AT OLJEPRODUKSJONEN KAN
FALLE MED 65% INNEN 2050.**

**DERFOR KAN GAMLE ANALYSER KAN KASTES -
FORDI BILDET UTDATERES NESTEN ÅRLIG.**

ANALYSE/FORECAST INSTITUSJONER SOM IEA HAR KONSEKVENT BOMMET PÅ ANSLAGENE I FLERE TI ÅR

DET ER KATASTROFALT DÅRLIGE ANALYSER – NESTEN INFORMASJONSUNDERSLAG.

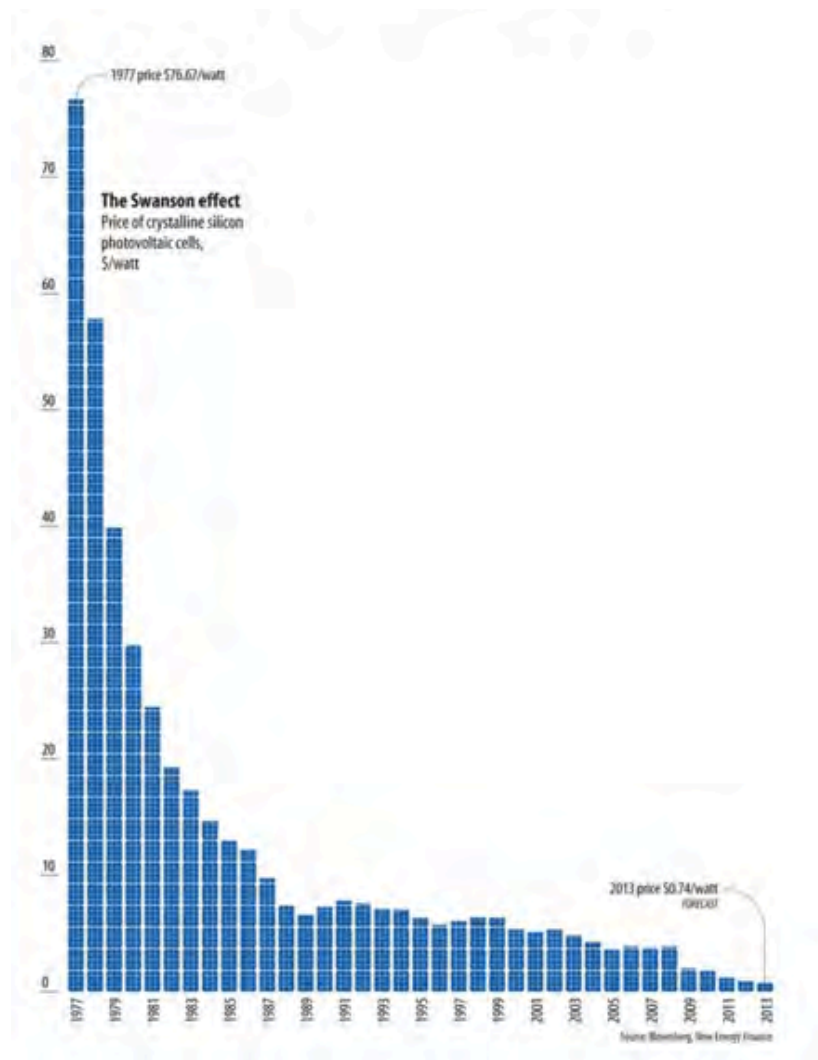
REGJERINGER, OLJESELSKAP OG FOLK FLEST ER VILLEDET.



► The International Energy Agency's predictions for solar PV growth vs historical data. Photograph: Carbon Tracker

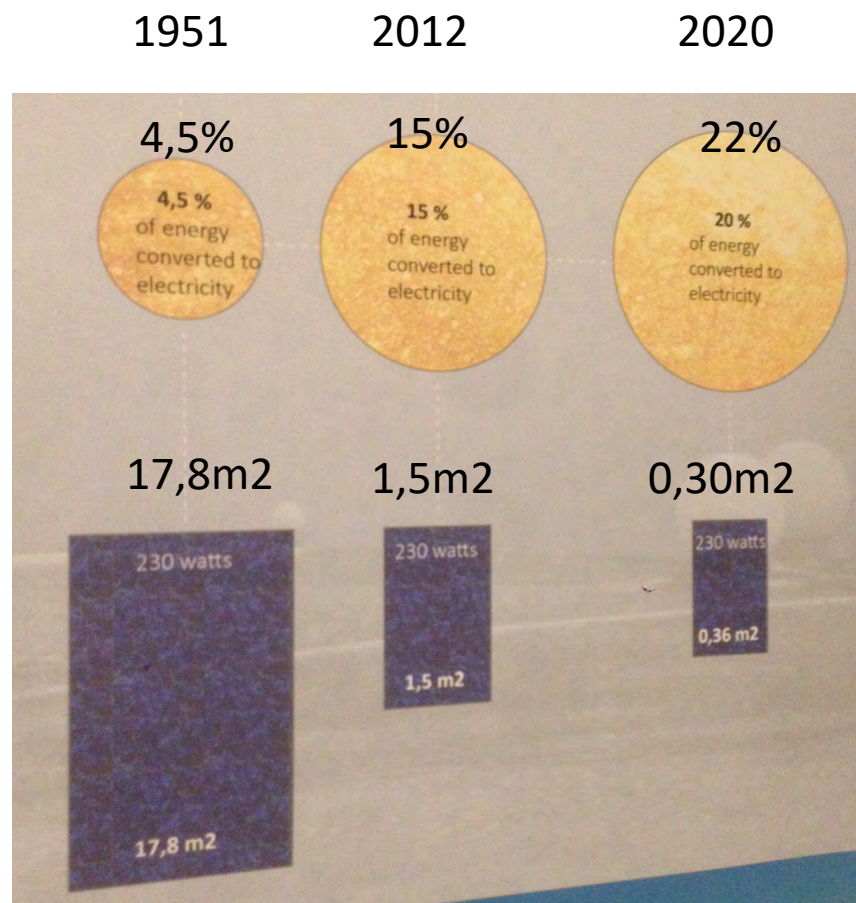


MENS PV-PRISENE FALLER

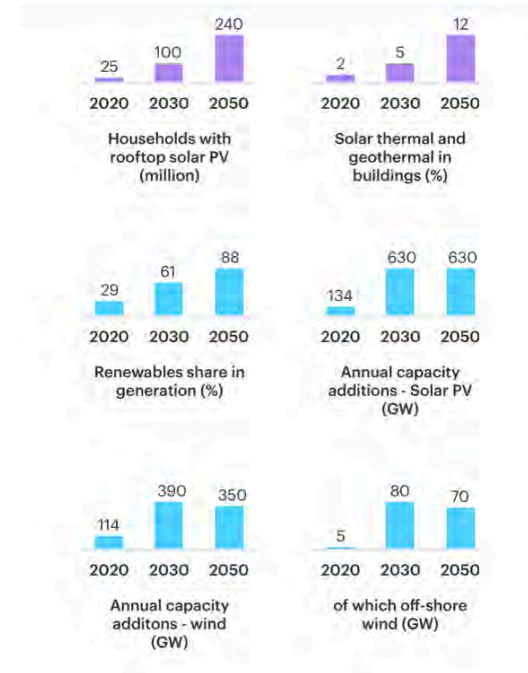


OG EFFEKTIVITETEN ØKER

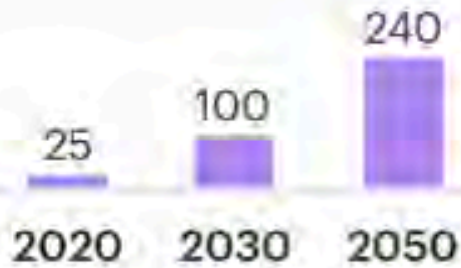
SOLSTRØM
PV



PLUTSELIG NYE TAKTER: IEA RAPPORT LANSERT 18 MAI 2021



- Få grunner til å fortsette å bore etter ny olje, globalt.
- Å ta vare på det som allerede er funnet er tilstrekkelig.
- Dette fordi oljeetterspørselen vil falle dramatisk. Den utkonkurreres.



Households with rooftop solar PV (million)



Solar thermal and geothermal in buildings (%)



Renewables share in generation (%)



Annual capacity additions - Solar PV (GW)



KEY:

- Buildings
- Industry
- Transport
- Electricity
- Other

FINANCIAL TIMES OG THE GUARDIAN HAR LENGE SETT HVOR DET BÆRER -

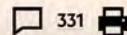
Energy groups must stop new oil and gas projects to reach net zero by 2050, IEA says

Radical move would have to be compensated by huge investment in clean energy



A stark report from the IEA lays bare the challenge to achieving net zero emissions by 2050 © Andrey Rudakov/Bloomberg

Leslie Hook and Anjli Raval in London AN HOUR AGO



NÅ BRÅVÅKNER OGSÅ NORSKE IEA-LOYALE MEDIER SOM TILSYNELATENDE TIDVIS HAR FUNGERT SOM EN FORLENGET ARM AV IEA OG OLJESELSKAPENES INFORMASJONSAVDELINGER, OG DERMED BIDRATT TIL DET STORE INFORMASJONSUNDERSLAGET.

Stavanger Aftenblad
 Grunnlagt 1. september 1903 av Lars Oftedal

Nytt veiskille for oljeindustrien

LEDER: Oljeindustrien er for viktig for Norge til å la politikken bli en ideologisk slagmark. Den nye rapporten til det internasjonale energi byrået demonstrerer dette poenget.

Det internasjonale energi byrået (IEA) publiserte i går en livstykke for neste ukebladet Dags Næringsliv. Den legger klart uttrykk for at det ikke trengs noen nye olje- og gassfelt eller nye kraftverker etter 2020. Omstillingen blir svært utfordrende, pågår det energi byrået, som kaller den nødvendige tekniske utrustningen utrustning.

Gravsteinen til et datter-analyse vil være viktig, etter rapporten, er at IEA vil nå ha prøvd å legge ned på en lang tid, og det er et stort poenget å kjøpe den, og at den på den tiden har det nå er en svært viktig del av den nye energi byrået. Det er viktig å se på den nye energi byrået, som kaller det nødvendige tekniske utrustningen utrustning.

Når IEA nå er klar på at alle nye olje- og gassfelt fra og med 2020, vil det selvfølgelig bli innført som en del av den nye energi byrået, som kaller det nødvendige tekniske utrustningen utrustning.

Rapporten vil fungere som en opplyst til den globale klimainformasjonen COP26 som finner sted i Glasgow i september. Den er en klimainformasjon som er utrustning.

La oss se på det nye IEA rapporten og se på den nye energi byrået, som kaller det nødvendige tekniske utrustningen utrustning.

FREDAG 21. MAI 2021 DAGENS NÆRINGS

Kommentar
 Bård Bjerkholt er kommentator i Dagens Næringsliv

**Bård Bjerkholt
 Ulønnsom olje**

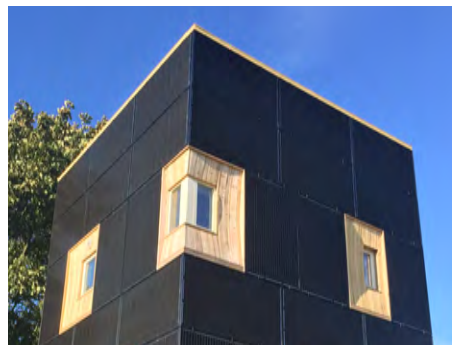
Problemet med norsk oljepolitikk anno 2021, er at den oppfordrer til at ulønnsom olje og gass blir hentet opp.

● Denne uken ga det internasjonale energi byrået ga ut et omfattende rapport om veien til nullutslippssamfunnet. Rapporten peker på et dramatisk fall i oljetterspørselen, dersom verden skulle lykkes med bestrebelser på å holde temperaturøkningen på 1,5 grader. Det er ingen bombe at verden må kutte ned på forbruket av fossil energi, dersom klimamålet skal nås. Kruttet i rapporten lå i konklusjonen om at det ikke er behov for noen nye olje- og

Olje og energiminister Tina Bru mener det også vil være plass til norsk olje og gass på vei til nullutslippssamfunnet. Problemet er at

3 BYGNINGSINTEGRASJON

HVIS SOLCELLENE ERSTATTER ANDRE
BYGNINGSMATERIALER PÅ VEGGER ELLER TAK
ER SOLCELLER I DAG NEDBETALT ETTER
0 TIL 5 ÅR SAMMENLIGNET MED
DE DYRESTE FASADEMATERIALER
(AVHENGIG AV MATERIALTYPE).



DOBBEL FUNKSJON REDUSERER KOSTNADER. SOLCELLER ERSTATTER TAK, VEGGER OG ANDRE FLATER.

