Overview of solar energy in Norway

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and on behalf of the
Research Centre for Sustainable Solar Cell Technology (SUSOLTECH)

UiO : University of Oslo

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Outline

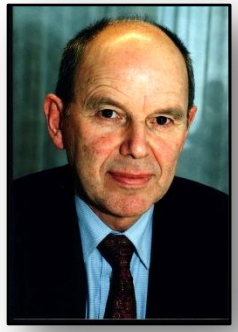
- A *very* short Norwegian solar history
- The Norwegian PV market
- The Norwegian sustainable energy strategy
- The solar «landscape» in Norway
- SUSOLTECH – the Research Centre for Sustainable Solar Cell Technology

A *very* short Norwegian solar history

1916: Edvard Munch - *The Sun*
University of Oslo

1994: Scanwafer established in Glomfjord
Production capacity ~75 MW

2006: REC listed on stock exchange
full chain from silicon to modules



Alf Bjørseth
- a chemist from UiO

2013: Scatec Solar finishes South African 75 MW project

Installed PV in Norway

Source: Multiconsult

Installed PV in Norway

#	Name	kW_p	Year
1	Asko Vestby	3 380	2017
2	Asko Vest	2 000	2017
3	Asko Midt	1 406	2017
4	UNIL Våler	1 322	2016
5	Asko Kalbakken	1 147	2016
6	Asko Sør	720	2016
7	Posten-Bring Trondheim	670	2016
8	Asko Hedmark	537	2017
9	CC Vest	363	2017
10	Powerhouse Kjørbo	312	2014

Source: Multiconsult

The Norwegian PV market - summarized

- **Trends and drivers**
  - Near zero energy or energy positive buildings
  - Environment-conscious companies
  - Increasing interest from households

- **Barriers/disincentives**
  - Quite low electricity prices
  - Low feed-in tariffs
  - Reluctant distribution service operators (DSO)
  - Installation costs still quite high

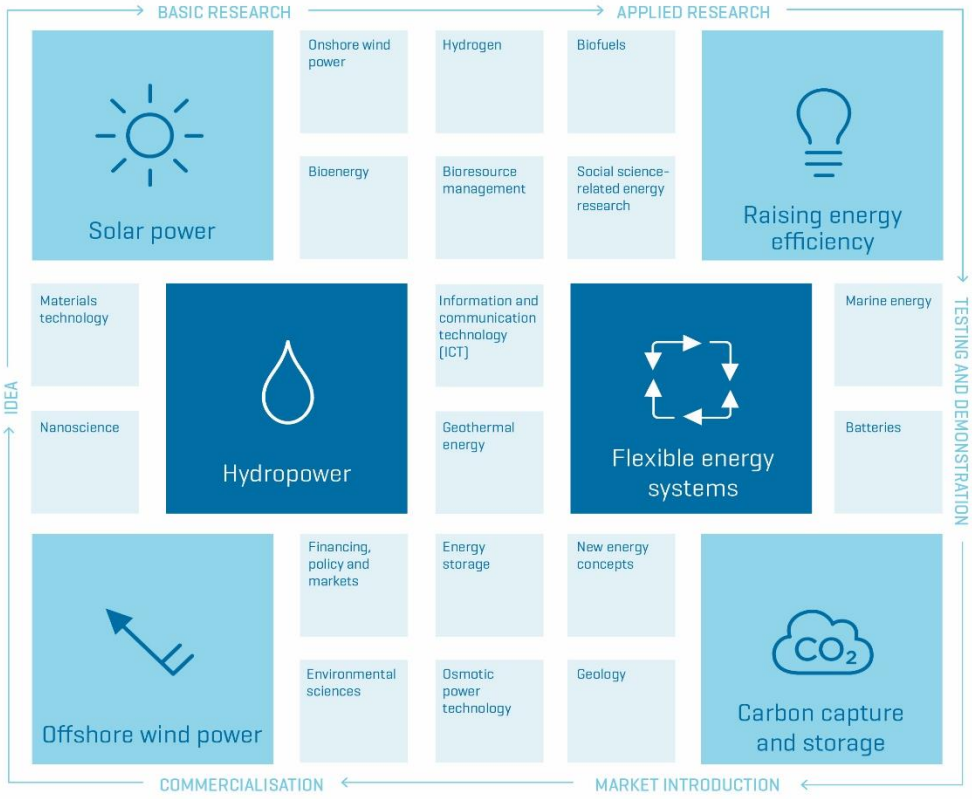
Energi21

energi21

A collective R&D strategy for the energy sector

- **Permanent strategic advisory body** with mandate from the **Norwegian Ministry of Petroleum and energy**. Established in 2009.
- Norway's **national RD&D strategy** for renewable and climate friendly stationary energy technology
- Strategic work is based on multidisciplinary **cooperation** between business communities, research institutes, universities and authorities
- **Industry led board** appointed by the Minister of Petroleum and Energy

