



**Advanced Model Development and Validation for the
Improved Analysis of Costs and Impacts of Mitigation Policies**



The research leading to these results has received funding from the European Union's Seventh Framework Programme [FP7/2007-2013] under grant agreement n° 308329

RE Resource Potentials

Patrick Sullivan, NREL
Yvonne Scholz, DLR

PIK
Potsdam, 20 Feb 2013

1. RE Resource Potentials

Existing offshore wind supply curves

- Source: Blended Sea Winds
- Dataset and technical report available at http://en.openei.org/wiki/Global_Renewable_Resource_Potential

Pending global wind supply curves

- Onshore and offshore
- Source: NCAR CFDDA reanalysis database

Solar supply curves

- Source: global GHI and BNI from NASA/GEWEX (3-hourly) + DLR clear sky irradiance (hourly)
- PV and CSP

2. Format of Wind Supply Curves

Quantity (MW or MWh) at resource quality level, by country

- Offshore also by depth class and distance from shore
- Onshore also by distance from load centers
- No imbedded cost information: model team responsibility

Blended Sea Winds Offshore Wind Supply Curves

GW of Potential within 100 nautical miles of shore

IAM Country Names	Shallow: 0-30m					Transitional: 30-60m					Deep: 60-1000m					Grand Total
	4	5	6	7	Total	4	5	6	7	Total	4	5	6	7	Total	
Afghanistan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albania	0	0	0	0	0	0.02	0	0	0	0.02	13.1	14.78	0	0	27.88	27.9
Algeria	0	0	0	0	0	0.08	0	0	0	0.08	5.18	0	0	0	5.18	5.26
Angola	0	0	0.02	0	0.02	0	0.66	0.48	0	1.14	0	7.52	16.86	1.18	25.56	26.72
Argentina	2.34	47.6	220.6	25.94	296.48	3.6	74.26	385	48.82	511.68	44.28	255.56	1053.58	849.22	2202.64	3010.8
Armenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australia	159.02	257.74	268.1	157.2	842.06	94.2	342.56	309.26	483.24	1229.26	80.88	255.38	1199.08	1841.94	3377.28	5448.6
Austria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Azerbaijan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bahamas	90.36	36	0.06	0	126.42	4.14	5.28	0.02	0	9.44	99.62	137.3	9.26	0	246.18	382.04
...																

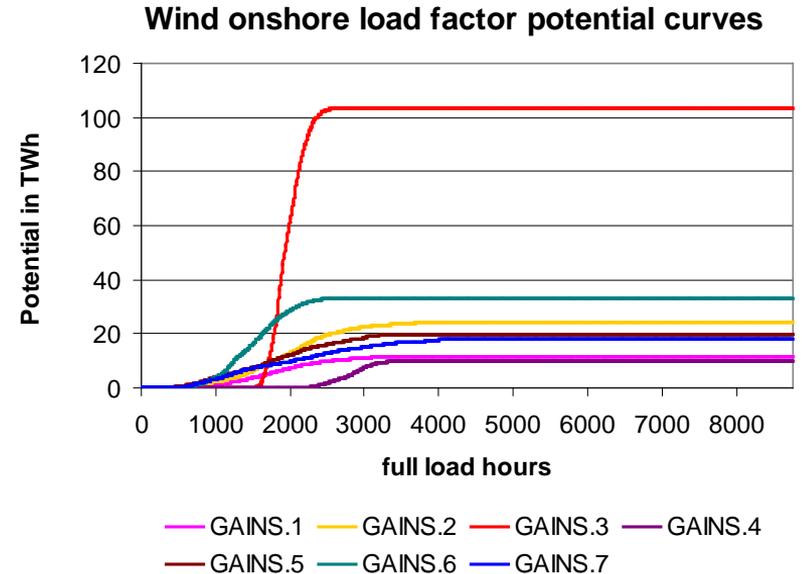
3. Prognosis for CFDDA Wind Supply Curves

We are in the final stages

- Database layers are complete (wind, population, land use type, elevation & terrain,...).
- After processing dataset, testing & validation once more, then sharing.
- Give to one team first for rapid testing before sharing with all teams?
 - Volunteer?
- At first, single set of supply curves with static assumptions
 - but designed for flexibility: teams could make or request custom supply curves with different assumptions (depth classes, turbine technologies,...).