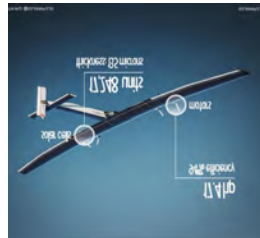
SOLBÅT



SOLBIL



SOLFLY



DOBBELFUNKSJON REDUSERER MERKOSTNADENE.



Solstrømproduserende sykkelsti i Nederland.

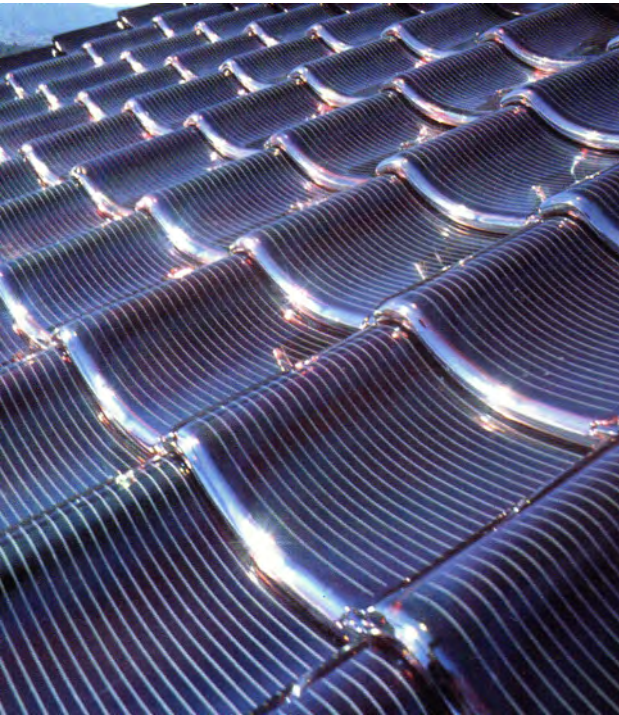


Milevis med motorvei støyskjermer i Sveits og Tyskland.

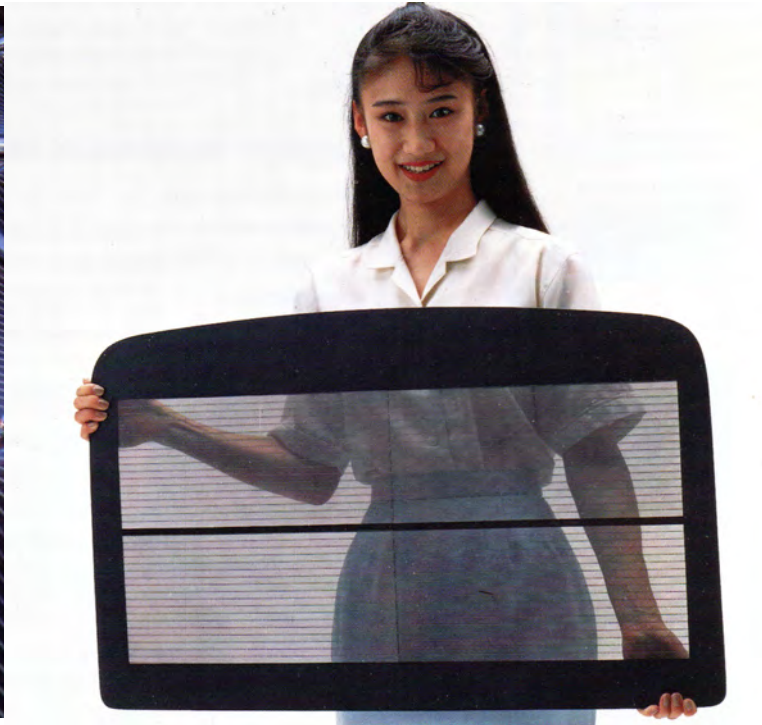


Det arbeides med 1.000 km sykkelsti Frankrike belagt med solcelle'asfalt'.

SOL PV TAKSTEIN OG SOL PV VINDUSGLASS



Sanyo, Japan - 1989



NTNU 2020



Blackfriars Station
solar bridge, London.

SOLCELLER PÅ VANN

Amerikanske forskere: Dekk kanalene med solceller



California har verdens største drenerings- og vanningsystem, som dekker 35 millioner mennesker og 20.000 kvadratkilometer jordbruksland.

Kan hindre fordamping og gi elbillading samtidig.

ELLEN SYNNØVE VISETH 21. MAI 2021 - 14:00

Forskere i California har regnet på hva som ville skje hvis man la solcellepaneler på statens 6.437 kilometer med kanaler, inkludert California

SOLENERGI I POLEN

Kull dekker nærmere 80 prosent av Polens energibehov – men nå kommer solenergien



Solceller er blitt svært populære i Polen etter at myndighetene valgte å gi solide støtteordninger til folk for å få dem til å skifte ut gamle kullfyrte kjeler med ny og ren energi. (Foto: Frank May / NTB)

Kullgruvene må stenges innen 2049 for å nå EUs planer om utslippskutt.

NTB 21. MAI 2021 - 07:19

CO2-UTSLIPP FRA VEITRANSPORTEN

IEA: 60 prosent av alle nye biler må være elbiler innen 2030



Elbiler må spille en avgjørende rolle om verden skal bli karbonnøytral innen 2050. (Foto: Eirik Helland Urke)

Fossilbiler må forbyes senest i 2035.

MARIUS VALLE 20. MAI 2021 - 19:00

HURTIGLADESTASJONER

Kutter effekttoppene med stort batteri: Her lynlades elbilen med kortreist solenergi



Her lader vi Ford Mustang Mach-e med energi delvis generert av solceller på taket av ladestasjonen. Foto: Mathias Klingenberg (Mathias Klingenberg)

Er det slik fremtidens energistasjon ser ut?

MATHIAS KLINGENBERG 21. MAI 2021 - 19:00

Kongsberg: Samtidig som ordene du leser skrives ned, lynlades vår testbil Ford Mustang Mach-e med kortreist solenergi på Circle K Kongsbergporten.

ALLE BYERS – OGSÅ TREHUSBYERS OG EKSISTERENDE BYGNINGERS UTFORDRING:



Mandal



Stavanger

SKAL TAK OG VEGGER VERNES - ELLER KAN MAN VISE FLEKSIBILITET ?

DAGENS PROBLEMSTILLING ER OFTE KONFLIKTFYLT

Ulovlig monterte solceller blir beordret fjernet.



BYGNINGSINTEGRASJON ELLER TAK KAOS



Solpaneler på tak i Syd Europa begynte for 30 år siden å ødelegge den vakre skyline. Det er ikke slik vi vil ha det. Arkitekter og byplanmyndigheter må engasjere seg for å hindre dette.

INGENIØR JULETRE

PRODUSERE EGEN STRØM

Lyset til Tore (44) gikk hele tiden. Nå er strømbrudd noe av det morsomste han vet



Energipark: Tore Neverås har bygd opp solcelle- og vindparken i hagen sin siden 2011. Teknologien blir stadig bedre og billigere.

Et eksempel på et rotete idealistprosjekt som heller skader solenergiens omdømme enn å fremme det.

Dessverre - for prosjektet er velment. TU 29.10.2016.

EKSEMPEL

**I TREHUSBYER
BØR ENØK TILTAK
PRIORITERES
PÅ STORE
NÆRINGSBYGG
DER TAK OG
VEGGFLATER
ENORME OG
SOLENERGI-
PRODUKSJONEN
GIR MER ENERGI.**



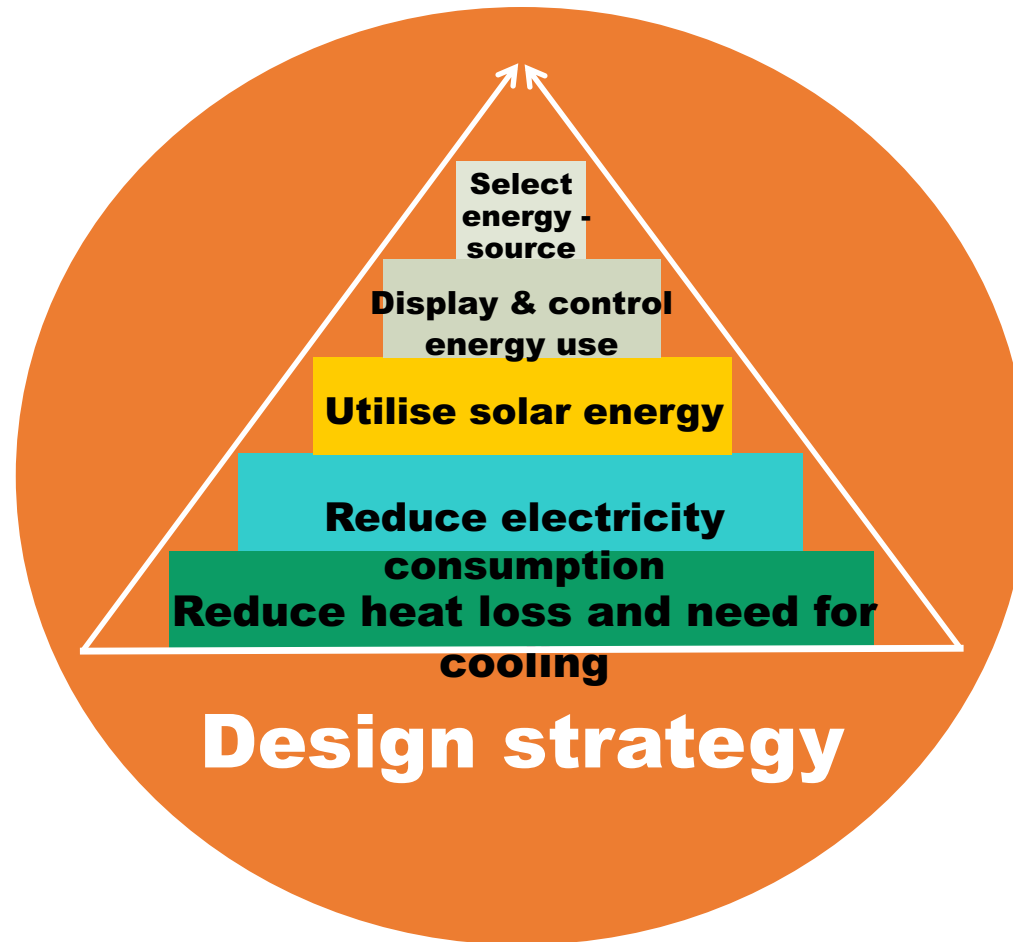
TYPISK TREHUS I EN TREHUSBY
UTEN BETYDELIGE ENØK TILTAK
HAR ET ÅRLIG ENERGIFORBRUK

25.000 kWh per år

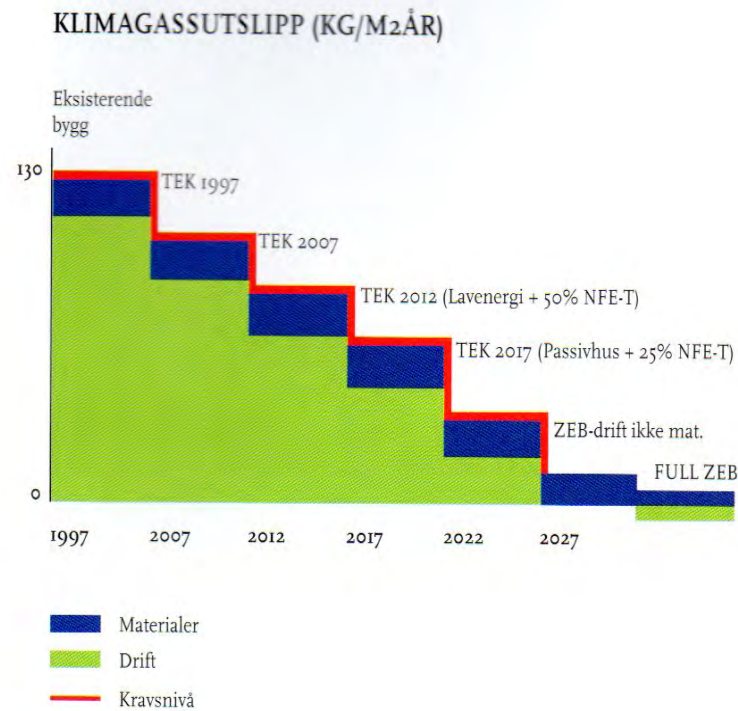
ET 20 m² SOLSTRØMANLEGG
VIL BIDRA MED 120 kWh/m/år

2.400 kWh per år = 10%

(Typiske anlegg i Norge 15-20%.)



NÆR NULL ENERGI BYGG (NZEB) STANDARD FOR NYBYGG FRA DESEMBER 2020 IFLG EUs BYGNINGSDIREKTIV.



Klimagassutslippene til drift faller til null mens klimagassutslippene som oppstår ved produksjon av byggets materialer består.