Six priority focus areas



energi21

Energi21 – Solar power

energi21
A collective R&D strategy for the energy sector

- The major motivation for solar is to develop (and maintain) industry that is competitive **globally**
- The growing **international market** opens many new business areas, for example related to financing, service and operation of solar energy projects

Ambitions include

- To develop the silicon-based solar industry of tomorrow – an upstream industry that is leading on quality and innovation
- To develop businesses in other parts of the value chain, both internationally and in Norway
- Research institutions that are both visible and attractive internationally

The solar «landscape» in Norway

Research Centre for Sustainable Solar Cell Technology

Research
~20 partners
(universities, research institutes, industry)

Business development
~75 partners
(industry, research institutes, universities)

The Norwegian Solar Energy Cluster

The Norwegian Solar Energy Society

Public outreach
~500 members
(individuals, companies)


SUSOLTECH
The Norwegian Research Centre for Sustainable Solar Cell Technology

What is SUSOLTECH?

Research Center for Sustainable Solar Cell Technology

- *Centre of Excellence*
- Appointed by Research Council of Norway (RCN)

- 8 years of funding
  - Research council: 50%
  - Industry Partners: 25%
  - Reserach Partners: 25%

- In total - 250 MNOK (100 mill BRL)

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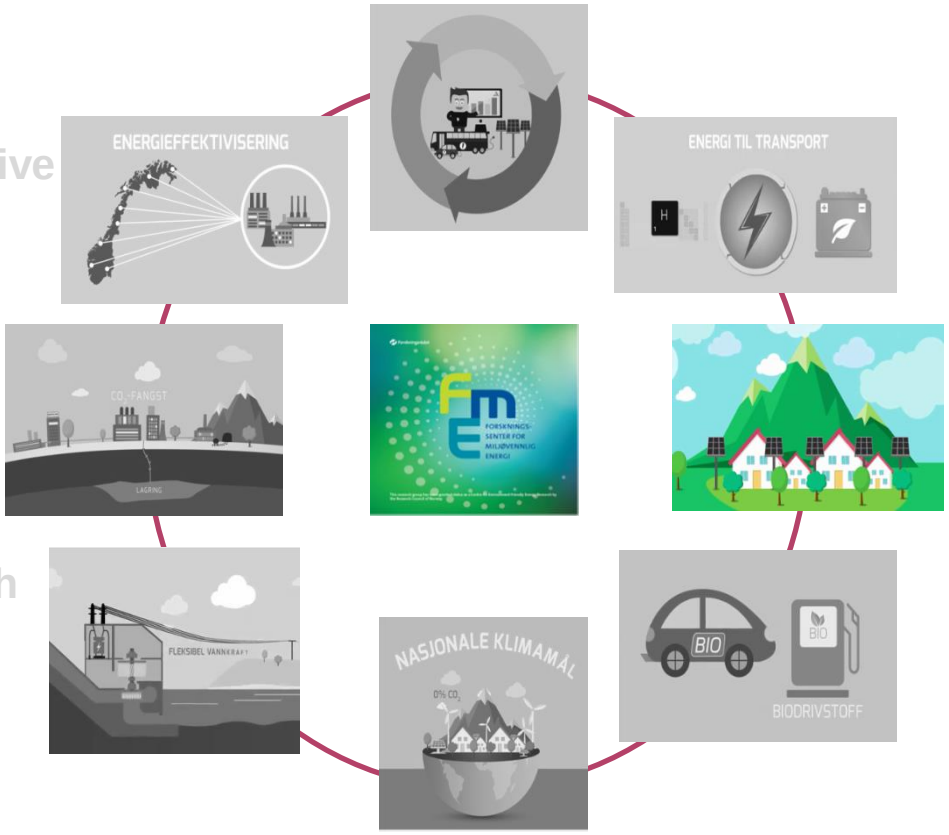
Centers for Environment-friendly Energy Research

Centre for intelligent electricity distribution – CINELDI

Centre for an Energy Efficient and Competitive Industry for the Future – HighEFF



Mobility Zero Emission Energy Systems – MoZEES

Norwegian CCS Research Centre – NCCS

Research Centre for Sustainable Solar Cell Technology

Norwegian Research Centre for Hydropower Technology – HydroCen

Norwegian Centre for Sustainable Bio-based Fuels and Energy – Bio4Fuels

The Research Centre on Zero Energy Neighbourhoods in Smart Cities – ZEN Centre

Who is SUSOLTECH?

