SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

How Recent Advances in Solar Resource Assessment Support Large-Scale Solar Development

Plenary Speech by
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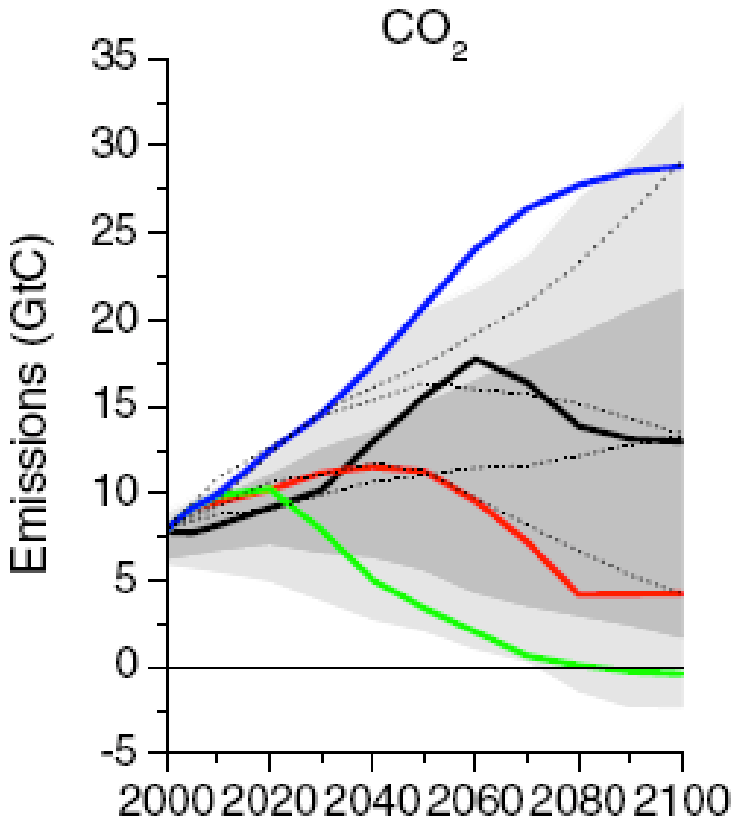
Outline of Talk

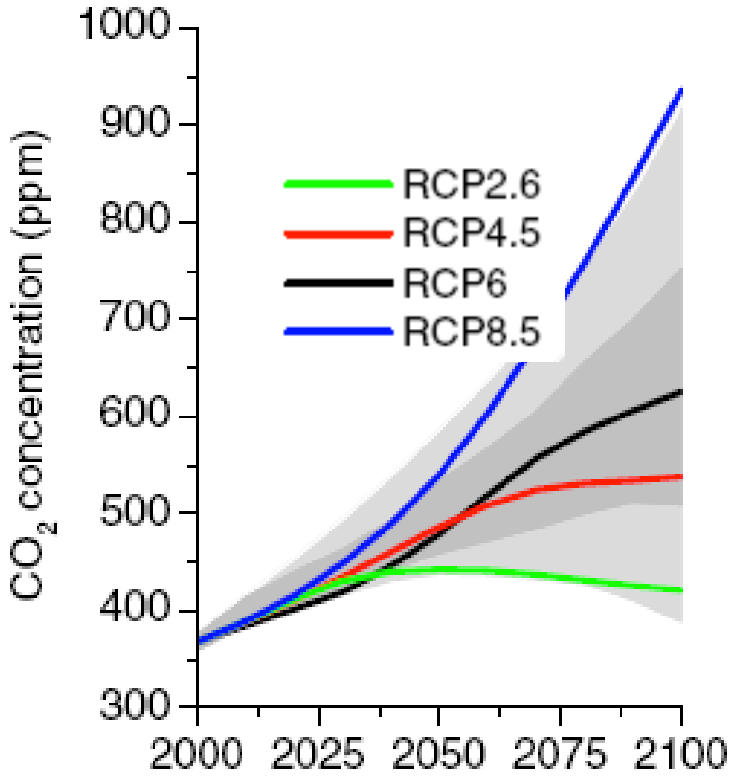
- The climate challenge
- Solar Energy as a Mitigation Strategy
  - Current status
  - Future trends and opportunities
- Integrating solar into the grid
- Summary points

A Key Challenge: Climate Change

- ~2000 $GtCO_2$ emitted since 1750 (~1/2 of this in past 40 years); leading to +0.85 ^0C since 1850
- To stabilize climate change at today's level by 2100, cumulative CO_2 emissions must not exceed ~1000 $GtC0_2$ between now and 2100
- However…emission rates are *increasing* (currently ~30 $GtCO_2$/yr)
- …and current carbon-burning infrastructure alone can approach 1000 $GtCO_2$ in next 40 years.

Which Scenario?