4 EGENE LØSNINGSORIENTERTE PROSJEKTER

MITT GRØNNE PERSPEKTIVS AMBISJONSNIVÅ ER BASERT PÅ 40 ÅRS ARBEIDE MED BÆREKRAFT.

UTDANNET **ARKITEKT** VED UNIVERSITY OF MANCHESTER.

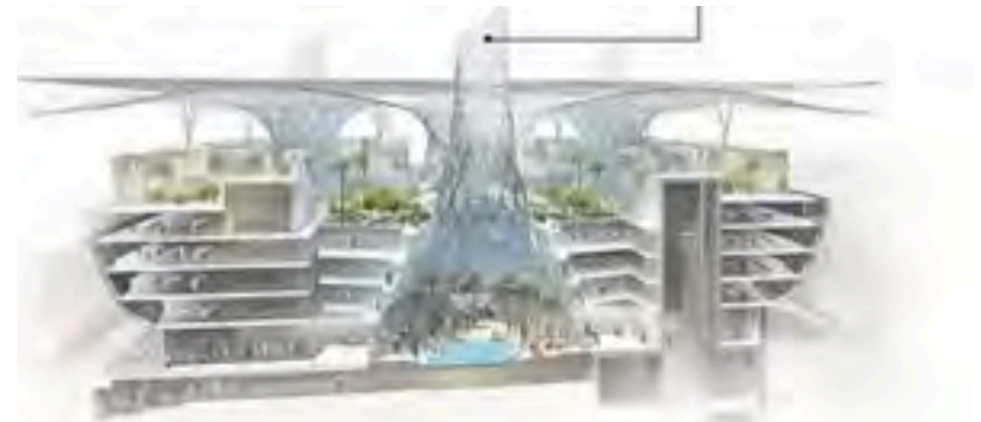
BYEN ER KJENT FOR DEN INDUSTRIELLE REVOLUSJON.

EN AV VERDENS FØRSTE DATAMASKINER –
MARK1 BYGGET DER.

EN REKKE NOBELPRISVINNERE UNDERVISER DER.

INTERNASJONALT KJENTE STUDENTER:

- ALAN TURING**, ENIGMA CODE BREAKER.
- LUDWIG WITTGENSTEIN**, FILOSOF.
- NORMANN FOSTER**, ARKITEKT.



MASDAR FORNYBARBASERT
ENERGISELVFORSYNT BY.
ARKITEKT: NORMAN FOSTER



HVORDAN HAR UNIVERSITETET MARKERT SEG ?

RANKET BEST I VERDEN AV 1200 UNIVERSITETER
PÅ «ACTION ON SUSTAINABLE DEVELOPMENT»
- ALTSÅ HANDLING IKKE BARE ORD.

MAI 2021.

MANCHESTER
1824

The University of Manchester

Development and Alumni Relations
We've been ranked 1st in the world for action on sustainable development

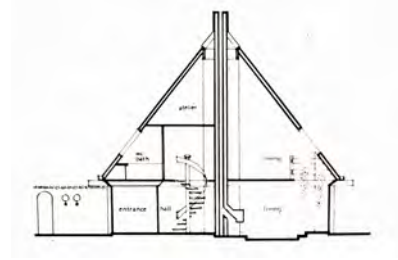
**The world's best university
for action on sustainable
development**

University of Manchester
RANKED 1st

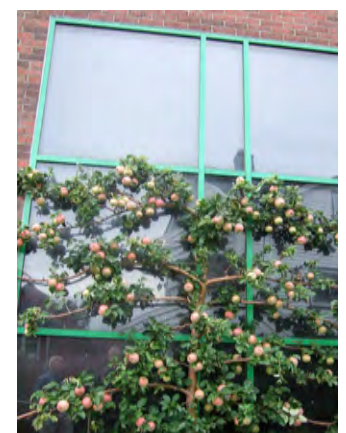
**THE IMPACT
RANKINGS 2021**
www.thewur.com

**We've been named number one
in the Times Higher
Education Impact Rankings**

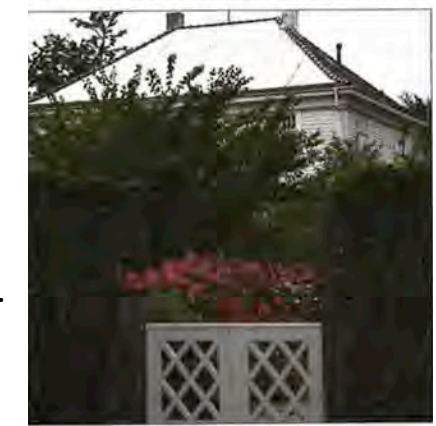
The University topped the table of more than 1,200 universities from around the world on action taken towards the United



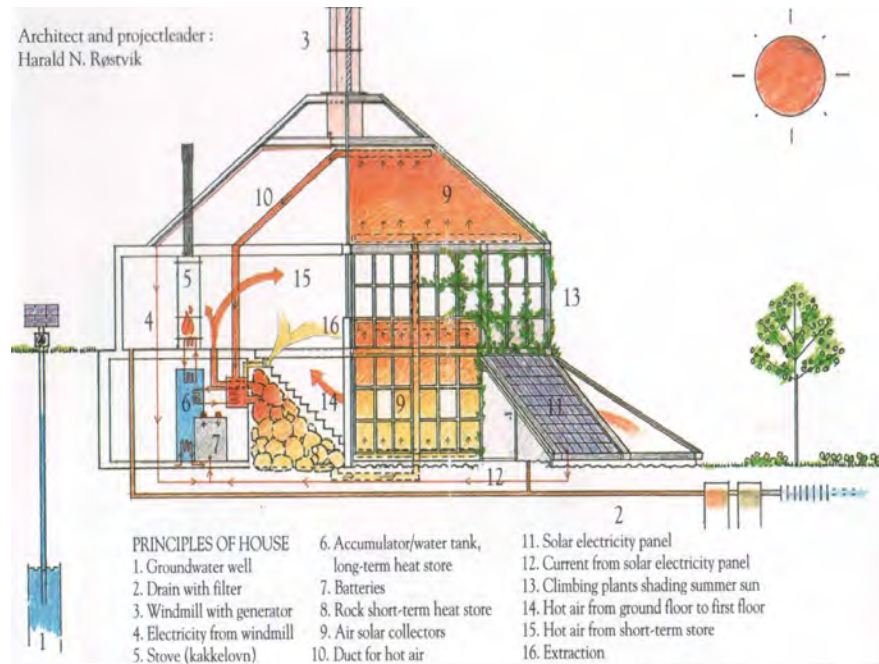
Norges første hytte med med Solstrøm (PV) 1978.



Bolig Natvig
1918 rehabilitert med sol tak 1979.



MER FARGE I ARKITEKTUREN – REF ARKITEKTUROPPRØRET



BYGG FOR FREMTIDEN 1988.
Europas første moderne
ZEB inkl PV, solvarme & vind.

IMPORT AV NORGES FØRSTE MODERNE ELBIL MED A-HA OG BELLONA HVOR VI VISTE ELBIL LADING MED SOLSTRØM I 1989.



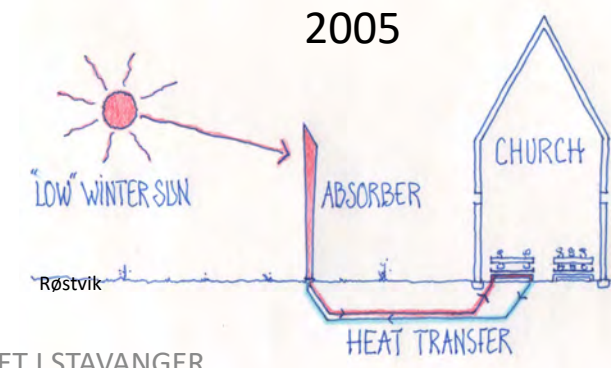
REHABILITERING

Boligblokker fra 50-tallet i Gøteborg.



Solenergi basert rehabilitering 1995 av Tilførsel av energi (varme) erstattet Langt mer omfattende etterisolering.

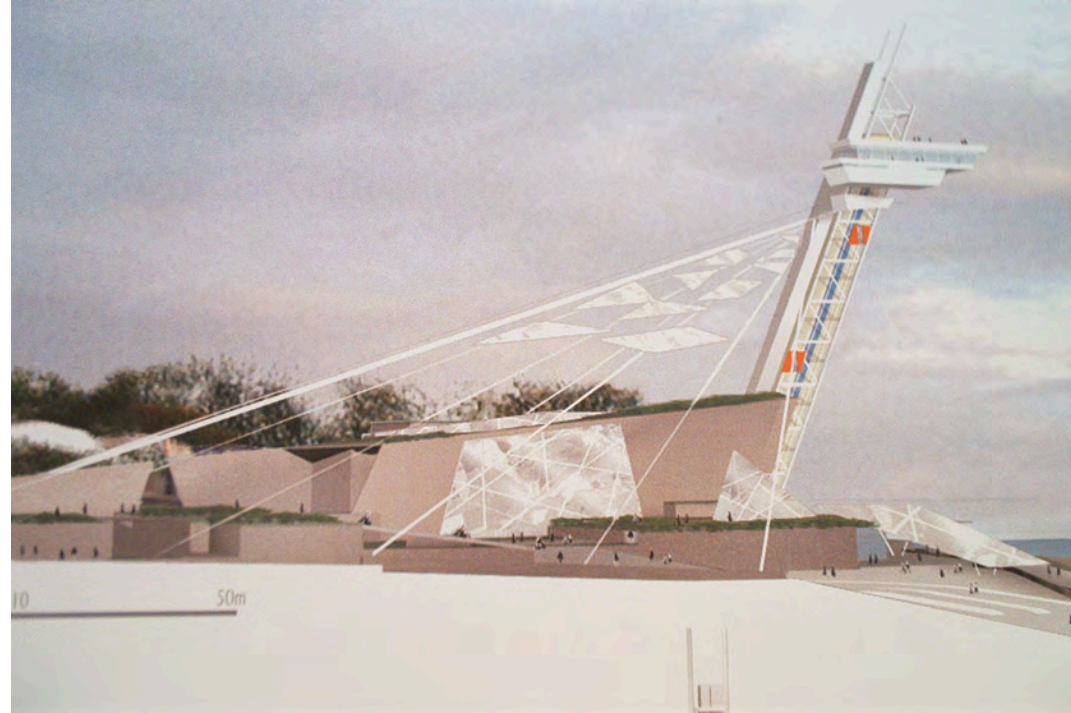
Hol kirke rehabilitering m solvarme (EU).



INTERNASJONALE ARKITEKTKONKURRANSER
100% SOL- OG VARMEPUMPEDREVNE KONSERTTHUS



Kristiansand 2005



Stavanger 2003

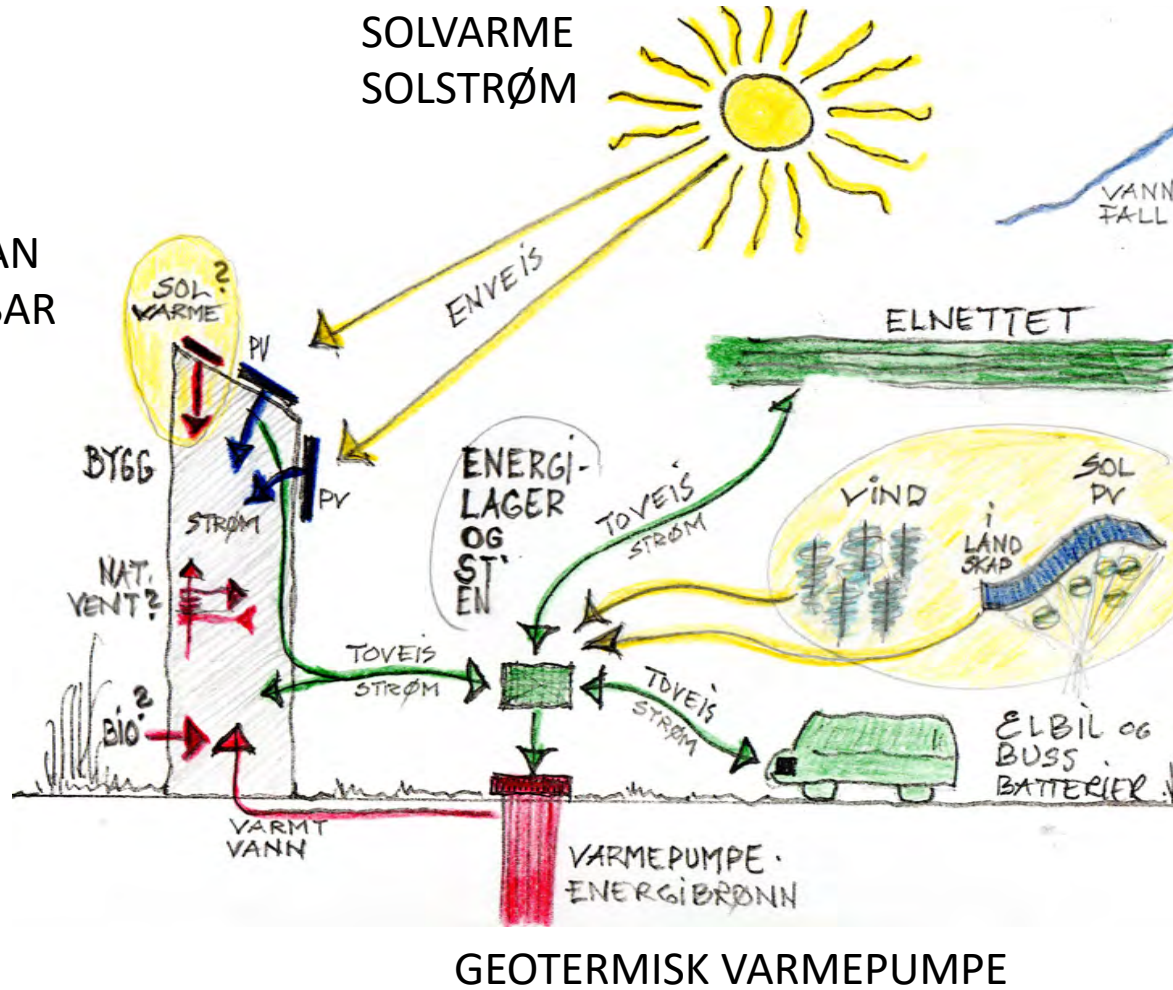
Samarbeide med Meletitiki, Tombazis, Aten.