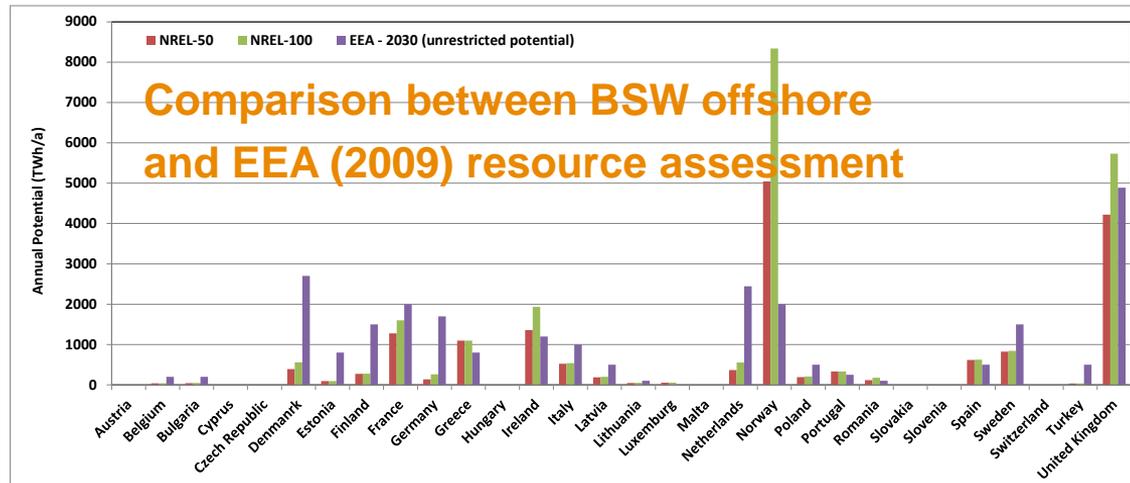
4. Prognosis for Solar Supply Curves

- Solar PV, solar CSP (and wind) supply curves available for Europe; might serve as a test-dataset.
- Global supply curves can be generated for
 - Wind onshore
 - Wind offshore
 - Solar (PV)
 - Solar (CSP base load)
 - Solar (CSP intermediate load)
 - Solar (CSP peak load)
- Harmonisation of European / Global data and tools required within DLR in order to adopt the method to the global data.
- Wind potentials: cross-checking with NREL data.



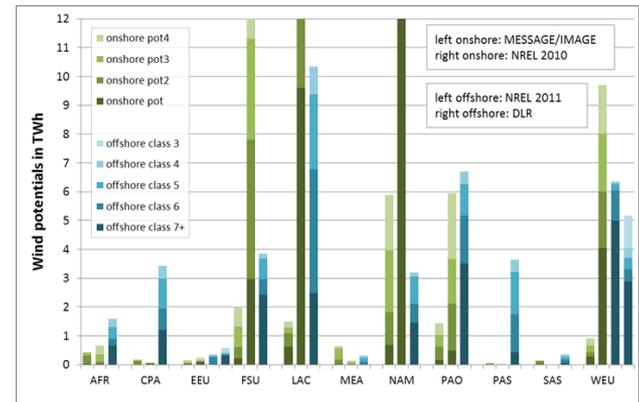
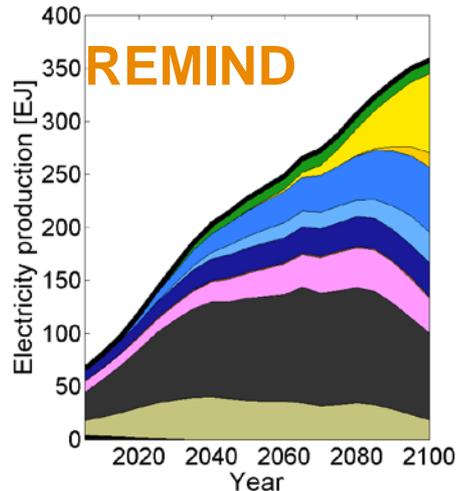
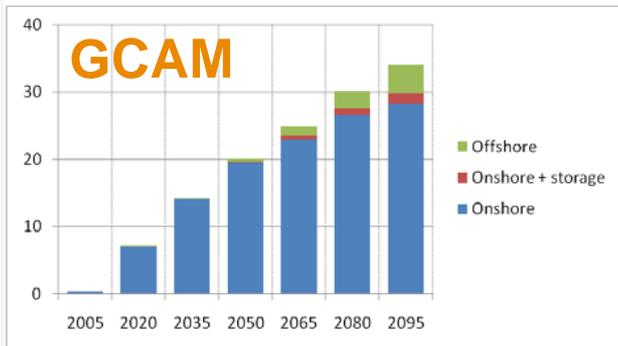
5. Dataset cross-comparison