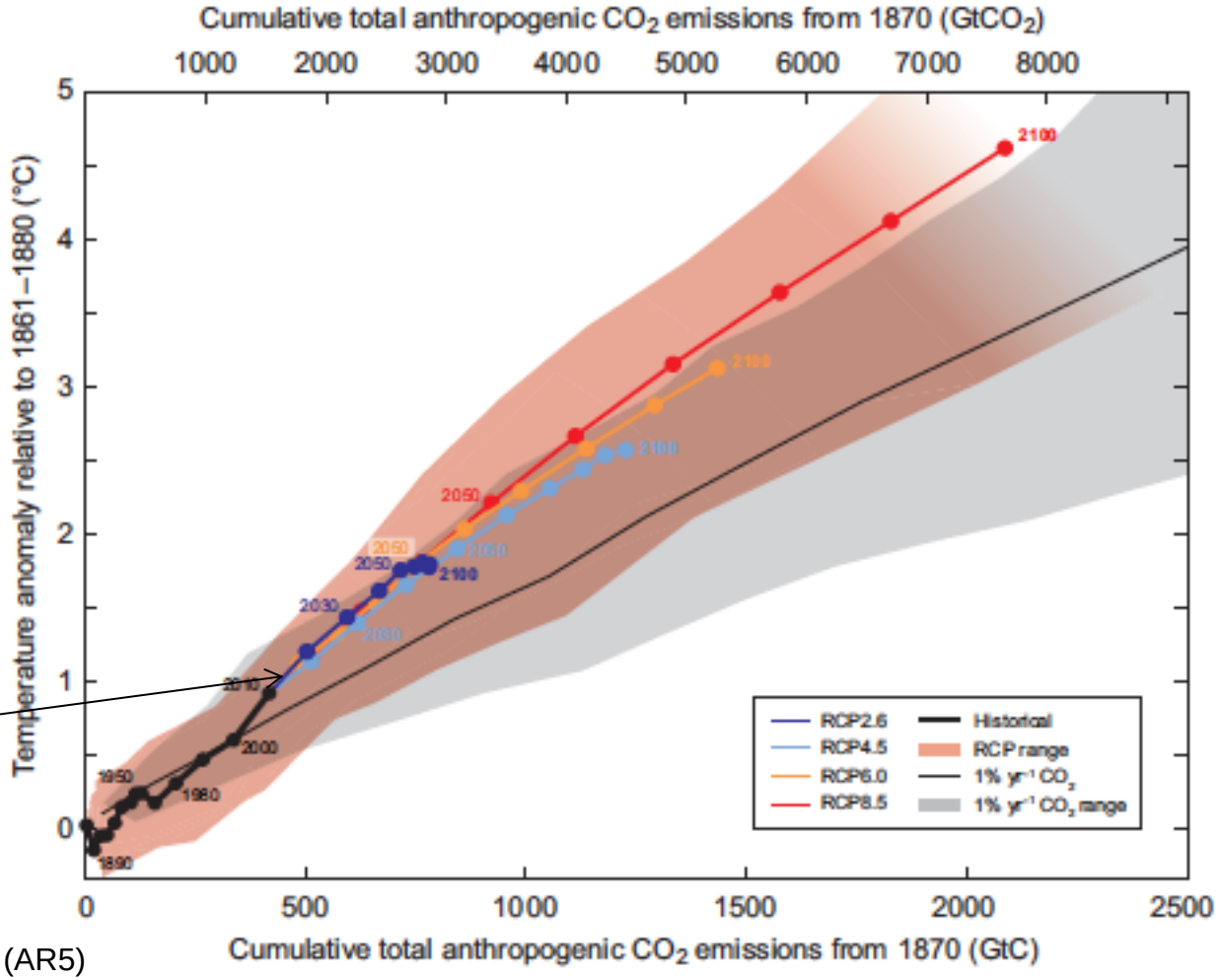




Source: IPCC, 2014 (AR5)

RCP 2.6 is our best opportunity to limit global warming to <2.0 ^{0}C in the long term

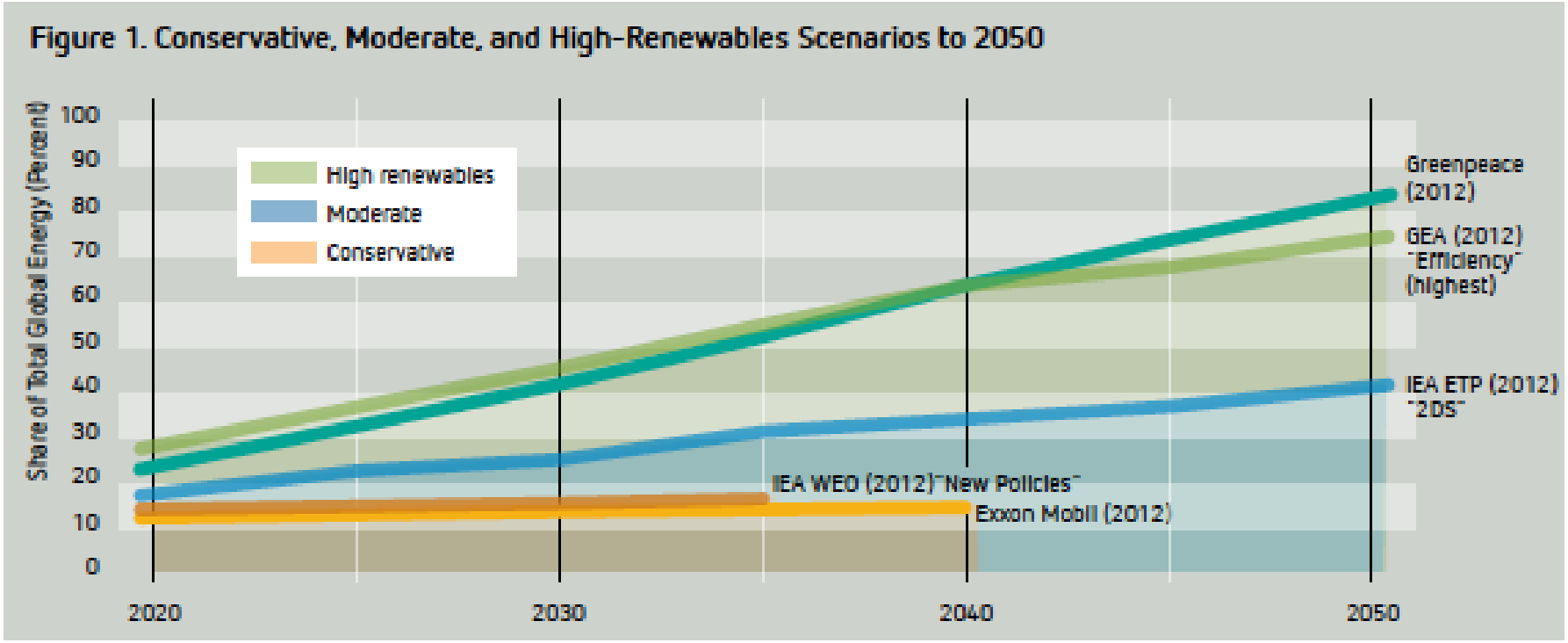
Which Scenario?