FRA ENKELTBYGG TIL BYDEL SOM PED (POSITIVE ENERGY DISTRICT) TIL HELE BYER SOM KRAFTVERK

STOR AMBISIØS PLAN
PED – 100% FORNYBAR

Madla Revheim,
Stavanger.

Ny by
for 10 000
Mennesker



GEOTERMISK VARMEPUMPE

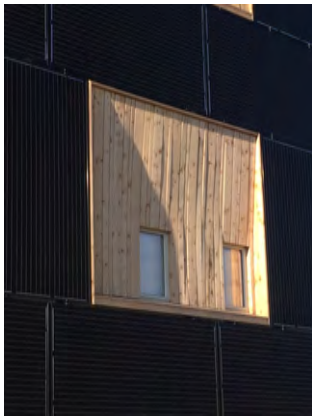
ELLER BLIR DET EN
PUSLETE REALISERING
MED GRØNNVASKING?



2018



Stendahl Gård, Randaberg



LANDSKAPSINTEGRERTE SKULPTURELLE SYSATYEMER



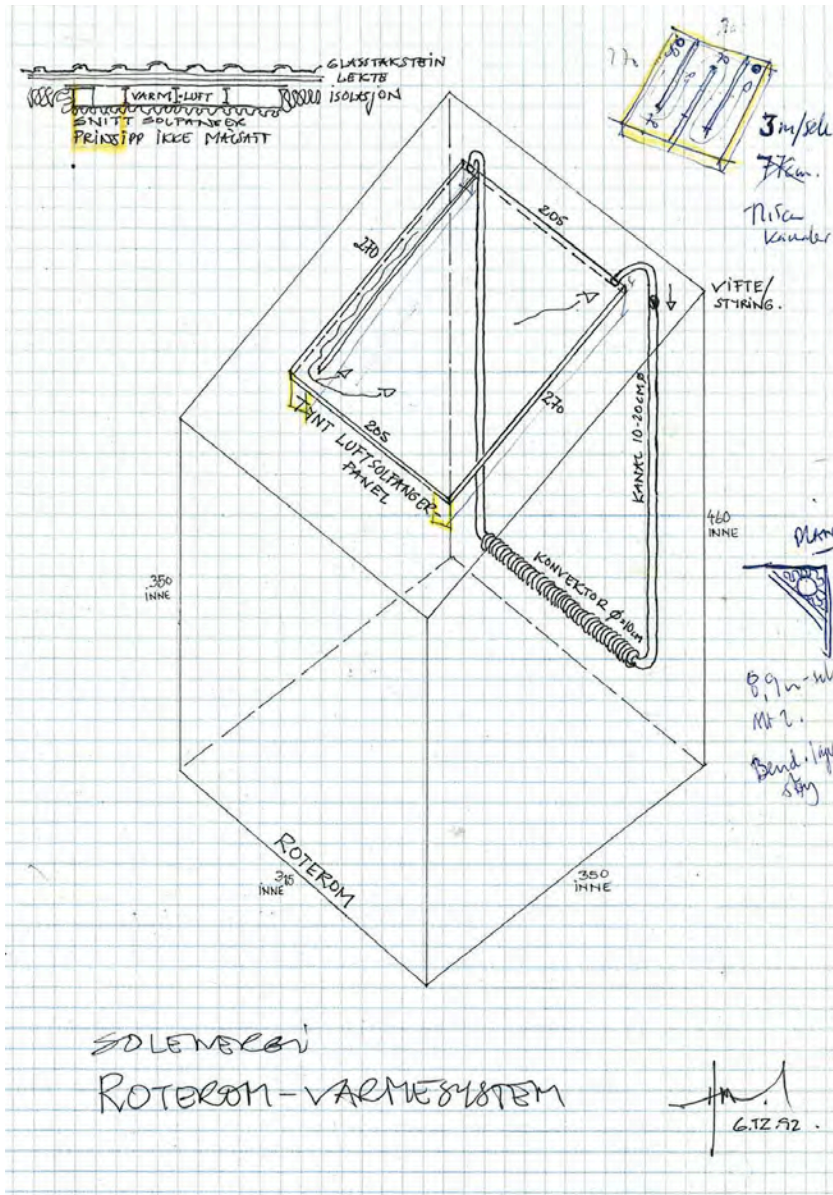
St Paul de Vence, Syd Frankrike og Sørlandet, Norge.

I LIGURIA; ITALIA 1992.

Village of Thor Heyerdahl (RA-expeditions).

For the artist Fritz Røed
in the Medieval village, Villa Feraldi,
solar thermal was used to heat the building.





NYBYGG

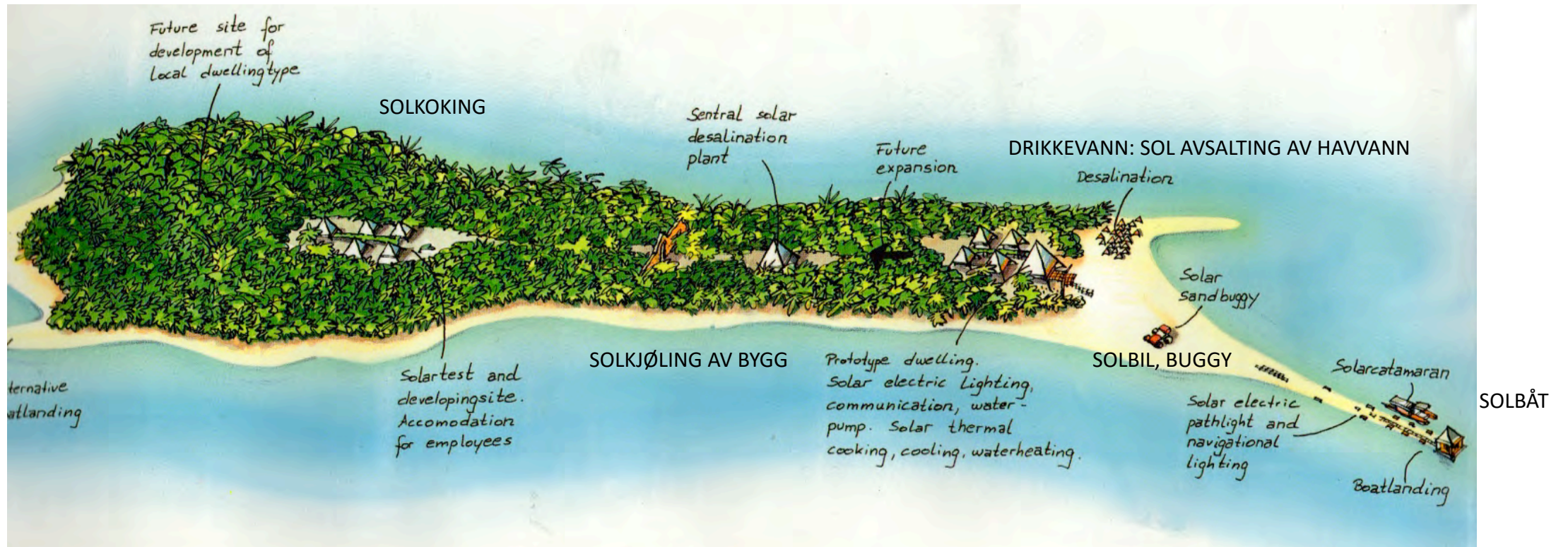
DOBBELFUNKSJON: SOLCELLETAK SOM SKYGGE, VANNSAMLER OG TAK.

WGM, YATV, COLOMBO, SRI LANKA.



MALDIVENE PROSJEKTET SELVFORSYNT SOLDREVET ØY – RASFARI

SAMARBEIDE MED MORTEN HARKET

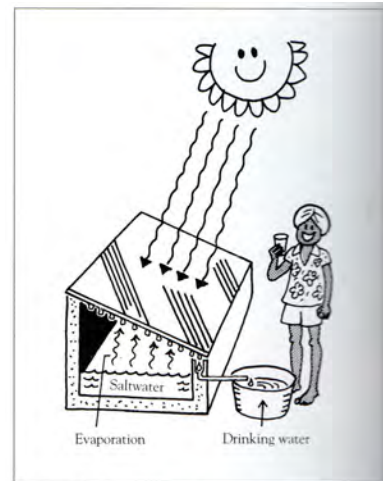


AVSALTING AV HAVVANN
FOR Å SKAFFE
DRIKKEVANN.

SRI LANKA



... and supplies drinking-water to a family of 6, free of charge and for ever...



Typical desalination plant. Evaporation and condensation.



Solar desalination plant. Sri Lanka. A Suntec Foundation project.

SunTec project
1981.

CYPRUS INTERNATIONAL UNIVERSITY STRATEGY

Et soldrevet universitet selvforsynt med energi. Er det mulig?

Verdens første energiselfforsynte universitetscampus drevet av solenergi var ambisjonen jeg presenterte da jeg første gang i 2010 møtte ledelsen ved Cyprus International University (CiU). I dag er drømmen realisert. Har vi noe å lære av dette eksemplet?

Mange festtaler

Mange universitet i verden har allerede i årevis arbeidet målrettet for å bli grønnere, mens Norge er akterutseilt. Dette vil svekke vår konkurranseevne hvis fremtidens studenter velger å studere på steder som tilbyr fremtidsrelevante kurs og campuser som i praksis viser hva som prekes. Det handler jo ikke bare om akademisk kvalitet og relevans, men om evnen til å praktisere hva fremtiden kommer til å handle om. Campuser blir grønne, energiselfforsynte, fornybarbaserte miljøfyrtårn – fullskala fremtidslaboratorier.

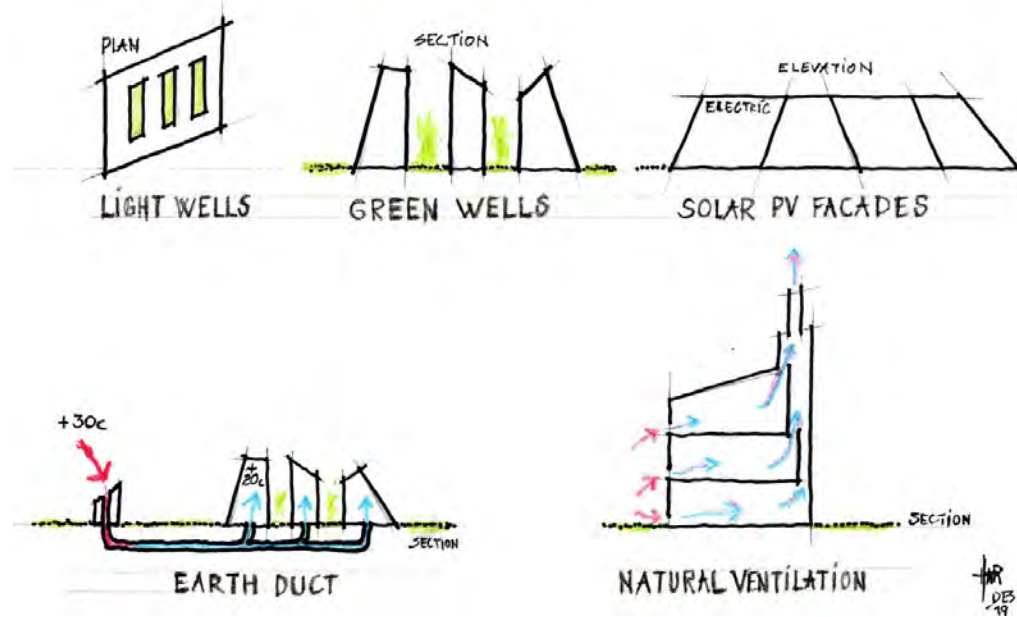
Cyprus International University

- *Arkitekt:* Saffet Kaya Design Ltd, London.
- *Energi system design:* Professor Harald N. Røstvik, Arkitekt MNAL, Stavanger.
- *Ventilasjons rådgiver:* Max Fordham Ltd, London.
- *Earth duct rådgiver:* Skelly & Couch UK, London..