- Blended Sea Winds Offshore to CFDDA Offshore – NREL
 - In process
- CFDDA Onshore/Offshore to previous work/literature – NREL
 - In process
- CFDDA Onshore/Offshore to model historical (e.g., Hoogwijk) – individual model teams
- CFDDA Onshore to NASA Onshore – NREL & DLR
- NASA/DLR Solar to model historical – individual model teams



6. Publication (making it official)

- NREL will publish algorithms & assumptions behind CFDDA wind supply curves (as technical report or journal article).
- DLR will publish a paper about PV, CSP and wind potential analyses which are the basis for the supply curves
- Opportunities for publishing results of including new datasets in models.
 - Individual or collaborative



MESSAGE



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RE Integration in IAMs

Patrick Sullivan, NREL
Falko Ueckerdt, PIK

PIK
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8. Integration Mechanisms in EMF27 Models

	Cost Penalty	Storage	Backup Capacity	Load Duration Curve	Maximum share	Integration costs @20% share, \$/MWh	No Mechanism
AIM-Enduse		Y			50% (solar+wind)		
BET			Y	Y	30% (solar + wind)		
DNE21+		Y	Y	Y (4)	15% wind, 15% solar		
EC-IAM					Y		
ENV-Linkages							Y
FARM					Y		
GCAM		Y*	Y* (either gas or battery)	Y in USA (4)	N		
GRAPE					Y		
IMACLIM				Y (8)	Y		
IMAGE			Y	Y			
MERGE	Y					W: 15	
MESSAGE	Y	Y	Y				
Phoenix							Y
POLES			Y				
ReMIND	Y	Y				W: 14-24, PV: 12-30, CSP: 8-18	
TIAM-WORLD				Y (6+1)			
WITCH	Y						

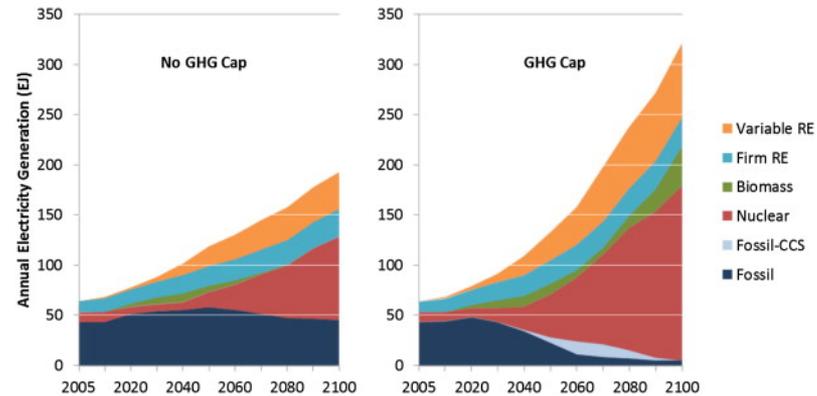
9. There are many possible integration mechanisms

First step is understanding how current approaches drive model results.