We are here

Source: IPCC, 2014 (AR5)

RE Projection Scenarios



Source: REN 21 Global Futures Report 2013, by Eric Martinot

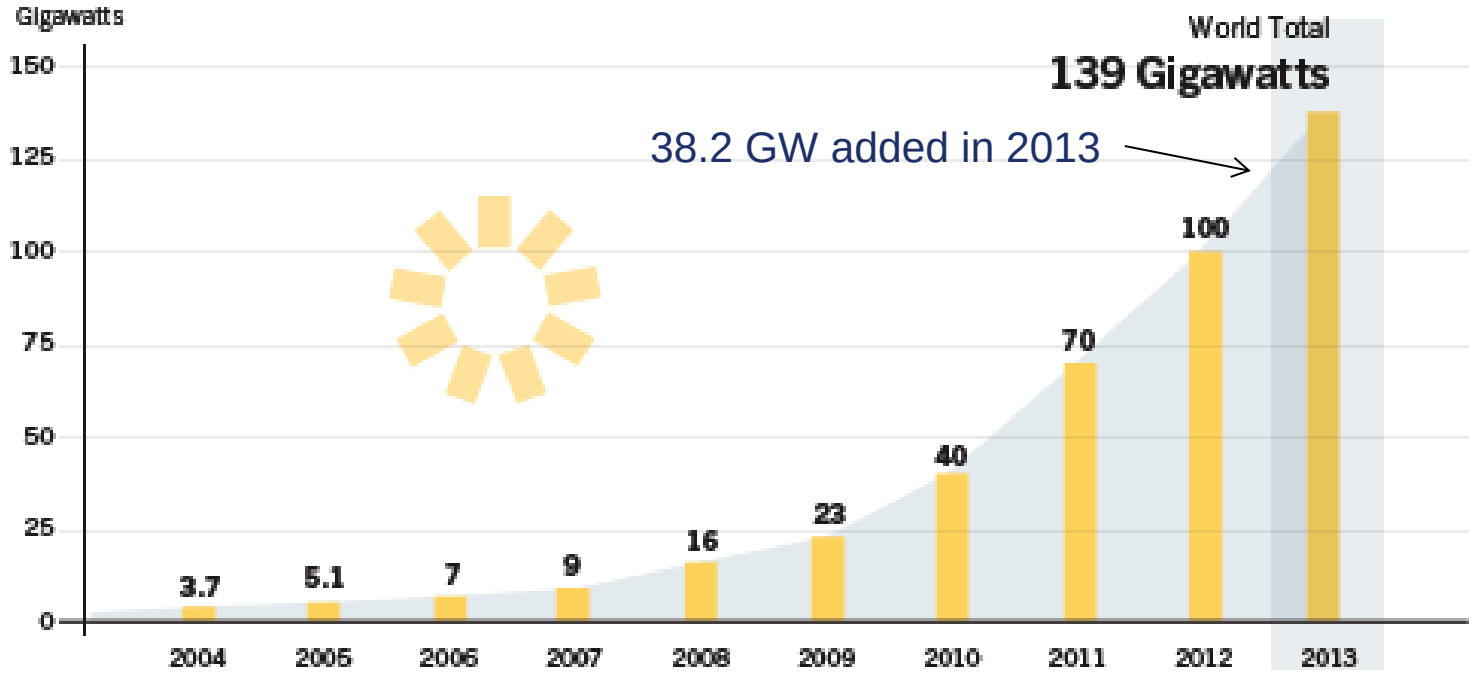
Growth in Solar Thermal Technologies

Solar Water Heating capacity estimates: 326 GW_{th}

CSP capacity estimates, 2013: 3.4 GW
(up from 1.1 GW in 2010)