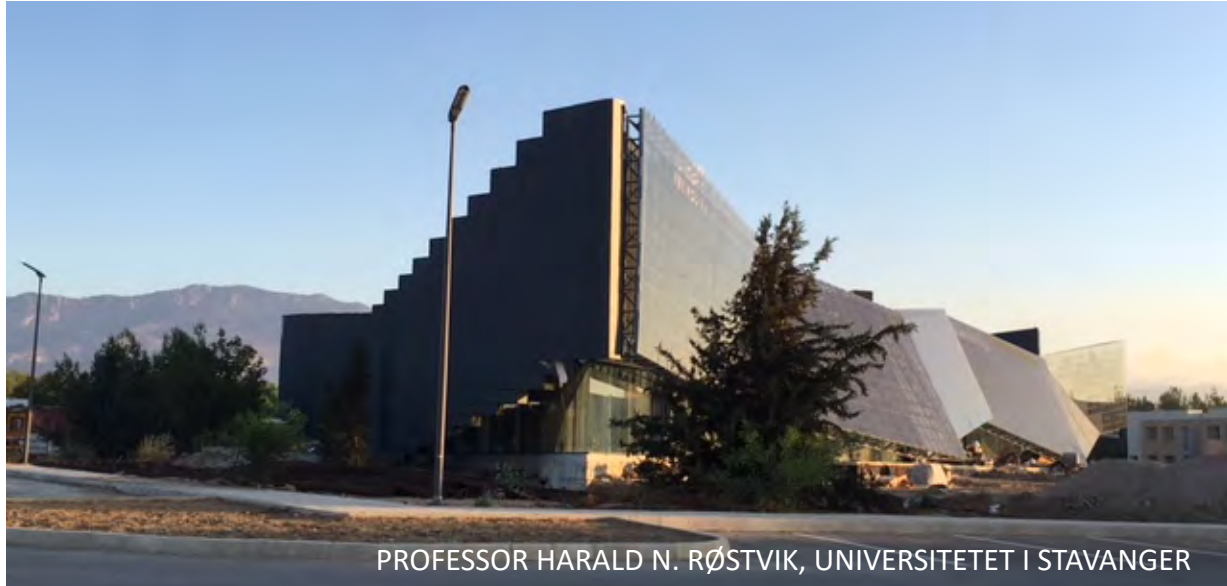
Tekst fra tu.no /Røstvik

CYPRUS INTERNATIONAL UNIVERSITY

PRINCIPLES · ENERGY



CIU ENGINEERING FACULTY BUILDING, CYPRUS, COMPLETED 2018.



PROFESSOR HARALD N. RØSTVIK, UNIVERSITETET I STAVANGER



Saffet Kaya Design

*Energy system concept designer and advisor:
Professor & Architect **Harald N. Røstvik**, Norway.*

*Natural Ventilation **Max Fordham Ltd***



NORSK SOLENERGIFORENING ETABLERT 1981

STYREMEDLEM OG STYRELEDER EN PERIODE



AKTIV I EUROSOLAR OG
WORLD COUNCIL RENEWABLE ENERGY

ETABLERT AV TYSKE HERMANN SCHEER



FNs RIO-KONFERANSE I 1992

FORSØKTE Å FÅ ENERGI OPP SOM EGET TEMA



ETABLERTE IRENA

MEDLEM AV RÅDGIVENDE KOMITE

PROFESSOR HARALD N. RØSTVIK, UNIVERSITETET I STAVANGER

HAR SKREVET TI BØKER

OM SOLSKINNSREVOLUSJONENS MULIGHETER OG OM MOTKREFTENE.

ARKIVET MITT ER DONERT TIL AKTIVVERKET. DET VISER HERSKETEKNIKKENE OG EKSKLUSJONEN PIONERER UTSETTES FOR.



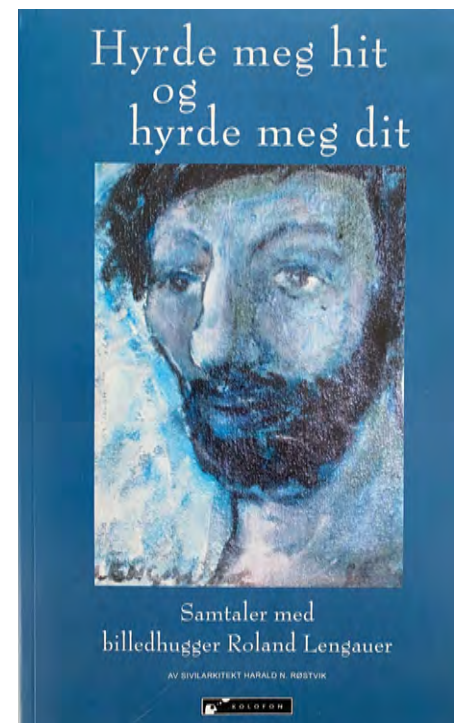
THE SUNSHINE
REVOLUTION
1992



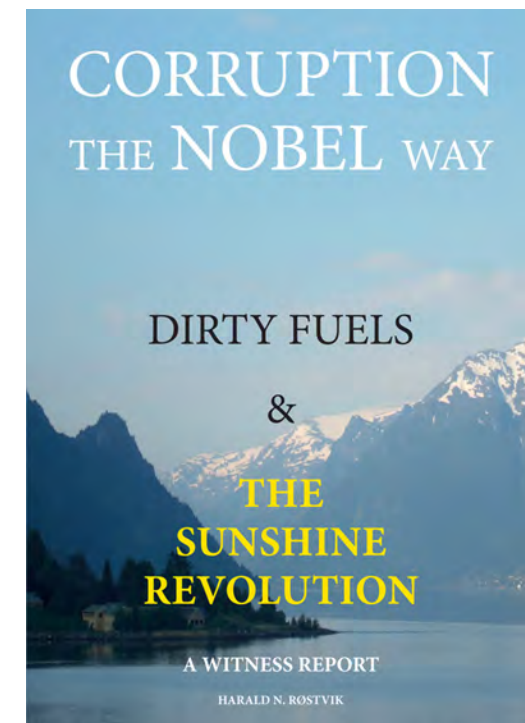
SOLBILLOPET
1996



EKSIL
2001



SAMTALER MED
ROLAND LENGAUER
2008



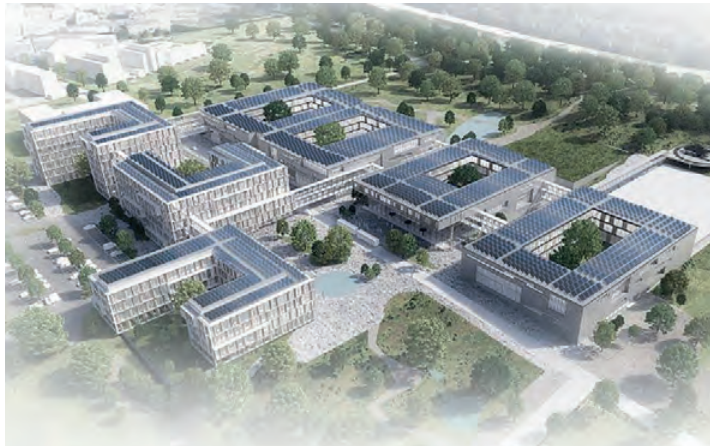
CORRUPTION
THE NOBEL WAY
2015

5 UNIVERSITETET I STAVANGER

Professor i Bærekraftig by- og regionplanlegging (2017-)
Professor i Holdbar (Resilience) Bergen Arkitekthøgskole (2008 – 2017)

SUSTAINABLE ULLANDHAUG 2040

Can Ullandhaug (UiS + SUS)
Become a Plus-energy area?
Can the transport issues be solved?



Work of Masterstudents in BYG 610



FUTURE ENERGY HUB
ÅPNET 2019

PROFESSOR HARALD N. RØSTVIK, UNIVERSITETET I STAVANGER

KOBLING MELLOM UNDERVISNING OG PRAKSIS. KAN DET VI PRODUSERER I UNDERVISNINGEN BLI BRUKT ?

BYG 610 (SUSTAINABLE CITY REGIONS) OG
BYG 655 IDEAS AND TECHNOLOGIES FOR SUSTAINABLE CITIES
(NYTT KURS 2016 - VEKST FRA 9 STUDENTER TIL 47 PÅ TRE ÅR).



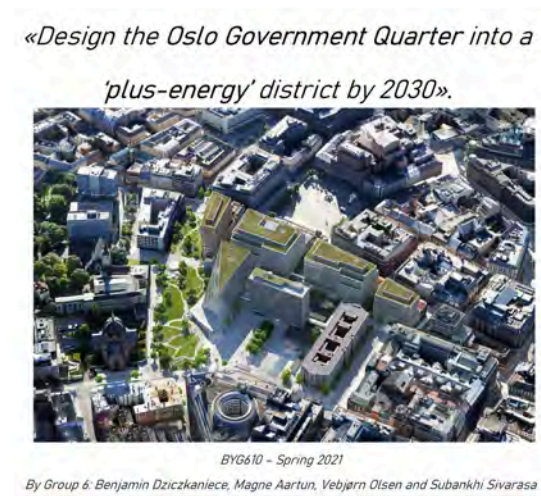
Norge



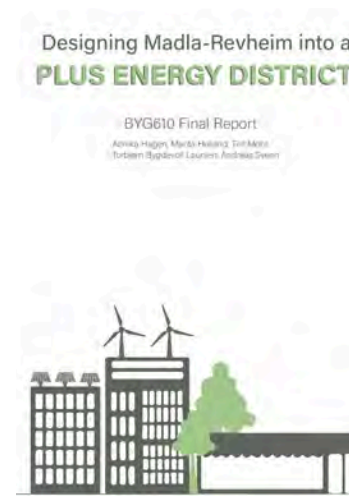
Stavanger regionen



Stavanger



Regjeringskvartalet



Madla Revheim

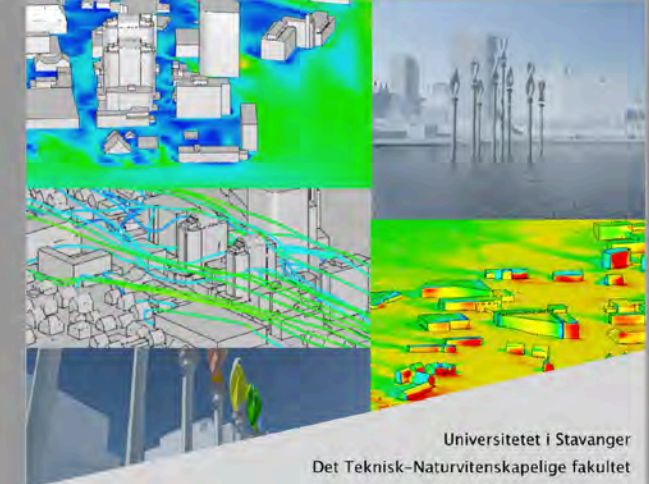


UiS Campus

MASTER BYG 610 GROUP WORK – MAKING PLUS ENERGY DISTRICTS (PED) - REDUCING CO2 EMISSIONS BY 80%

FLERE EKSEMPLER PÅ MASTER OG BACHELOR OPPGAVERT; 2020

VERTIKALAKSEL VINDMØLLER I BYEN



Universitetet i Stavanger
Det Teknisk-Naturvitenskapelige fakultet
BYGBBAC – Byplanlegging
Forfatter: Sonja Karlsen
Veileder: Harald N. Røstvik

Vertikalakslede vindturbiner i bebygde områder
casestudie av St. Olavskvartalet og
Campus Ullandhaug, UiS

Bacheloroppgave
Våren 2020

System

SONJA KARLSEN
Bachelor thesis 2020

KAN SOLA FLYPLASS DRIVES MED SOLENERGI ?



