



# MONITORING PROGRESS TOWARDS A CLEAN ENERGY ECONOMY

## Framing the Workshop Discussion: Assessing Energy Technology Progress and Frameworks For Monitoring Progress

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# Workshop Objectives

- Objective #1:** Near Term: Provide Informed Input to IEA's ETP 2012 and its Section on "Technology Progress" to be Previewed at the Next Clean Energy Ministerial, London, in April 2012
- Objective #2:** Long Term: Contribute to Enhanced Framework of Metrics for Routinely Monitoring and Measuring Technology Progress
- Comparative Benchmark:** UNFCCC Goal, as Interpreted by IEA's ETP BLUE Map: Reductions of at least 50% in global CO<sub>2</sub> emissions compared to 2000 levels by 2050, to limit the long-term global average temperature rise to between 2.0°C and 2.4°C.



# Clean Energy Ministerial (CEM)

The CEM has emerged as an effective forum through which countries representing over 80% of global greenhouse gas emissions and 90% of global clean energy investment can accelerate the global transition to clean energy through supporting the implementation and improvement of smart policy.

>90% of Global Clean Energy Investment    > 80% of Global GHG Emissions



**Australia**



**European Commission**



**Brazil**



**Canada**



**China**



**Denmark**



**Finland**



**France**



**Germany**



**Hungary**



**India**



**Indonesia**



**Italy**



**Japan**



**Korea**



**Mexico**



**Norway**



**Russia**



**South Africa**



**Spain**



**Sweden**



**United Arab Emirates**



**United Kingdom**



**United States**

# CEM Initiatives

## Participation in Clean Energy Ministerial Initiatives

November 2011

	AUSTRALIA	BRAZIL	CANADA	CHINA	DENMARK	EUROPEAN COMMISSION	FINLAND	FRANCE	GERMANY	INDIA	INDONESIA	ITALY	JAPAN	KOREA	MEXICO	NORWAY	RUSSIA	SOUTH AFRICA	SPAIN	SWEDEN	UNITED ARAB EMIRATES	UNITED KINGDOM	UNITED STATES	TOTAL
APPLIANCES (SEAD)	●	●	●		●		●	●	●			●	●	●		●	●	●	●	●	●	●	●	16
BIOENERGY		●			●							●								●				4
BUILDINGS AND INDUSTRY (GSEP)	●		●		●	●	●	●		●			●	●	●		●	●		●			●	14
CARBON CAPTURE (CCUS)	●		●	●				●	●				●	●	●	●		●			●	●	●	13
CLEAN ENERGY POLICY	●							●		●		●	●		●			●		●	●		●	10
ELECTRIC VEHICLES (EVI)				●	●		●	●	●	●			●					●	●	●		●	●	12
ENERGY ACCESS (SLED)												●											●	2
HYDROPOWER		●						●							●	●							●	5
SMART GRID (ISGAN)	●		●	●		●		●	●	●		●	●	●	●	●	●			●		●	●	16
SOLAR AND WIND	●	●			●	●		●	●				●	●	●	●		●	●		●	●	●	15
WOMEN IN CLEAN ENERGY (C3E)	●				●										●	●		●		●	●	●	●	9
<b>TOTAL</b>	<b>7</b>	<b>4</b>	<b>4</b>	<b>3</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>8</b>	<b>5</b>	<b>5</b>	<b>0</b>	<b>4</b>	<b>7</b>	<b>5</b>	<b>8</b>	<b>5</b>	<b>3</b>	<b>7</b>	<b>2</b>	<b>7</b>	<b>5</b>	<b>6</b>	<b>10</b>	

Clean Energy Policy was Formerly the "Clean Energy Solutions Center;" Energy Access was Formerly "Off-Grid Lighting;"

SEAD: Super-Efficient Equipment and Appliance Deployment Initiative  
 GSEP: Global Superior Energy Performance Partnership  
 CCUS: Carbon Capture Use and Storage Action Group  
 EVI: Electric Vehicles Initiative

SLED: Solar and LED Energy Access Program  
 ISGAN: International Smart Grid Action Network  
 C3E: Clean Energy Education and Empowerment Women's Initiative