REN-21 2014 Global Status Report; photo credits NREL Pix

Global PV Capacity Growth

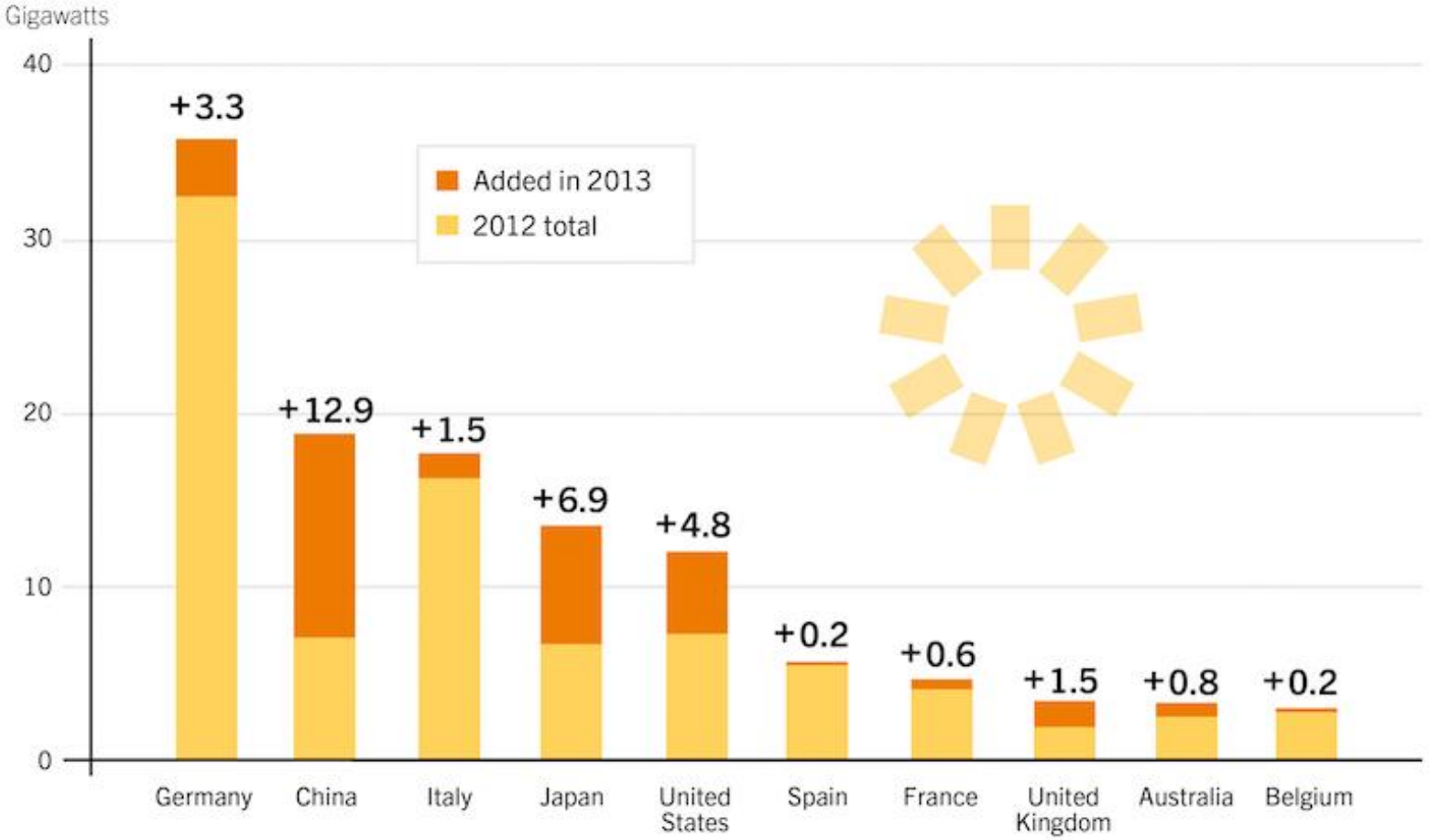


Source: REN-21 2014 Global Status Report

For first time since 2003 Asia exceeded Europe with capacity additions; China was the lead