University of Stavanger
FACULTY OF SCIENCE AND TECHNOLOGY
MASTER'S THESIS

Study program specialization: City and Regional Planning
Spring/ Autumn semester, 2020
Open: Confidential

Author: Chandra Prakash Pareru
Programme coordinator: Stine Thu Johansson
Supervisor(s): Harald Nils Røstvik

Title of master's thesis: What are the site related and most sensitive parameters to optimize a large-scale PV installation at Stavanger Airport?

Utvæire: 30
Keywords: photovoltaics, solar energy, airport, utility, land-use, large-scale, deployment, installation, optimization, installation, site-related sensitive parameters, simulation

Number of pages: 70
+ supplemental material (if any):
Submission date: 12 June 2020



Figure 23: Spatial Setup of Large-scale PV system at Cochin Airport, India
(source: sustainableinfacts.com)




Figure 24: Organic farming underneath the solar PV system at Cochin airport.
(source: CIEL website)

PROFESSOR HARALD N. RØSTVIK, UNIVERSITETET I STAVANGER



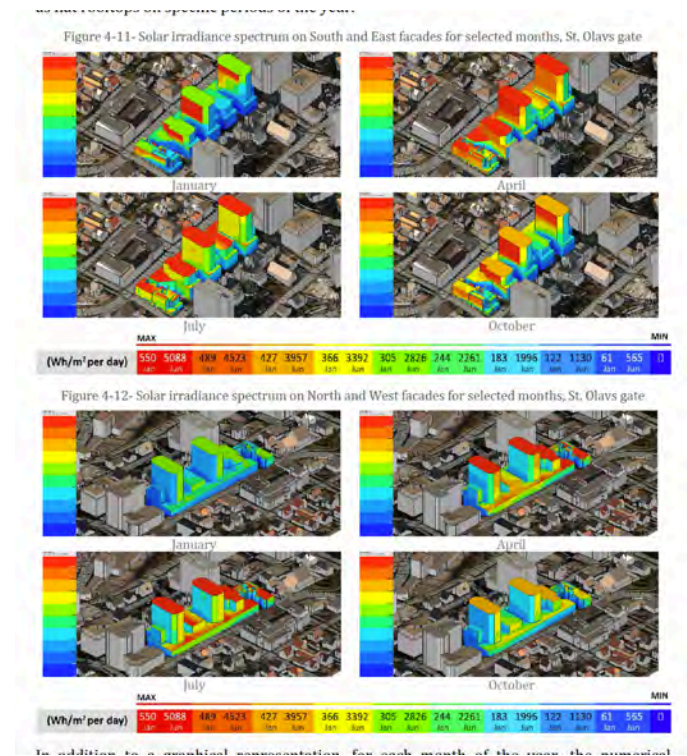
CHANDRA PRAKASH
Master thesis 2020

KAN ST OLAV KVARTALET OG HOLMEN I STAVANGER DRIVES AV BIPV SOLENERGI

 University of Stavanger FACULTY OF SCIENCE AND TECHNOLOGY	
MASTER'S THESIS E:\old windows\Downloads\front page master's thesis.jpg	
Study programme/specialisation: City and Regional Planning	Spring Semester, 2020 Open
Author: Mehrdad Rahimi, Ayda Joudavi	
Programme coordinator:	
Supervisor(s): Professor Harald N. Røstvik	
Title of master's thesis: Solar Energy Potential in Urban Environments, Case of Stavanger	
Credits: 30	
Keywords: <i>Solar potential, Urban Environments, Solar analysis, Photovoltaic, BIPV, Positive Energy District (PED), Net-zero Energy</i>	Number of pages: 99 + supplemental material/other:
Stavanger, 15.06.2020 date/year	



Urban block at St. Olavs gate, Eiganes
 Urban block at Øvre Holmegate, Stavanger Sentrum
 Figure 1-1- The two urban blocks selected for further studies



MASTER THESIS 2020: MEHRDAD RAHIMI & AYDA JOUDAVI

BYG 655 NEW IDEAS AND TECHNOLOGIES FOR SUSTAINABLE CITIES



OVERARCHING THEME AUTUMN 2020: COVID – WHAT WE LEARNED AND HOW WE CAN MAKE USE OF IT

THAT'S IT !

SOLENERGIREVOLUSJONEN OG OLJELANDET



***« DET ER SELVE FREMTIDEN SOM ER I SPILL.
NÅ HANDLER OM Å GI UNGDOMMEN TRO
PÅ AT DET NYTTER Å SLOSS FOR VIKTIGE SAKER.»***

HARALD N. RØSTVIK
PROFESSOR

University of Stavanger
Faculty of Science and Technology
Department of Safety, Economic and Planning (ISØP)
City- and Regional Planning Group



BIPV in Europe

Solenergirevolusjonen og Oljelandet

Hassan Gholami

27 May 2021

About Me

Education

- ❑ **BSc:** Electrical and Power Engineering, University of Tabriz (2006-2010)
- ❑ **MSc:** Electrical Energy Management, Amirkabir University of Technology (2010-2012)
- ❑ **PhD:** Solar Energy, University of Stavanger (2018-2021)
Solar Energy contribution to energy transition of cities and zero energy cities or positive energy districts.

Recent Activities

- ❑ Visiting Researcher, University of Cambridge
- ❑ Involved in projects with companies such as Steni AS and Forus Næringspark AS
- ❑ Solar Energy potential and challenges in urban areas
- ❑ Economic feasibility of BIPV
- ❑ Levelised cost of electricity of PV and BIPV

Solar Energy Potential in Europe



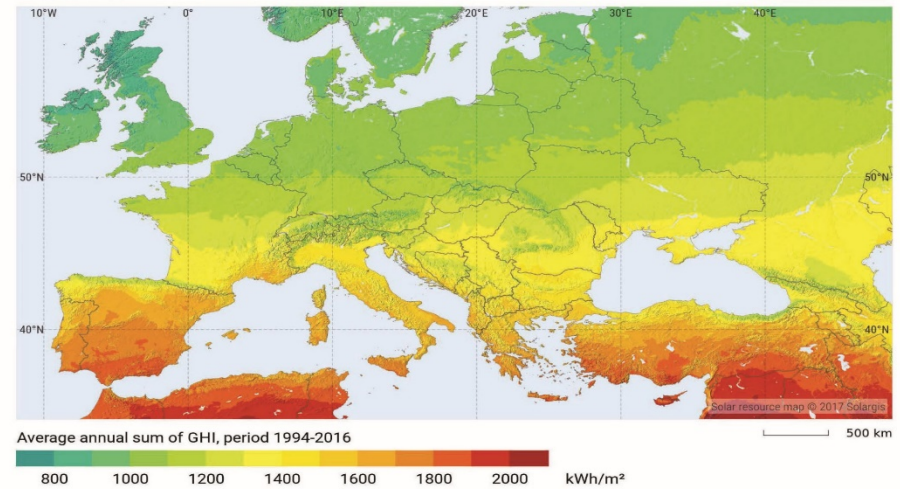
Global irradiation and solar electricity potential
Horizontally mounted photovoltaic modules

NORWAY / NORGE



GLOBAL HORIZONTAL IRRADIATION EUROPE

SOLARGIS



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Solar Energy Potential in Europe

No	Country	Capital	Average annual radiation (kWh/sq.m.)				
			Roof	South	East	West	North
1	Austria	Vienna	1225	1004	702	736	294
2	Belgium	Brussels	1073	902	649	656	295
3	Bulgaria	Sofia	1352	1042	797	743	332
4	Croatia	Zagreb	1312	1031	734	773	301
5	Cyprus	Nikosia	1928	1330	1044	1040	348
6	Czechia	Prague	1132	935	672	680	293
7	Denmark	Copenhagen	1051	926	634	664	271
8	Estonia	Tallinn	932	830	571	601	252
9	Finland	Helsinki	926	836	552	600	240
10	France	Paris	1174	975	712	667	302
11	Germany	Berlin	1079	922	661	652	288
12	Greece	Athens	1819	1286	990	997	338
13	Hungary	Budapest	1309	1069	756	762	302
14	Ireland	Dublin	975	862	613	597	291
15	Italy	Rome	1640	1262	937	846	309
16	Latvia	Riga	980	858	601	616	265
17	Lithuania	Vilnius	986	829	598	596	270
18	Luxembourg	Luxemburg	1121	900	677	681	300
19	Malta	Valetta	1875	1281	986	1056	341
20	Netherlands	Amsterdam	1065	902	636	675	291
21	Poland	Warsaw	1087	912	658	654	281
22	Portugal	Lisbon	1751	1277	953	1029	339
23	Romania	Bucharest	1406	1071	761	805	305
24	Slovakia	Bratislava	1253	1018	720	735	291
25	Slovenia	Ljubljana	1249	958	613	752	292
26	Spain	Madrid	1788	1401	1035	1015	321
27	Sweden	Stockholm	961	886	608	632	263
28	UK	London	1046	900	645	639	300
29	Norway	Oslo	911	865	568	594	245
30	Switzerland	Bern	1252	1045	754	735	302

2020: 4.9 GW
Total: 54 GW

2020: 40 MW
Total: 160 MW

2020: 400 MW
Total: 1 GW

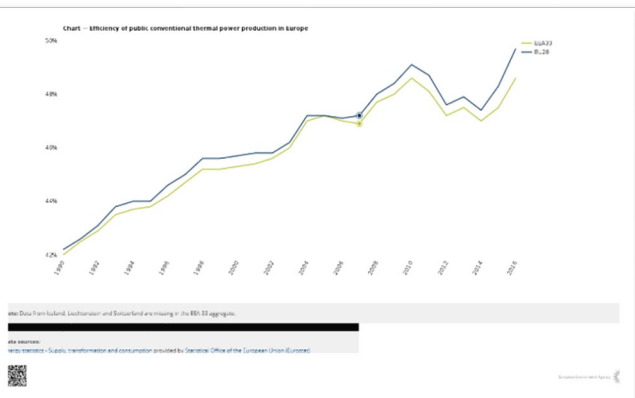
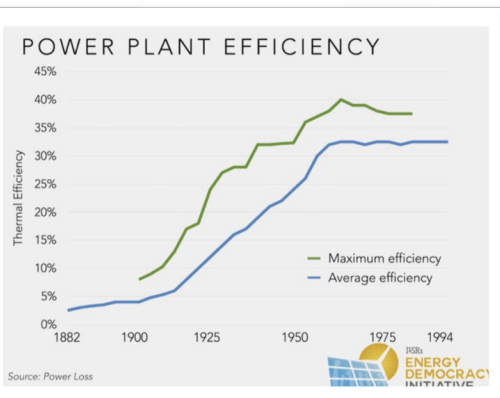
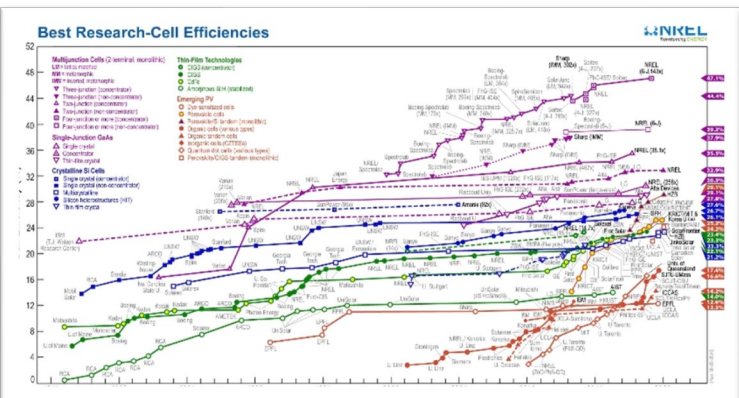
PV vs. Fossil Fuel Power Plant Efficiency Timeline

PV:

1975-2020: The efficiency of commercialized PV panels reached to 18-22%
 Primary energy resource: Free and clean solar energy

Fossil Fuel Power Plant:

1882-1994: The efficiency of fossil fuel power plants reached to 40%
 Primary energy resources: Oil, gas, and coal



Building Integrated Photovoltaics (BIPV)

BIPV is a PV system integrated to the building skins and perform as a building envelope materials while producing power.