# IEA Progress Report to CEM, April 2011

**Table 1. Recent deployment growth compared with clean energy targets\***

Technology	Current rate	Required annual growth to 2020	Current status	Blue Map target 2020
Biofuel	18%	7%	2.54 EJ	5.04 EJ
Biomass power	7%	4%	54 GW	82 GW
Hydropower	5%	2%	980 GW	1219 GW
Solar PV	60%	19%	21 GW	126 GW
Wind power	27%	12%	195 GW	575 GW
Energy intensity of manufacturing	-1.30%	-0.60%	3.73 MJ	3.81 MJ
Geothermal power	4%	7%	11 GW	21 GW
Nuclear power	3%	4%	430 GW	512 GW
CSP	8%	50%	0.6 GW	42 GW
Electricity generation with CCS	Zero projects	3 GW per year	Zero projects	28 GW
Electric vehicles	-	Doubling of sales each year from 10 000 EV/PHEV sales in 2011 to reach Blue Map target	-	7 million sales in 2020

	Achieving or exceeding levels, maintain the course
	Progress but more concerted effort needed
	Sizeable gap between deployment and goals

Source: Clean Energy Progress Report, IEA Input to the Clean Energy Ministerial, IEA April 2011

\* Targets and Progress, Based on ETP 2010 BLUE Map scenario and country submissions.