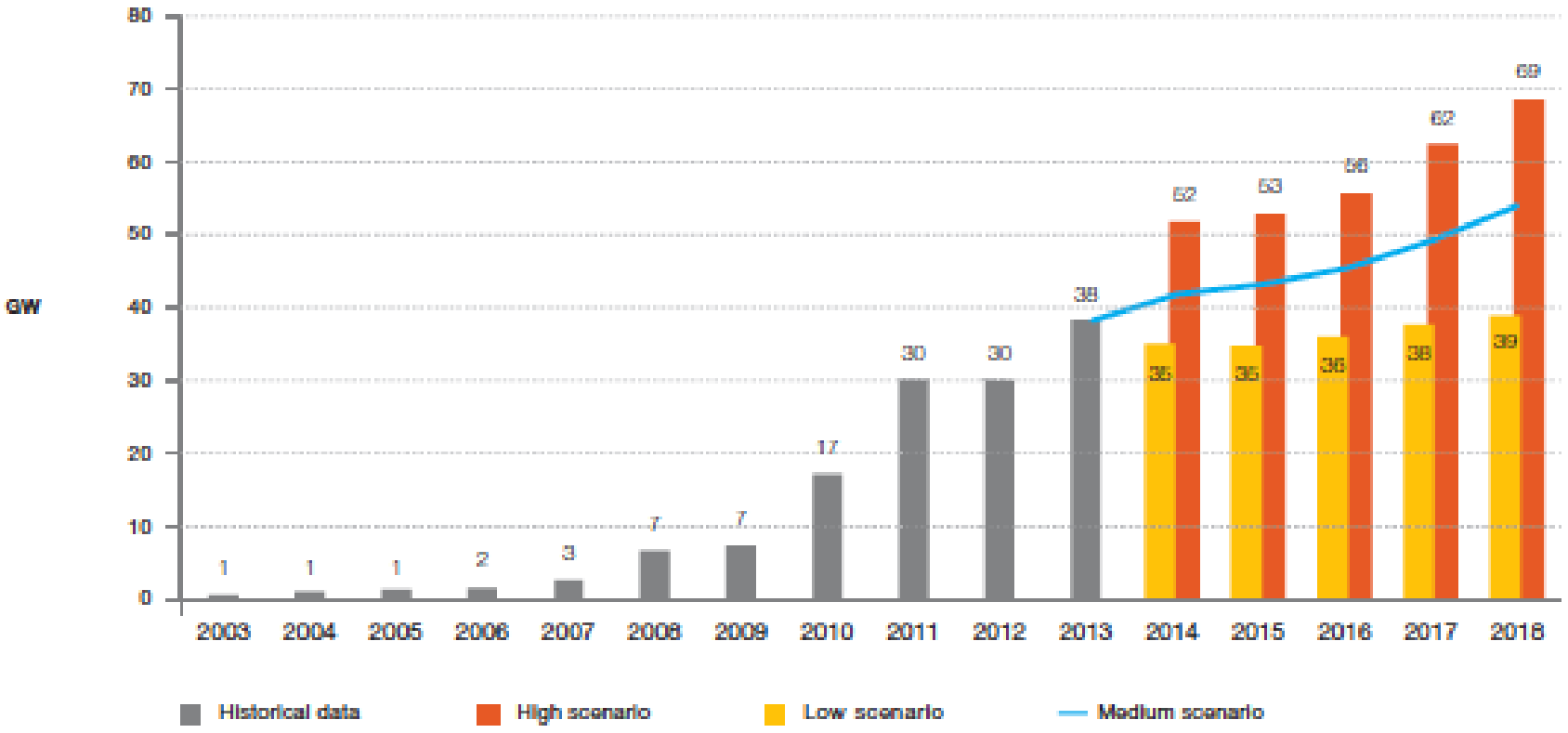
Source: EPIA 2014

PV Capacity and Additions: Top 10 Countries



Source: REN-21 2014 Global Status Report

PV Capacity Projections to 2018

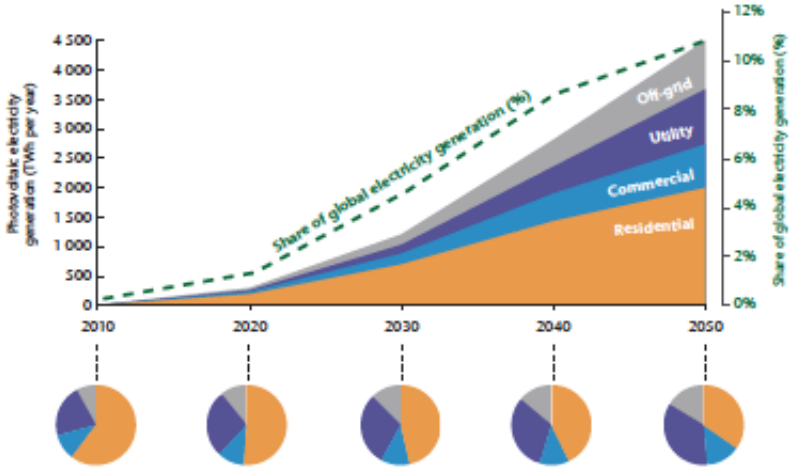


Projections are 321 to 430 GW Cumulative PV by 2018

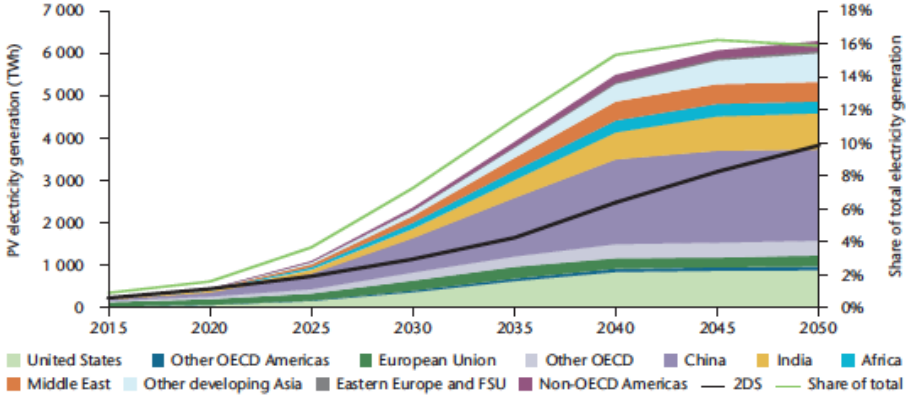
Source: EPIA 2014

IEA's PV Roadmap Projections

Source: IEA PV Roadmap, 2010 and 2014



2010: ~11% of total electricity supply by 2050

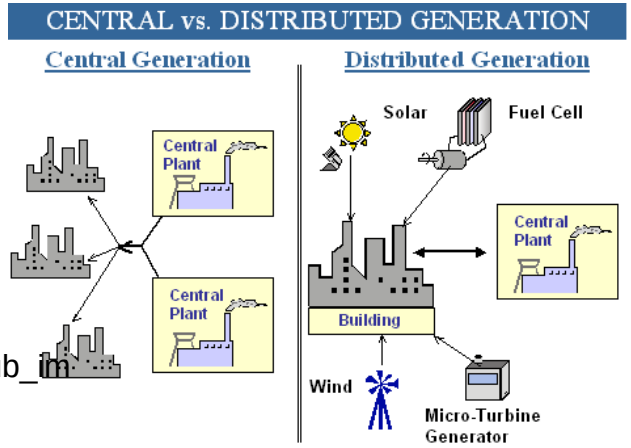


2014: ~16% of total electricity supply by 2050

Note: Shift from residential to large-scale PV over time

Pathway to 100% RE Requires:

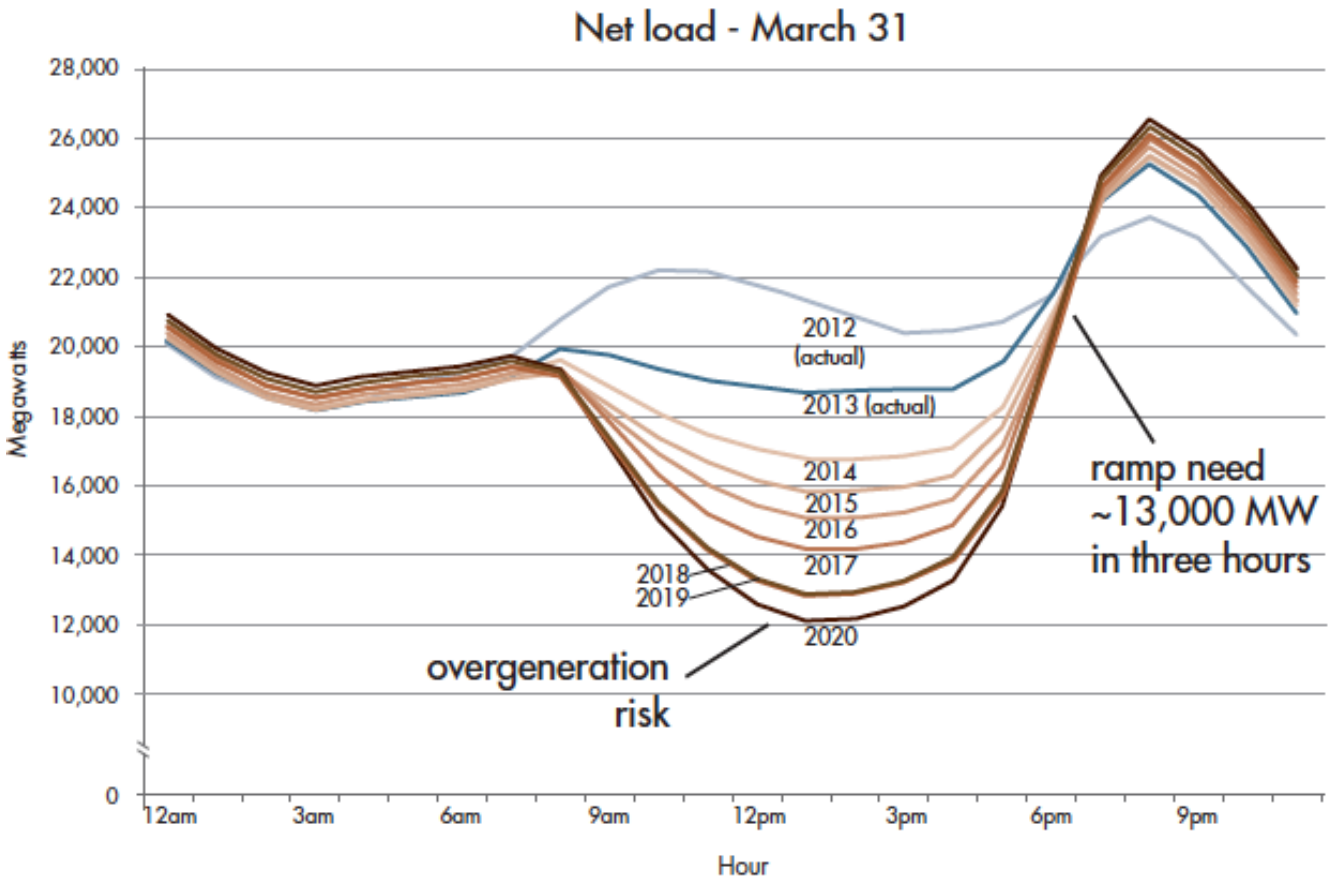
- A *transformation* of our energy systems
- Increased system flexibility
- More reliance on distributed generation, smart grids, microgrids
- Lower energy intensity per capita
- **Ability to incorporate high penetrations of Variable Renewable Energy (VRE)**