(a)



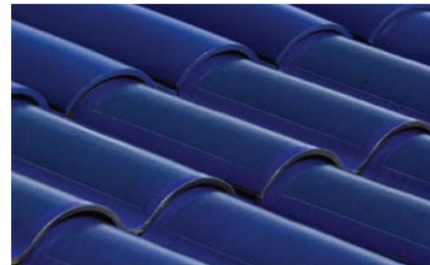
(b)



(a)



(b)



(a)

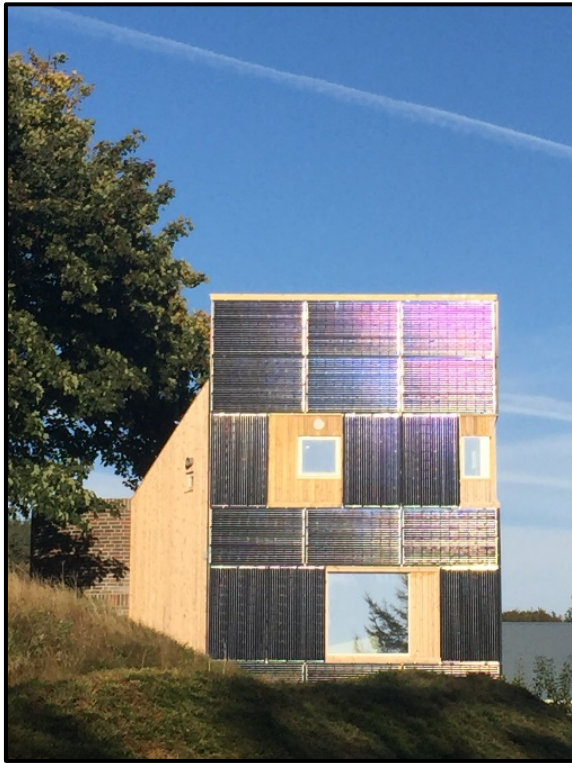


(b)

Source: “”<https://www.mdpi.com/1996-1073/9/1/21/htm>”

Building Integrated Photovoltaics: A Concise Description of the Current State of the Art and Possible Research Pathways

Examples of Recent BIPV Projects in Norway



**Kolnes, Randaberg
2018**

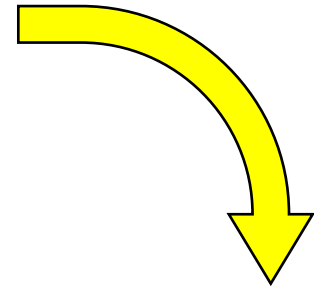
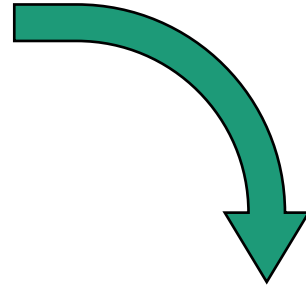


Solsmaragden Building, 2016



Oljedirektoratet, 2020

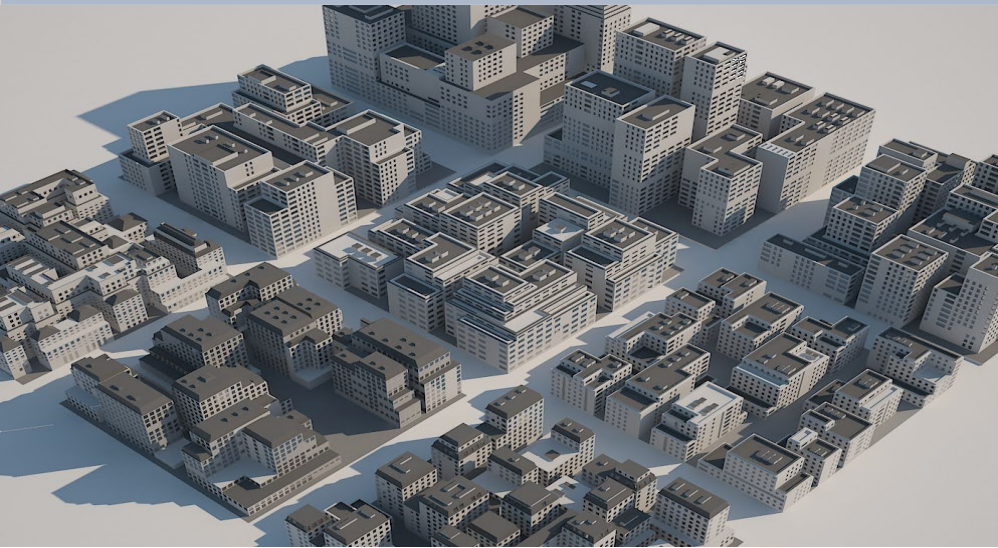
Why BIPV?



Energy Footprint on Nature

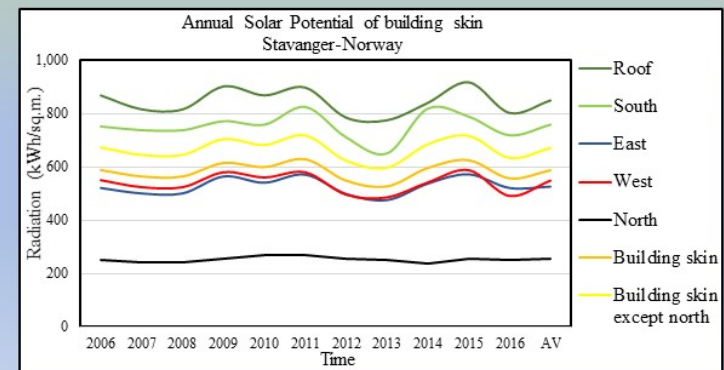
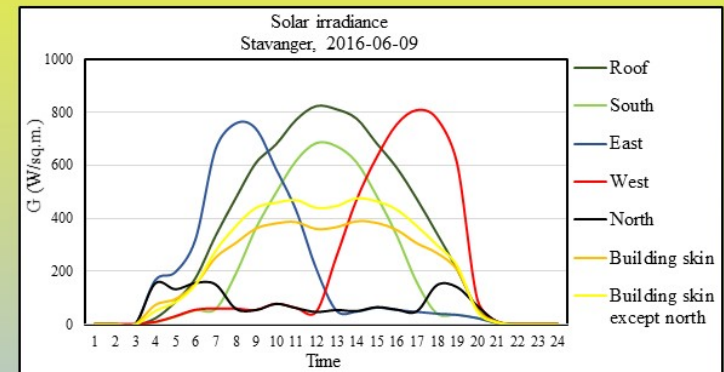


BIPV as a Building Envelope Material



- The possibility to achieve zero energy buildings (ZEB) or even plus energy building
- Better distributed electricity generation during the day
- The contribution of the system to enhance energy performance of the building envelope

Roof and south facade in urban areas of Scandinavian countries have the **maximum** solar potential. **But**, are those locations **optimal** for PV systems (or BIPV) when it comes to the economic analysis? **Not necessarily**. It depends on the **demand profile**, **network price**, **feed-in tariff** and several other factors.



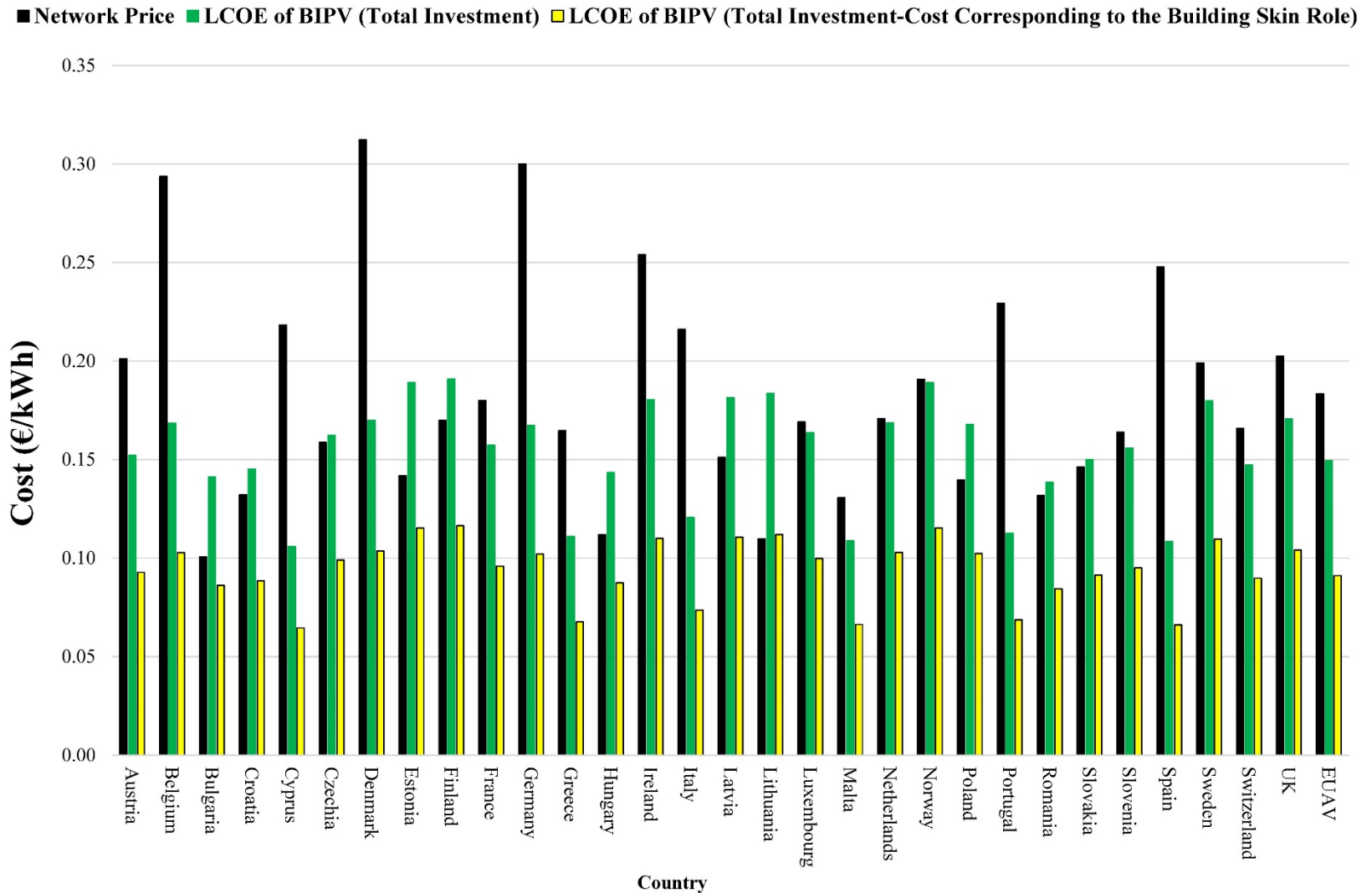
BIPV Price in Norway



BIPV project estimated cost breakdown.

Gross estimated cost	BIPV Facade		Glass facade		Δ	
	Total Cost (NOK)	Cost/sq.m.(NOK)	Total Cost (NOK)	Cost/sq.m. (NOK)	Total Cost (NOK)	Cost/sq.m.(NOK)
Facade panel delivery	2,767,590	2,415	655,512	572	2,112,078	1,843
Mounting system	435,480	380	435,480	380	0	0
Mounting labor	665,826	581	665,826	581	0	0
Elect. job and equipment	461,838	403	0	0	461,838	403
Lift	184,506	161	184,506	161	0	0
Contractor surcharge	0	0	184,506	161	-184,506	-161
Other costs	110,554	96.47	0	0	110,554	96.47
Sum	4,625,794	4,036	2,125,830	1,855	2,499,964	2,181

Network Price and BIPV Electricity Price



Various Approaches to Promote the BIPV Technology

Net metering

Prosumer get a bill based on their power generation and consumption over a period.

Feed-in tariff (FiT)

Prosumer are paid a fixed price for the energy they deliver to the power grid.

Export price

Prosumer and utility will have a power purchase agreement or PPA (long term contract).

Network charge

Prosumer will pay the network charge for the power they send to the grid and give it back from the grid later.

Tax exemption

Prosumer will be exempted from energy taxes in the retail price of energy.

Grant Schemes

Prosumer are granted a portion of the investments for the installed renewable energy resources.

Norway's Subsidy Plan

According to Enova:

- In 2021, Residential PV and BIPV owners can apply to receive a fixed sum of NOK 7,500 incentive, regardless of the system size, with an additional NOK 1,250 per kW installed system, to a maximum of 15 kW.
- The owners of PV systems up to 100 kW are allowed to sell surplus power to power providers.

Publication



Levelised Cost of Electricity (LCOE) of Building Integrated Photovoltaics (BIPV) in Europe, Rational Feed-In Tariffs and Subsidies

Hassan Gholami^{*} and Harald Nils Rostvik

Faculty of Science and Technology, City- and Regional Planning, Institute of Safety, Economics and Planning (ESOP), University of Stavanger, 4021 Stavanger, Norway; h.gholami@uis.no (H.G.)