# ERGD Agenda Topics –

## Sampling of Technologies Important to BLUE Map Scenario

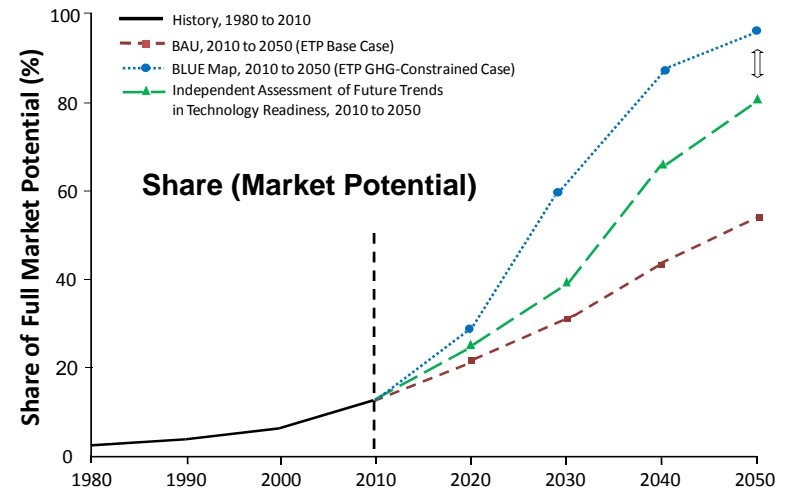
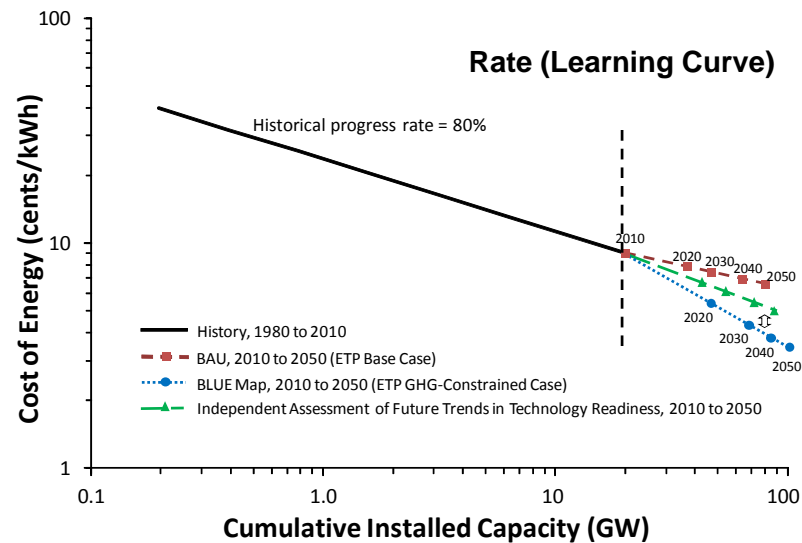
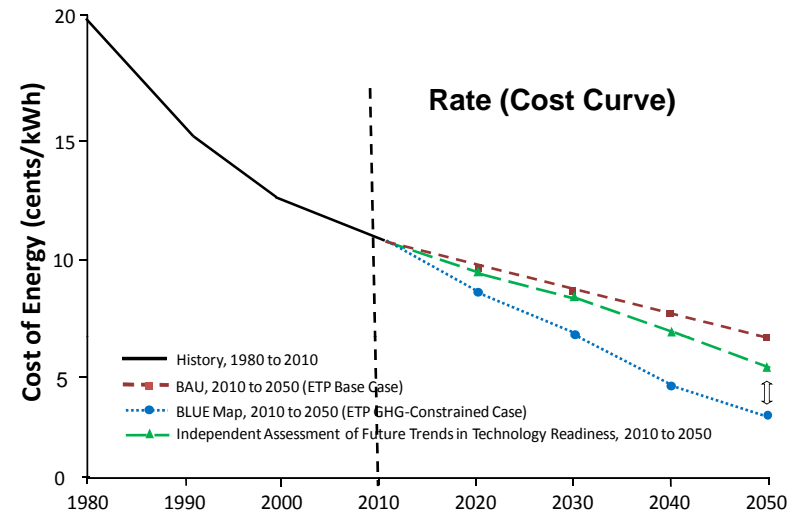
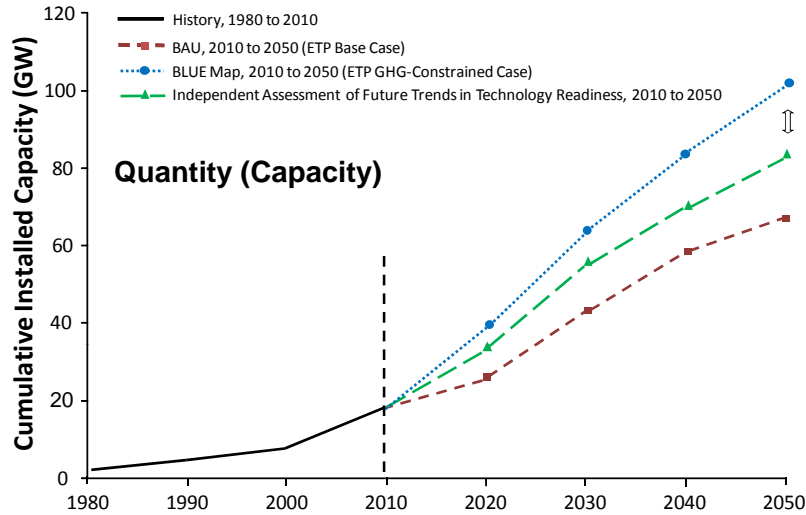
- Energy Supply
  - Solar Photovoltaics and CSP
  - Wind Power
  - Bio Fuels and Biomass
  - Coal Power Generation with CCS
- Energy Demand
  - Energy Efficient Buildings – Heating & Cooling
  - 4E – Efficient Electrical End-Use Equipment
- Cross Cutting
  - Energy Storage – Batteries
  - Smart Grids
- Sampling Includes 8 of 14 Technologies Important to BLUE Map Scenarios