http://www.teachengineering.org/collection/cub_/lessons/cub_images/cub_energy2_lesson07_activity3_fig2.gif

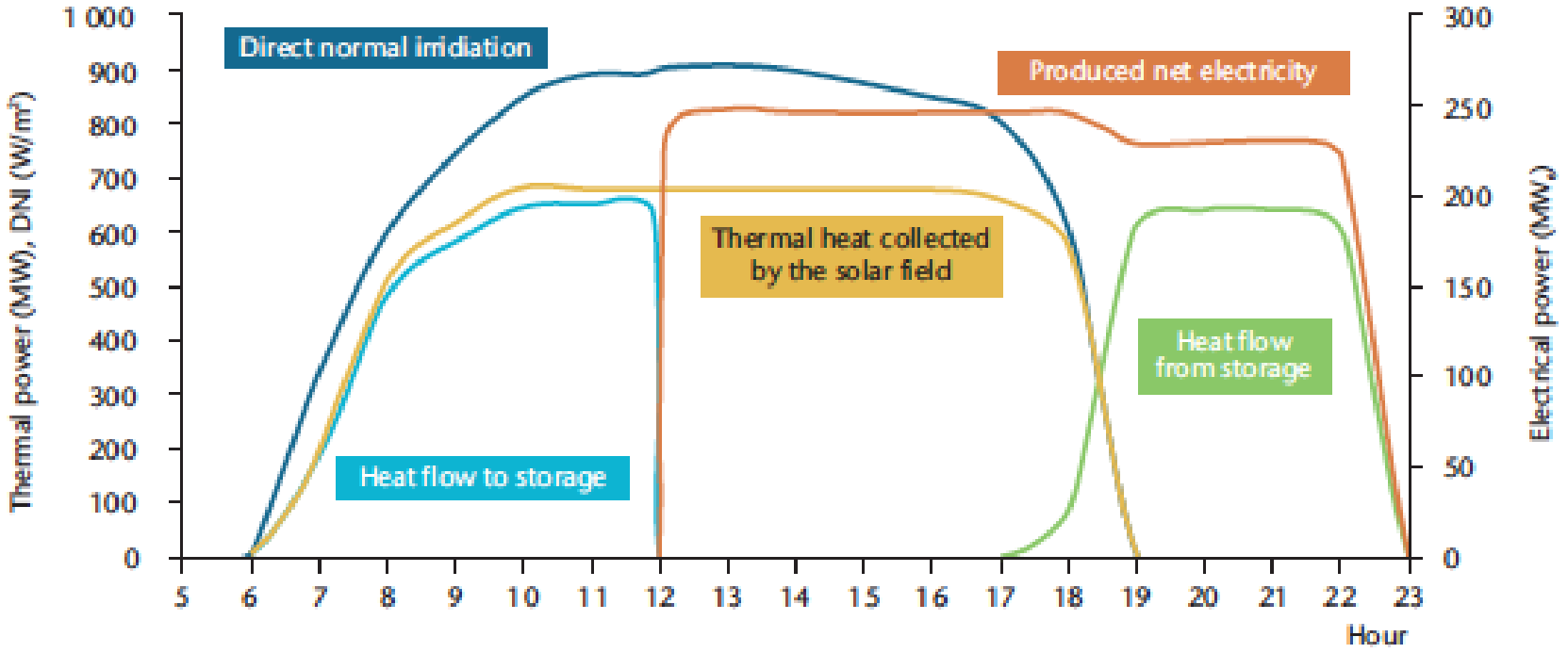
Managing Increasing Solar Penetration

The "Duck" Curve



Source: California ISO (www.caiso.com)

Energy Storage can Shift Time of Use of RE



Thermal Storage Uncouples Electricity Generation from Solar Energy Collection

Source: IEA Solar Thermal Roadmap, 2014

…enter Task 46

Solar Resource Assessment and Forecasting

- Successor to Task 36 "Solar Resource Knowledge Management"
- Four Focus areas:
  - Grid Integration of VRE
  - Improved Data Collection and Assimilation
  - Solar Forecasting
  - Solar Model Improvements
- Task Deliverables: Best Practices in Data Collection, Site Adaptation, and Forecasting