^{*} Correspondence: h.gholami@uis.no or h.gholami@econometrics.no; Tel.: +47 91838207

Abstract: Building integrated photovoltaics is one of the key technologies when it comes to electricity generation in buildings, districts or urban areas. However, the potential of building facades for the BIPV system, especially in urban areas, is often neglected. Facade-mounted building integrated photovoltaics could contribute to supply the energy demand in buildings in dense urban areas with economic feasibility where the availability of suitable rooftop areas is low. This paper deals with the levelised cost of electricity (LCOE) of building integrated photovoltaic systems (BIPV) in the capitals of all the European member state countries plus Norway and Switzerland and presents a merit to investigate a proper subsidy or incentive for BIPV systems. The results showed that the average LCOE of the BIPV system as a building envelope material for the entire outer skin of buildings in Europe is equal to 0.09 Euro per kWh if its role as the power generator is considered in the economic calculations. This value will be 0.15 Euro per kWh if the cost corresponding to its double function in the building is taken into the economic analysis (while the average electricity price is 0.18 Euro per kWh). The results indicate that the BIPV generation cost in most case studies has already reached grid parity. Furthermore, the analysis reveals that on average in Europe, the BIPV system does not need a



Citation: Gholami, H., Nils Rostvik, H. Levelised Cost of Electricity (LCOE) of Building Integrated



Levelised Cost of Electricity (LCOE) of Building Integrated Photovoltaics (BIPV) in Europe, Rational Feed-In Tariffs and Subsidies

Hassan Gholami^{*} and Harald Nils Rostvik

Faculty of Science and Technology, City- and Regional Planning, Institute of Safety, Economics and Planning (ESOP), University of Stavanger, 4021 Stavanger, Norway; h.gholami@uis.no (H.G.)

^{*} Correspondence: h.gholami@uis.no or h.gholami@econometrics.no; Tel.: +47 91838207

Abstract: The business model of building-integrated photovoltaics (BIPV) is developing exponentially and BIPV will soon be recognised as a building envelope material for the entire building skins, among other alternatives such as brick, wood, stone, metals, etc. This paper investigates the effect of climate on the solar radiation components on building skins and BIPV materials in the northern hemisphere. The selected cities are Stavanger in Norway, Bern in Switzerland, Rome in Italy, and Dubai in the UAE. The study showed that for all the studied climates, the average incident radiation on the entire building skins is slightly more than the average incident radiation on the east or west facades, regardless of the orientations of the building facades. Furthermore, the correlation between solar radiation components and different BIPV technologies is discussed in this paper. It is also found that when it comes to the efficiency of different BIPV cells, the impact of the climate on some of the BIPV technologies (such as LSC and CSC) is much more significant than others (such as c-Si, mc-Si and CIGS). The evidence from this study suggests that in climates with higher diffuse radiation or with more overcast days per year the correlation of BIPV radiation decreases. Therefore, the efficiency of BIPV materials that their overall response are dependent on the IR radiation (such as LSC and CIGS)



Citation: Gholami, H., Nils Rostvik, H. Levelised Cost of Electricity (LCOE) of Building Integrated

Energies 2020, 13(20), 486–621

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Economic analysis of BIPV systems as a building envelope material for building skins in Europe

Hassan Gholami^{*}, Harald Nils Rostvik

Department of Safety, Economics and Planning, University of Stavanger, 4021 Stavanger, Norway

ARTICLE INFO

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Keywords:
BIPV
Building integrated photovoltaics
LCOE
Levelised cost of electricity
PV power source
PV
Discounted payback period
Internal rate of return
Carbon tax

ABSTRACT

The main purpose of this study is to evaluate the economic feasibility of the BIPV system as a building envelope material for the whole building skins. The paper is dealing with the lifecycle cost analysis (LCCA) of BIPV systems in the capitals of all the European Member States (EU) as well as the capitals of Norway and Switzerland. The results revealed that by a discount related to the investment over the entire building skins in terms of traditional building envelope materials as an alternative option for building skins, there must be study about benefits after investment. Furthermore, the societal and environmental benefits of a BIPV system in Europe have its greatest impact on the south facade. Moreover, for all the studied directions of building skins with a (reference rate) of five percent to finance except the north facade, just the quantified amount of societal and environmental advantages of BIPV systems could offset rebound in the invested energy. The results illustrated that the BIPV system as a building envelope material for the whole building skins could not raise cost only at the investment stage, but also become a source of income for the building. © 2020 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Although the average cost of direct current electricity (DC) generated by photovoltaic modules has dropped below 0.02 Euro (€) per kilowatt hour (kWh) in many places worldwide, the current use with PV production is in the significant additional cost component related to transporting the electricity from the solar PV module to where and when it is needed. This is part of the latest report of the European Union PV Status report 2019 [1], which calls for solutions to tackle the emerging issues in supplying the increasing power demand of the world.

One of the most reasonable solutions is building integrated photovoltaic system (BIPV). BIPV system is photovoltaic cells that are capable of being integrated into the building skins such as roof or facade to generate clean energy from sunshine. Such a system plays two roles in the building. First, it functions as building skins.

Therefore, the system must have the specifications of conventional building envelope materials like weather and noise protection, heat insulation, structural strength, etc. Second, the system is a power generator for the building [2].

A BIPV system delivers the energy where the end-user needs it. Besides, with an energy storage system (ESS) or using the power grid as ESS, it can provide energy when the user needs it. This is also a response to the recent criticism, which has been raised regarding the consequences of solar farms on climate change and occupying the agricultural lands [3,4]. With the BIPV system, these concerns and worries are avoided because the system is located on buildings that use the energy as building skins.

The PV system can be developed and formed as photovoltaic thermal (PVT) systems with either active or passive ventilation to remove the heat and cool the PV module using air or water as a medium [5–8] and produce both electrical and thermal energy with a higher efficiency [9–11]. In a BIPV system with air ventilation, such as an example, the photovoltaic system is typically installed in



The Effect of Climate on the Solar Radiation Components on Building Skins and Building Integrated Photovoltaics (BIPV) Materials

Hassan Gholami^{*} and Harald Nils Rostvik

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Abstract: The business model of building-integrated photovoltaics (BIPV) is developing exponentially and BIPV will soon be recognised as a building envelope material for the entire building skins, among other alternatives such as brick, wood, stone, metals, etc. This paper investigates the effect of climate on the solar radiation components on building skins and BIPV materials in the northern hemisphere. The selected cities are Stavanger in Norway, Bern in Switzerland, Rome in Italy, and Dubai in the UAE. The study showed that for all the studied climates, the average incident radiation on the entire building skins is slightly more than the average incident radiation on the east or west facades, regardless of the orientations of the building facades. Furthermore, the correlation between solar radiation components and different BIPV technologies is discussed in this paper. It is also found that when it comes to the efficiency of different BIPV cells, the impact of the climate on some of the BIPV technologies (such as LSC and CSC) is much more significant than others (such as c-Si, mc-Si and CIGS). The evidence from this study suggests that in climates with higher diffuse radiation or with more overcast days per year the correlation of BIPV radiation decreases. Therefore, the efficiency of BIPV materials that their overall response are dependent on the IR radiation (such as LSC and CIGS)



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Holistic economic analysis of building integrated photovoltaics (BIPV) system: Case studies evaluation

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ABSTRACT

Recent trends and future objectives in sustainable buildings are to reduce energy consumption, and decarbonise energy to supply the energy demand within the building envelope, an environmentally friendly energy resource which leads to a nearly zero energy building (NZEB). Building integrated photovoltaics (BIPV), which is one of the latest generation of energy technologies, are integrated into photovoltaic cells that are integrated into the building envelope such as facade or roof to generate clean energy from sunshine and is the most reliable technology to contribute to green buildings. In this paper, an innovative approach of BIPV economic analysis is presented. The proposed method is to quantify the societal and environmental advantages of a BIPV system as a building envelope material for the whole building skins in terms of traditional building envelope materials as an alternative option for building skins with a (reference rate) of five percent to finance except the north facade, just the quantified amount of societal and environmental advantages of BIPV systems could offset rebound in the invested energy. The results illustrated that the BIPV system as a building envelope material for the whole building skins could not raise cost only at the investment stage, but also become a source of income for the building. © 2020 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The energy demand of the world is increasing and the building skins, which includes residential, commercial and public buildings, is currently responsible for 35% of the world's energy demand [1]. On the other hand, fossil fuels, which are currently used as the world's primary energy source, are generating serious issues such as those of energy shortages, environmental damage, and climate change [2,3]. Therefore, the need for alternative energy resources, which are renewable and non-polluting, is increasing.

As the world's demand and focus on renewable and clean energy are escalating, zero energy, plus energy, and zero emission buildings are rapidly gaining attention because such buildings conform to the earlier mentioned criteria. To become a zero energy or zero emission building, it needs to harvest energy from its surroundings, where solar energy is one of the obvious choices. In this regard, building integrated photovoltaics (BIPV), which refer

to photovoltaic cells that are integrated into the building envelope such as facade or roof, is a technology that generates electrical energy by capturing the incident solar radiation to the building skins. In this technology, solar cells are considered as building envelope materials like roof, floor, masonry or windows. The system retains current building skin material specifications like weather protection, privacy, noise protection, heat insulation, and simultaneously generates electrical energy for the building [4]. The BIPV lifetime is currently estimated around 30 years [5], while zero studies show it could be as long as 50 years [6,7]. BIPV can be employed in either new buildings or retrofitted ones [8]. The size of the BIPV system can vary from a few kilowatts (kW) for a residential building to several megawatts (MW) for a commercial application [9].

Based on the location of the installation in the building, it can be divided into two subgroups of BIPV roof and BIPV facade. Currently, BIPV rooftop type is the most prevalent place for integrating solar PV modules [10]. Generally, there is less shading at a rooftop system than at a facade system. Rooftops regularly give a significant unobstructed surface to BIPV applications and the annual solar incident radiation is higher than the radiation on the facade.

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Lifecycle cost analysis (LCCA) of tailor-made building integrated photovoltaics (BIPV) facade: Solmsraugen case study in Norway

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ABSTRACT

In dense urban areas, the use of building integrated photovoltaics (BIPV) facades as building envelope material is being increasingly used. However, at the same time, they also function as building envelope material. "Solmsraugen" is a case of a tailor-made building, that is integrated with BIPV facade with the peak power of 122.3 kW and owned by Green House Construction AS in Norway. In this paper, a lifecycle cost analysis (LCCA) of BIPV facade integrated to "Solmsraugen" is presented based on on-field recorded data after four years of operation (2016–2020). While the literature LCCA, a national model (one energy power generation, societal and environmental benefits, and financial impact) to those different and the national energy approaches were also considered, the "on-site based on the field recorded performance" showed that the net present value (NPV), discounted payback period, internal rate of return and internal rate of energy of the system is equal to 478,934 NOK, 22 years, 6% and 1.28 NOK/kWh, respectively. It is observed that the BIPV system as a building envelope material, for different orientation of building skins orientations was not only all the investment costs but also become a source of income for the building. The results also illustrate that the ground subsidy is substantially covering the societal and envi-

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A novel method for optimal performance of ships by simultaneous optimisation of hull-propulsion-BIPV systems

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ABSTRACT

Ships have been facing significant challenges due to strict limits imposed by the International Maritime Organization (IMO) to become more environmentally sustainable. In this regard, the use of solar energy, as a viable way to deal with the pollution emissions caused by ships, has been attracted considerable attention. However, considering the investment costs, high area demands, and low performance of ships equipped with the photovoltaic system have raised recently some of the significant challenges at the use of solar energy in the shipping industry. This paper proposes a novel method for the optimal performance of ships through the simultaneous optimisation of the hull-propulsion-building, integrated photovoltaic (BIPV) system. The proposed method, the interaction effects among the ship hull, the BIPV system, and the propulsion system, as well as the impact of the wind and ship speeds on the BIPV system efficiency are considered. Ship operational conditions, including the ambient conditions, the engine input, the ambient temperature, the friction of the hull, the view factor of the solar panels, the wind and ship speeds, and the ship hull form are also considered. Moreover, a probabilistic model profile is employed to avoid a subjective design at a single ship speed. The performance of the suggested method is evaluated by designing a generic ship equipped with a combined propulsion system that operates in the Korean Sea. The two-dimensional sailing performance (CO₂ and GHG) is used to solve the multi-objective optimisation problem of a planar hull-overview BIPV system. Eight cases are compared to demonstrate the performance of the proposed algorithm in different ship design problems with different configurations and BIPV rates-overview area ratios. The results show the high performance of the adopted approach in integrating costs and greenhouse gas (CO₂) emissions. Based on the results, the investment costs due to the BIPV system have been covered within a year for the studied cases and scenarios. It is also proved that the interaction effects among the ship hull, the BIPV system, and the propulsion system is important to create the optimal performance of a ship.

1. Introduction

In recent years, concern over environmental effects of the shipping industry has been increasing. Shipping, like a crucial role in the global economy as over 90% of the world's trade is carried by sea [1]. However, shipping, as a sustainable in environmental issues and accounts for approximately 2% of global CO₂, 14–16% of SO_x and 4–9% of SO₂ emissions [2,3]. Greenhouse gas (GHG) emissions from shipping have a profound negative impact on human health [4]. According to the International Maritime Organization (IMO), air pollution from ships will account for more than 570,000 extra premature deaths throughout the world between 2020 and 2025 [5]. As quantities of the

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Thanks for your attention!