## **II. QUANTITATIVE INPUT ON STATUS & PROSPECTS DERIVED FROM METRICS**



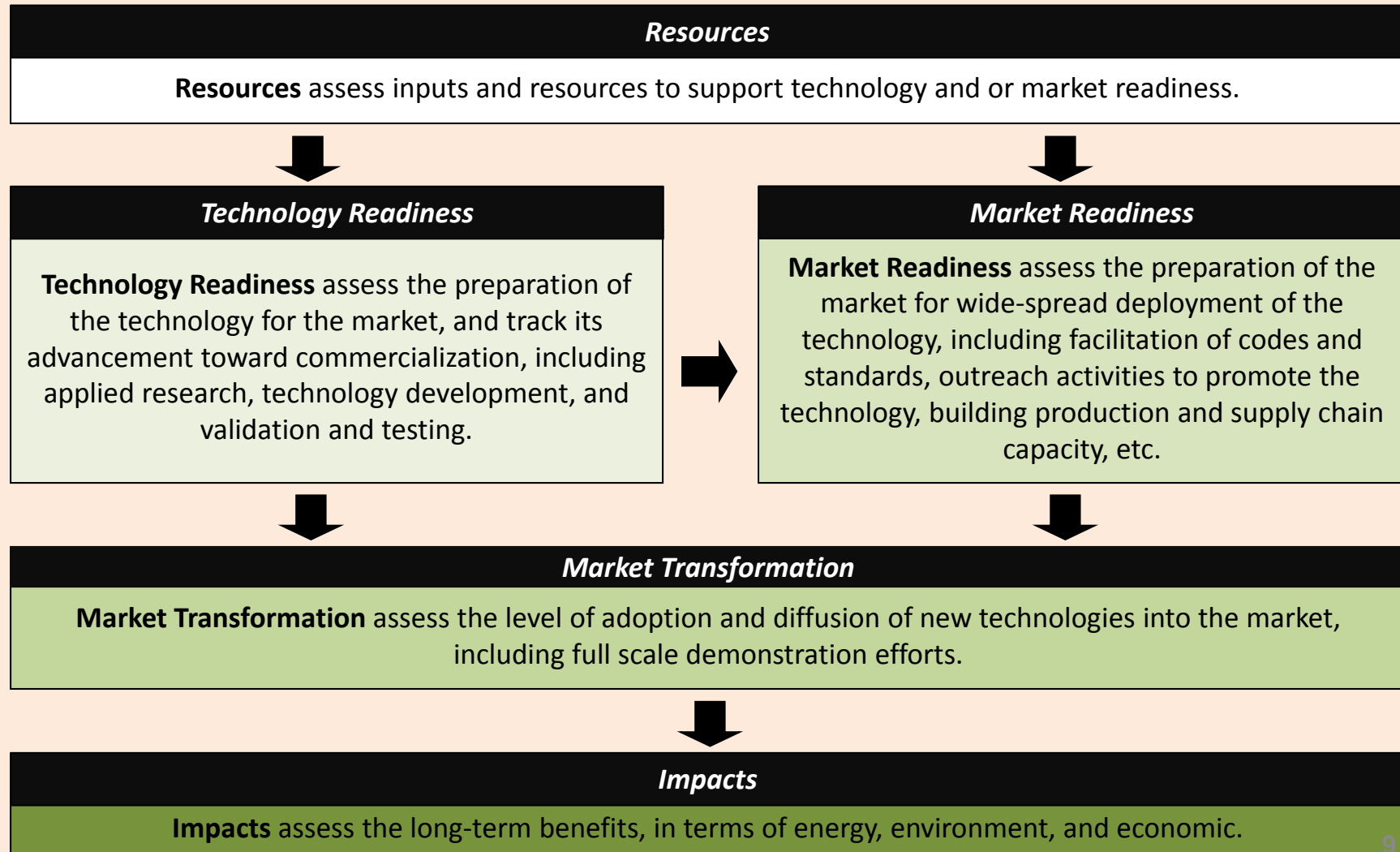
# How to Portray Past Progress and Future Prospects – 4 Visualizations