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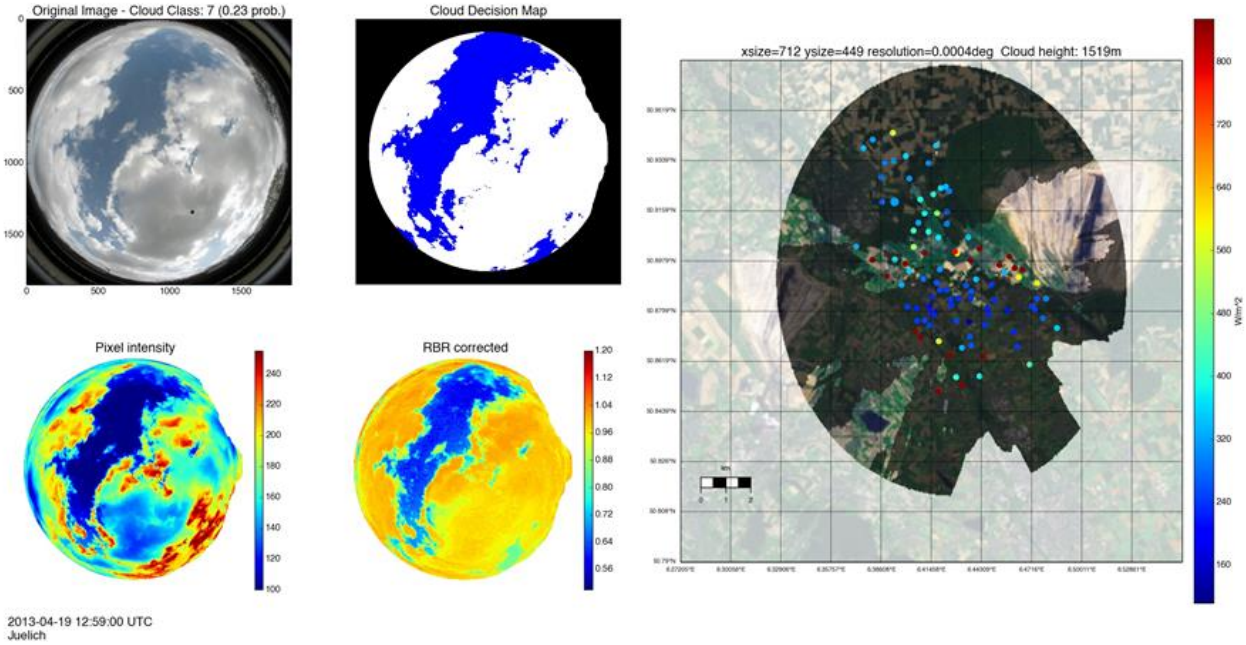
Solar Resource Forecasting

Forecasting Time Scale	Source of information/ method
Sub-hourly	Ground based observations • Radiometers • Total Sky Imagers • Visual Observations
1 – 6 hours	Cloud motion vectors (CMV) from satellites Numerical Weather Prediction (NWP) Models: • Global (ECMWF, GFS, NDFD) • Regional: (NAM, GEM, RUC) • Mesoscale: (WRF)
1 - 7 days	NWP output • NWP plus Mesoscale • Machine Learning Techniques