Glass og Fasadeforeningen

IFE Institute for Energy Technology

OMSORGSBYGG OSLO KF

THE QUARTZ CORP

DYNATEC

STEULER SOLAR ADVANCED CERAMICS

norwegiancrystals

NTNU Norwegian University of Science and Technology

SINTEF

Elkem A Bluestar Company

NorSun

NORGES BONDELAG

Statoil

Norges miljø- og biovitenskapelige universitet

UNIVERSITY OF AGDER

CODE

PVA TePla

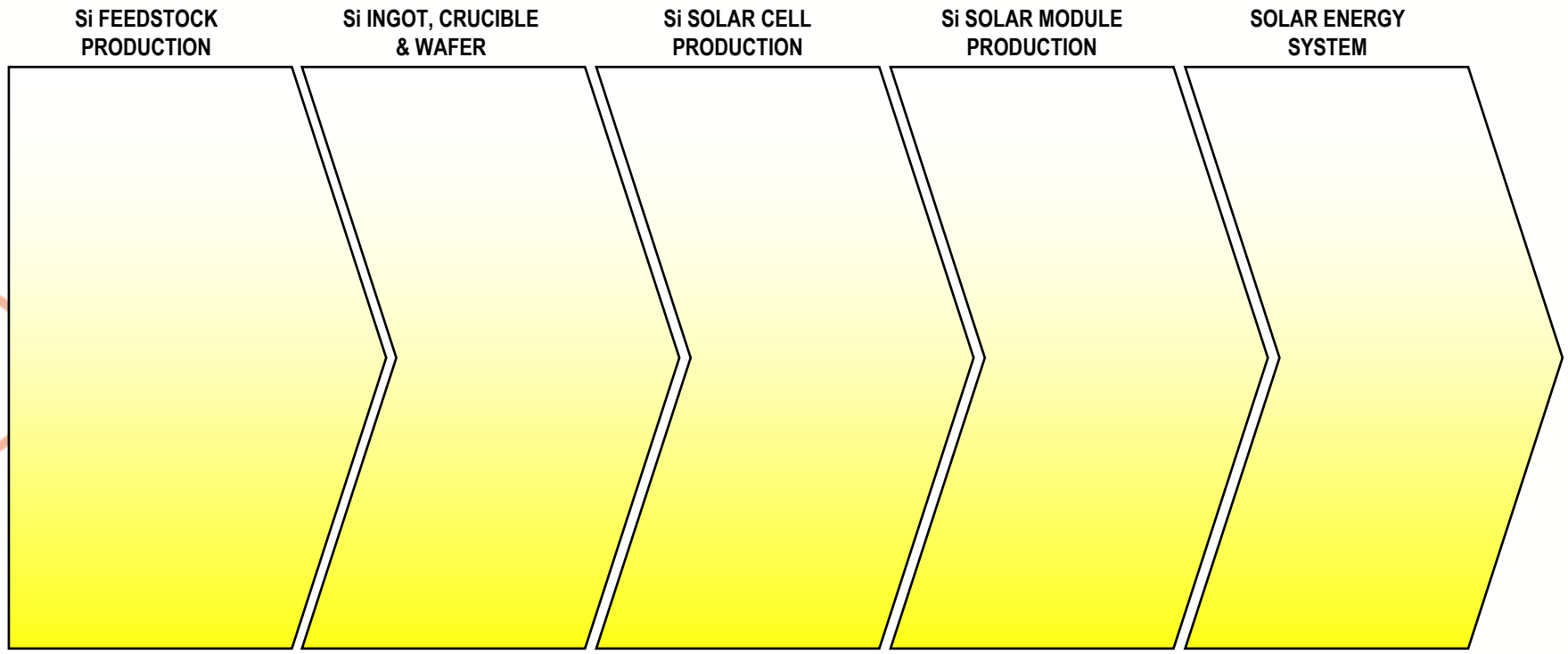
FUSen REN ENERGI TIL ALLE, ALLTID

4 universities – 2 research inst. – 11 companies – 1 government inst. – 1 non-profit

SUSOLTECH

The Norwegian Research Centre for Sustainable Solar Cell Technology

Who is SUSOLTECH?