# Organizing Framework for Classifying Indicators or Metrics





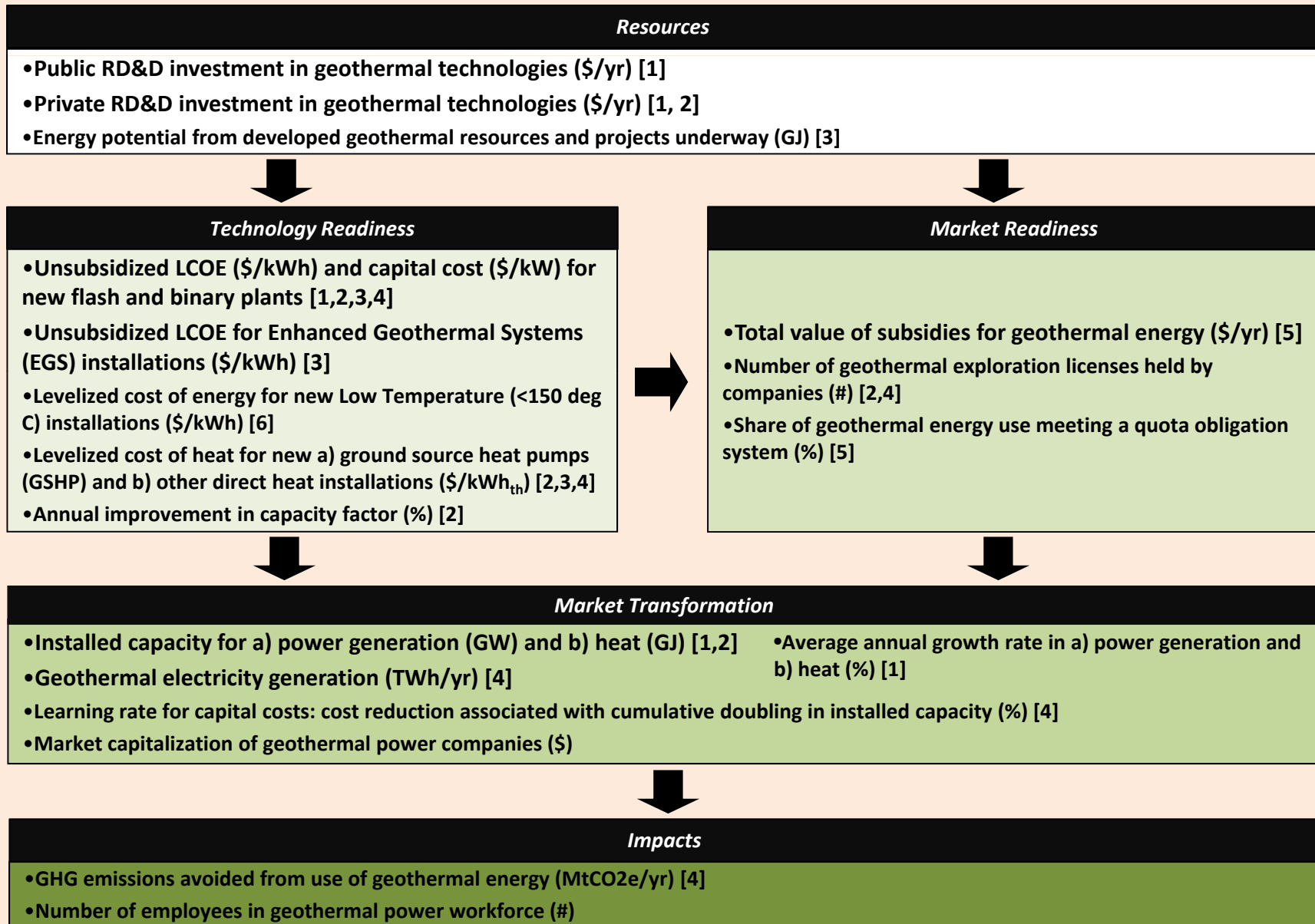
# Sample Metrics

## Geothermal Example

	Candidate Metric	Unit of Measure	Type of Indicator
Resources	Public RD&D investment in geothermal technologies	\$/yr	Leading
	Private RD&D investment in geothermal technologies	\$/yr	Leading
	Energy potential from developed geothermal resources and projects underway	GJ	Leading
Technology Readiness	Unsubsidized LCOE and capital cost for new (a) flash and binary plants, (b) Enhanced Geothermal Systems (EGS), and (c) low-temperature (<150 deg C) installations	\$/kWh; \$/kW	Leading
	Levelized cost of heat for new a) ground source heat pumps (GSHP), and b) other direct heat installations	\$/kWh <sub>th</sub>	Leading
	Annual improvement in capacity factor	%	Leading
Market Readiness	Total value of subsidies for geothermal energy	\$/yr	Leading
	Number of geothermal exploration licenses held by companies	#	Leading
	Share of geothermal energy use meeting a quota obligation system	%	Leading
Market Transformation	Learning rate for capital costs	%	Leading
	Installed capacity for a) power generation and b) heat	GW; GJ	Coincident
	Geothermal a) electricity generation and b) heat production	TWh/yr; TJ/yr	Coincident
	Average annual growth rate in a) power generation and b) heat	%	Coincident
Impacts	Number of employees in geothermal power workforce	#	Coincident
	GHG emissions avoided from use of geothermal energy	MtCO <sub>2</sub> e/yr	Lagging