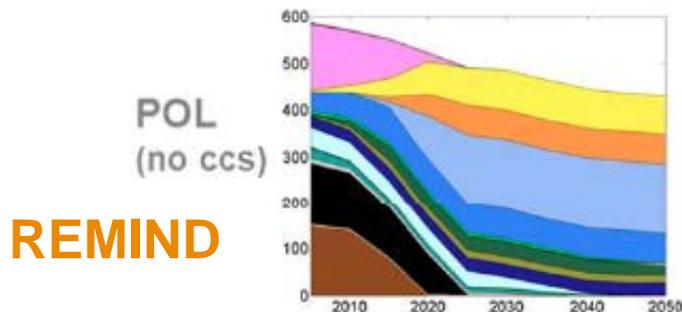
- (see after coffee break)

After stock-taking, think about how to upgrade models' variable renewable/system integration representations.

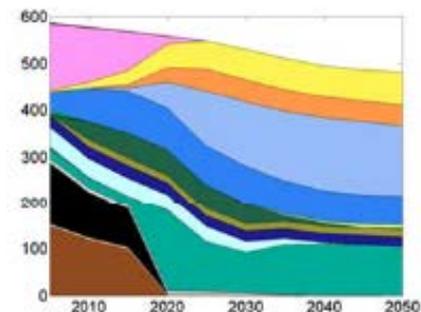
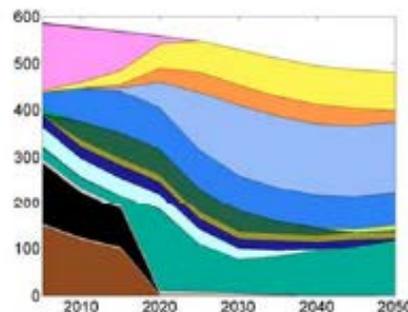
- NREL is willing (eager!) to help



MESSAGE



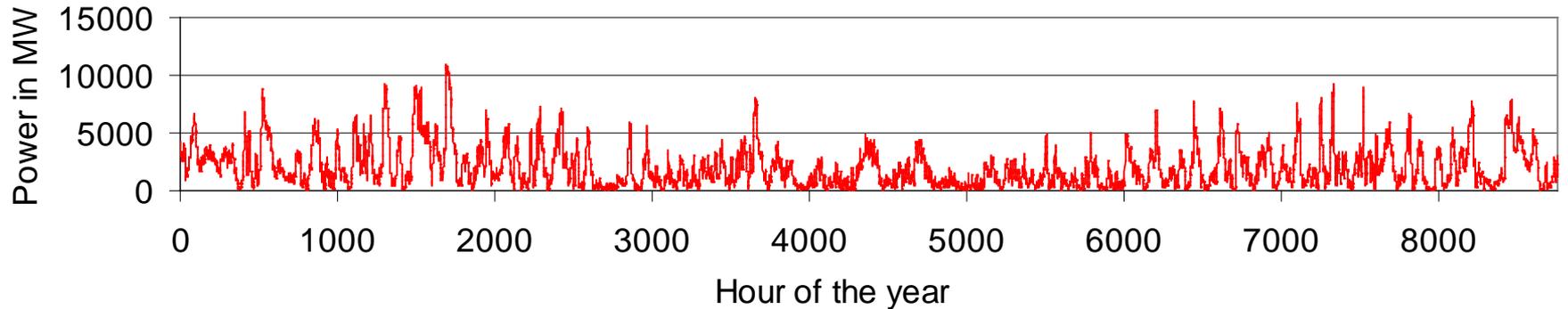
REMIND



10. ENERGEIO, WP4.C: temporal RE representation in IAM (Europe)

REMIX model time series of power generation

- Wind onshore
- Wind offshore
- Solar (photovoltaic)
- Solar (CSP, solar field)



Time series of power demand and power generation can be used to derive the demands on the dispatchable power plants in a supply system.

11. ADVANCE: Data for IAMs: 'nice to have'?

1) Load time series (global)?

2) 'Integrate integration' into technologies

- Generator + storage + backup as components of peak/medium/peak power plants
 - Three technologies each for solar (PV), wind onshore and wind offshore
- Additional 'mixed power plants' with different PV and wind turbine shares
- Dimensioning of the generator, storage and backup for each technology

→ High system reliability, low system efficiency

→ Easy to implement in IAMs?

3) Ranges of potentials (technical potential a/b/c) with different assumptions

- Area exclusion
- Usable area shares
- Technology parameters
- ...?

→ Possibility to assess and deal with uncertainties of potentials



Thanks!

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