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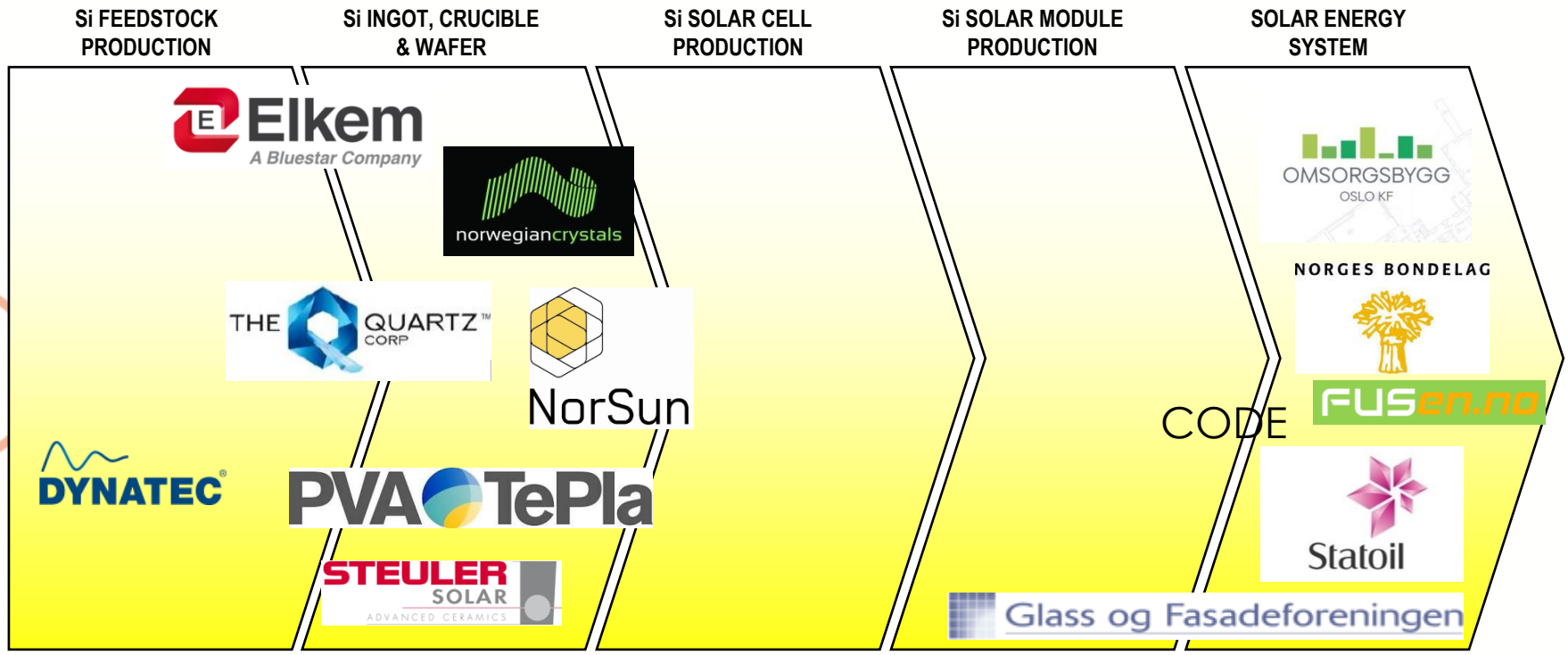
Who is SUSOLTECH?



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The Norwegian Research Centre for Sustainable Solar Cell Technology

What will SUSOLTECH do?

- The overall goal of the Centre is to increase the size and number of jobs in the **domestic solar cell industry**. These secondary goals support this goal:
  - To develop the most environmentally friendly production processes for Si feedstock for high efficiency, crystalline Si-based solar cells **in the World**
  - To develop processes for making affordable, high performance Si ingots and wafers, as well as selected materials and processes allowing for producing solar cells with **efficiencies above 25%** for Cz Si and 21% for HPMC Si
  - To demonstrate lower electricity costs, **improved performance and improved sustainability** due to the developed technologies on cell, module and system level
  - To contribute to a cost-effective and sustainable growth in the use of **solar energy systems in Norway**, with a particular emphasis on the building sector

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The Norwegian Research Centre for Sustainable Solar Cell Technology

Si FEED-STOCK PRODUCTION

What will SUSOLTECH do?