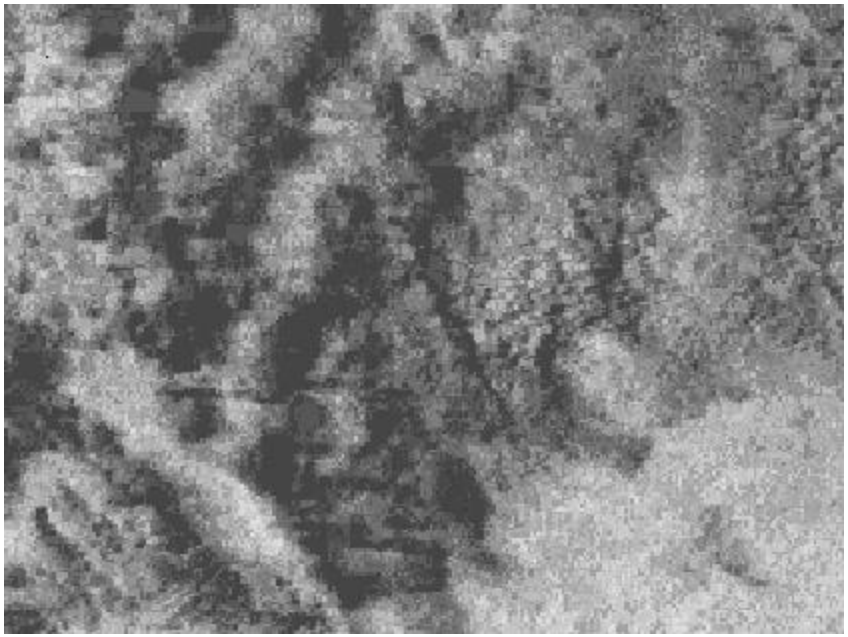
Cloud information from Sky Imagers



From the HOPE Campaign, Jülich Germany. 9 April 2013, 12:59 UTC

Source: Madhaven, et al., 2014, University of Oldenburg, Germany

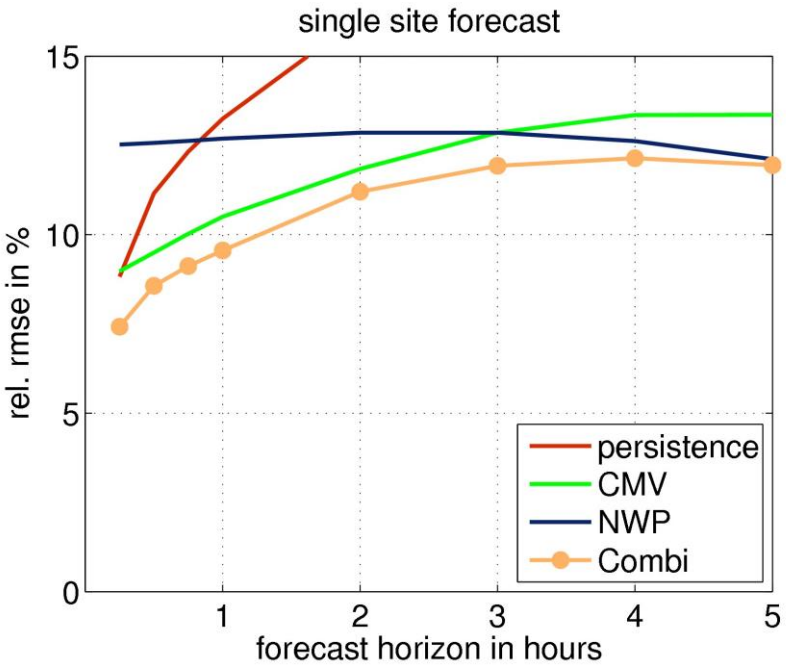
Cloud Motion Vector (CMV) Method



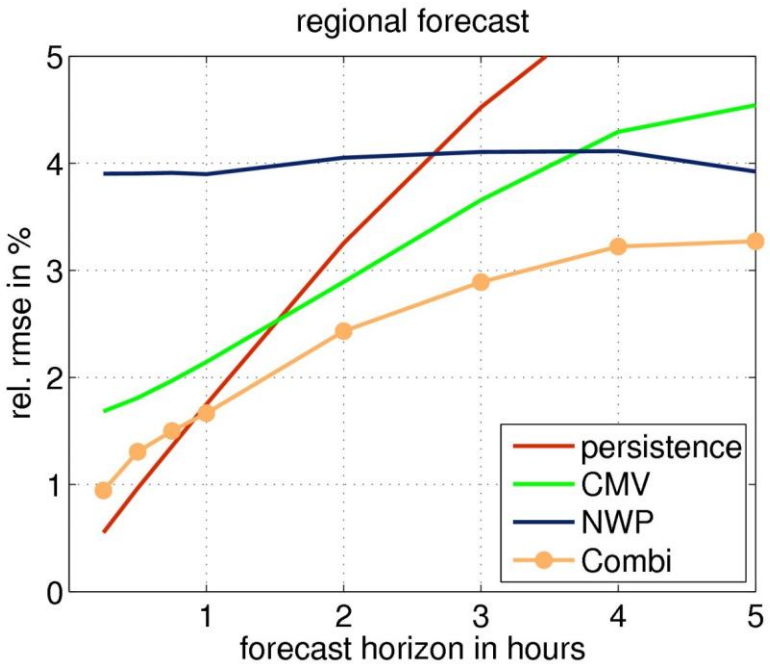
Cloud motion at 1-minute intervals interpolated from 2 satellite images taken 30 minutes apart

Source: Clean Power Research

Solar Forecasting in Germany



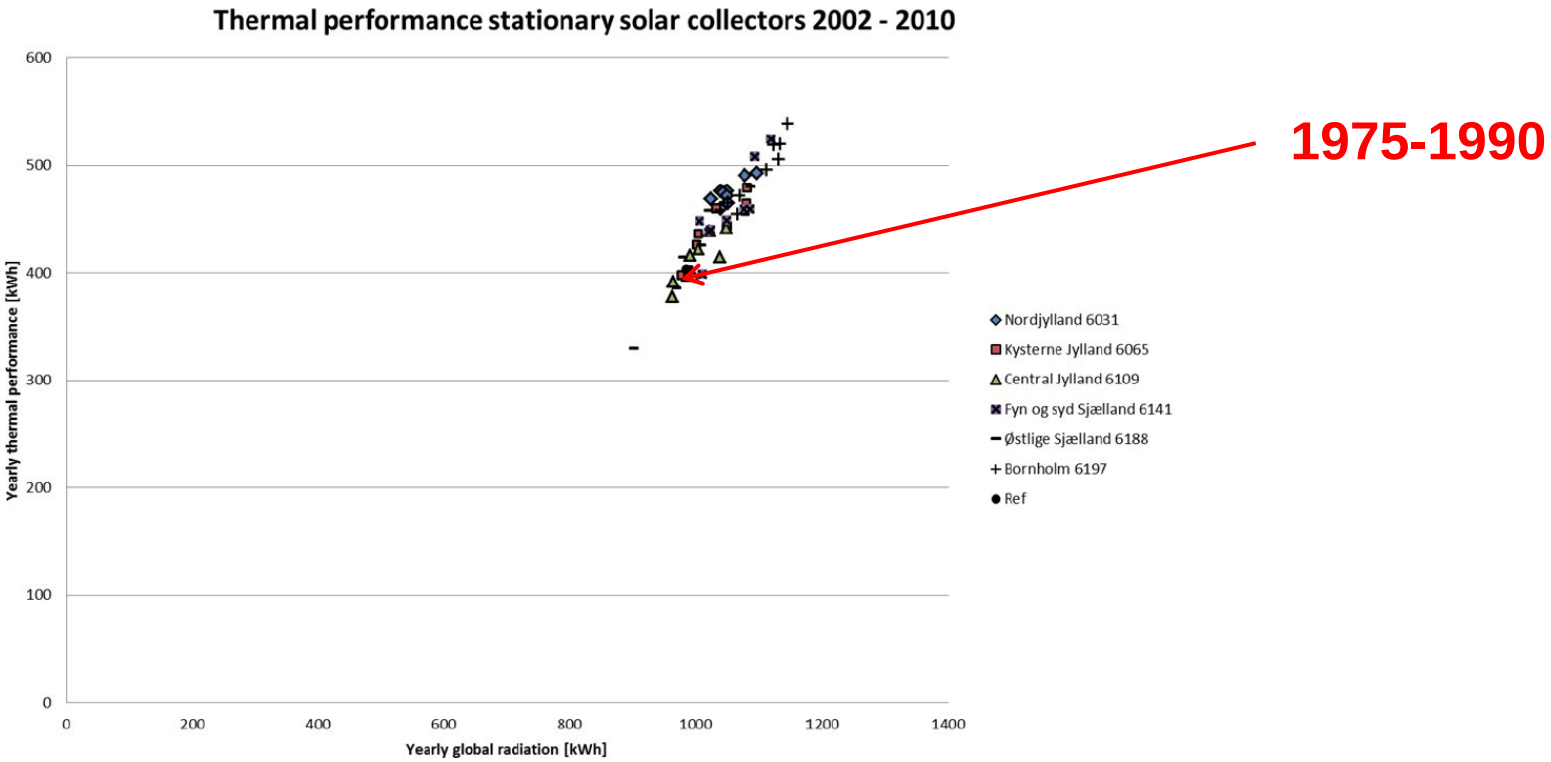
Single Site



921 Sites

Source: Lorenz, et al., 2014 (University of Oldenburg, Germany)

What about TMY Data?



Source: Danish Technical University

TMY = Typical Meteorological Year

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Summary Points

- RE will become a major energy source (and ultimately the only energy source) in this century
- Energy intensity at individual and community level must decrease
- Our method of delivering energy services is going through a transformation, and even a revolution
- Strategies to address variable renewable energy supply must include resource forecasting and energy storage
- With proper grid management, RE can supply both base and peak load energy

Thank you!

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