# Geothermal Heat and Power

## Sample Metrics for Measuring Progress toward a Global Clean Energy Economy



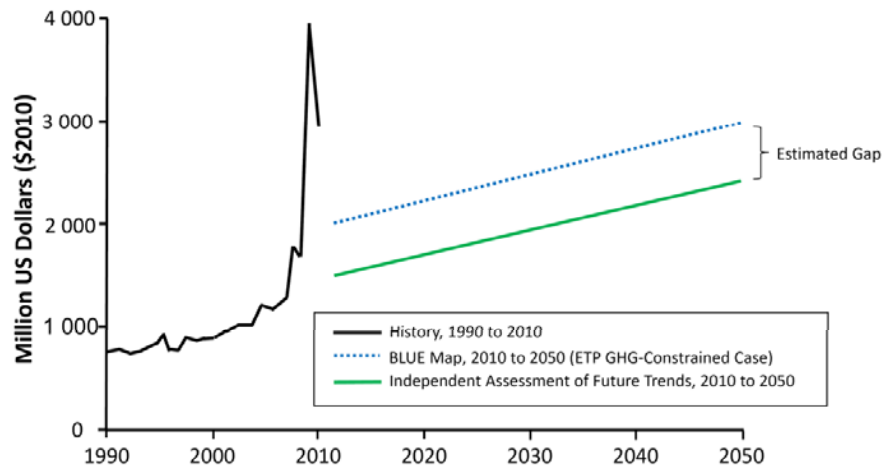
Note: Numbers in Brackets [ ] Refer to Literature Sources for Data. See Supplemental Material



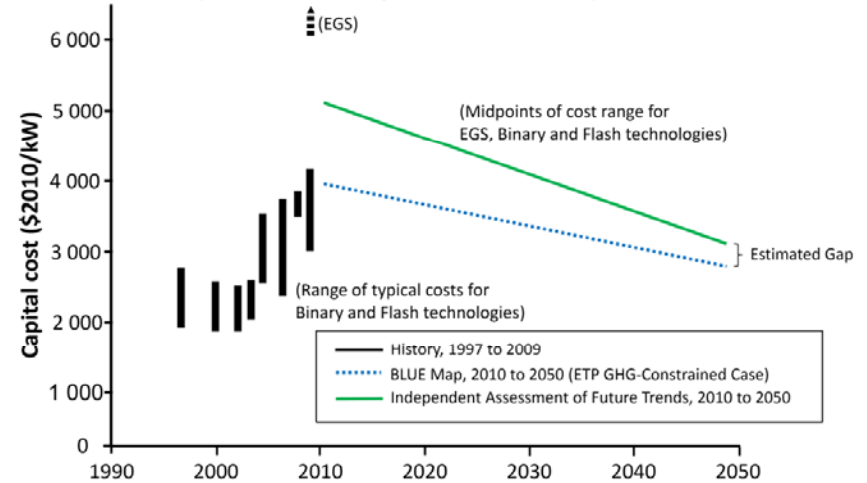
# Illustrative Results for Selected Metrics

## Geothermal Heat & Power

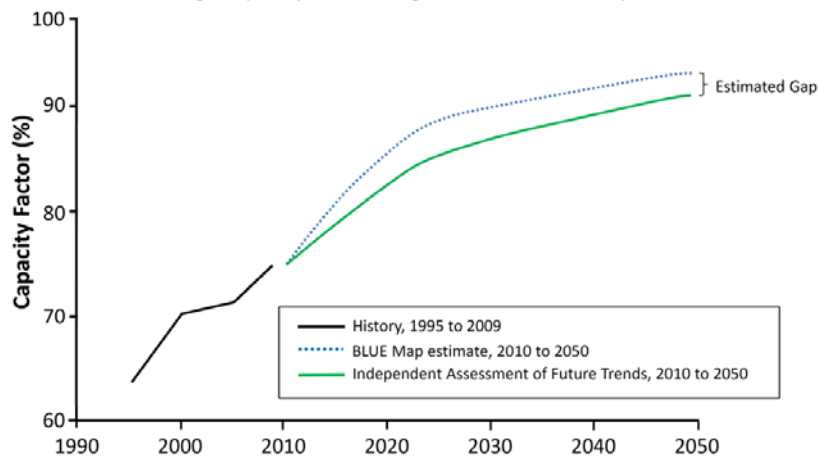
Metric: Public RD&D investment for geothermal energy (million USD/yr)