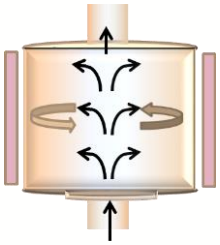
Metallurgical Si production

- Develop even more cost- and energy-efficient production processes
  - New reduction processes based on alternative materials
  - New refining methods for B and P removal

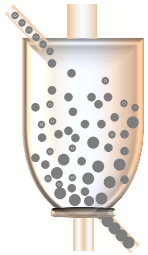
Elkem
A Bluestar Company

Chemical Si production

- Developing new production reactor technologies
  - Understanding decomposition of silane
  - New processes with optimized material morphology and purity



DYNATEC®

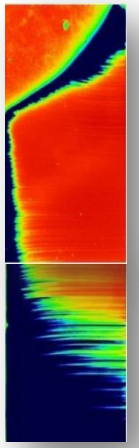


Si INGOT, CRUCIBLE & WAFER

What will SUSOLTECH do?

Monocrystalline Si

- High performance at low cost
  - Understand and reduce formation of microdefects
  - Fully understand the role of the crucible



NorSun

Multicrystalline Si

- High performance mc-Si materials
  - Understand and control impurities
  - Develop models of generation of crystal defects
  - Models for interaction between defects and impurities

STEULER SOLAR ADVANCED CERAMICS

Elkem A Bluestar Company

Kerfless Si

- The “holy grail” of Si substrate production
  - Novel techniques for epitaxial Si growth

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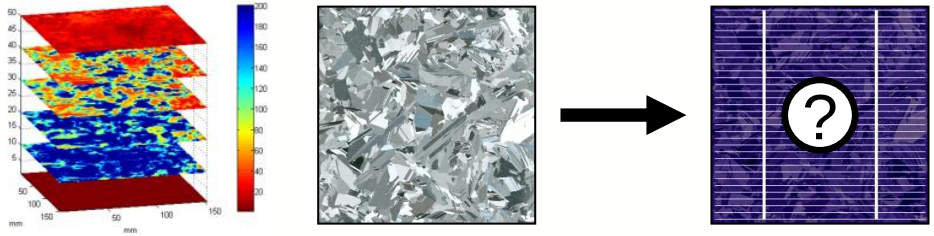
HIGH-EFFICIENCY SOLAR CELLS

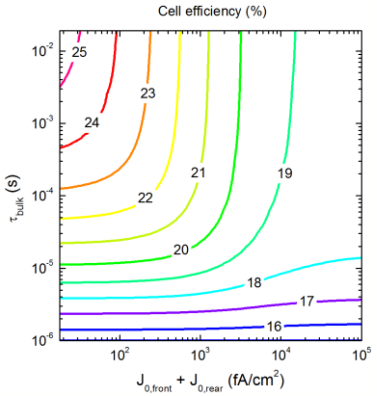
Si SOLAR MODULES PRO-DUCTION

What will SUSOLTECH do?

Wafer efficiency

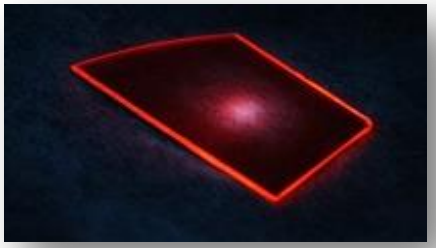
- How much does material quality matter?





Processes for high efficiency (> 25%)

- Investigate new concepts with potential for extremely high efficiency
  - Photon Energy Conversion
  - Si-based tandem solar cells



BIPV

- Make BIPV products more attractive
  - Aesthetics and efficiency

SOLAR ENERGY SYSTEM

What will SUSOLTECH do?

Strengthening the Norwegian solar cell industry

- Innovation studies
  - How can we improve the «solar cluster»?

Sustainability

- Collecting and disseminating LCA data
- Using LCA as a tool to develop improved value chains

Field performance

- Coordinating a growing, important activity in Norway
- Quantifying how improvements along the value chain affect overall performance criteria

The Norwegian Research Centre for Sustainable Solar Cell Technology