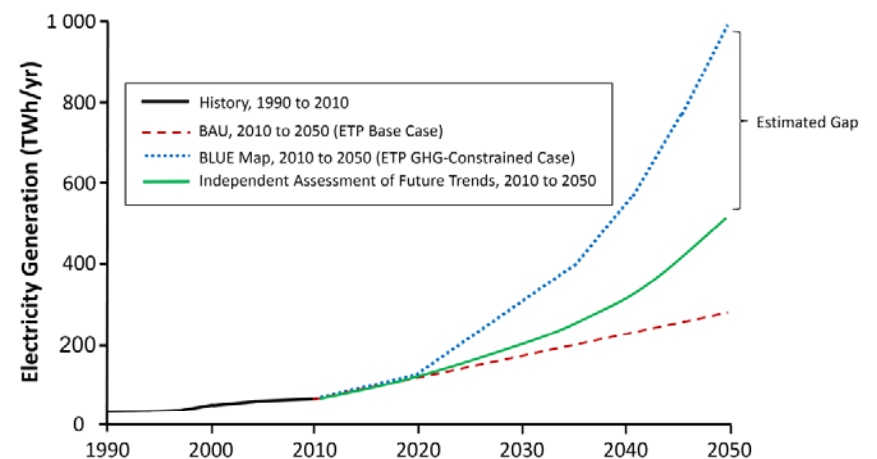
Metric: Capital cost for new geothermal electricity installations



Metric: Average capacity factor for geothermal electricity



Metric: Geothermal electricity generation (TWh/yr)



Sources for historical data: IEA online data services and IPCC Special Report on Renewable Energy and Climate Change Mitigation (2011).  
 Source for projections: IEA ETP 2010,



**III. QUALITATIVE INPUT  
ON  
STATUS AND PROSPECTS  
FROM EXPERT OPINION, BRIEFINGS &  
QUESTIONNAIRES**



# Questionnaires

- Energy Supply (4 kinds as Samples)
- Demand Side Technologies (Reduced Demand)
- Energy Storage – Vehicle Batteries
- Smart-Grids (Other Enablers)



# Objective 1 – Input to Progress Report

## Questions:

- Compared to ETP BLUE Map scenarios, from present day to 2050, which technologies appear to be making progress as expected, and which are not? [Express as Likelihood]
- What are the major barriers to inhibiting greater development and deployment? Can these be characterized by categories, such as: (a) policy; (b) socio-economic; and (c) technical and/or cost?
- What would be the most important messages for the audience (IEA Member Countries, Clean Energy Ministers, etc.)?
- What are the most important actions that IEA Member Countries might take to address barriers?
- For technical and cost-reduction barriers, what are the most fruitful areas or opportunities for enhanced R&D cooperation to address technologies that are not progressing as expected?



# Sample Questionnaire

## Objective #1

### ENERGY SUPPLY

Expert name: \_\_\_\_\_

Technology area: \_\_\_\_\_

- Solar PV and Concentrating Solar Power
- Wind Power
- Biofuels and Biomass Power
- Coal Power Generation with CCS and High-Efficiency Low Emissions Coal Technologies

Objective #1: Input to Progress Report				
1. What is the <b>likelihood</b> that the technology will deploy as described in the Blue Map scenario (select one):				
<input type="checkbox"/> Very Unlikely (<10%)	<input type="checkbox"/> Unlikely (10-40%)	<input type="checkbox"/> Maybe (40-60%)	<input type="checkbox"/> Likely (60-90%)	<input type="checkbox"/> Very Likely (>90%)
2. What is the most important <b>message</b> about advancing this technology to convey to leaders attending the Clean Energy Ministerial in April 2012?				
3. What opportunities exist for enhanced <b>R&amp;D</b> cooperation to address areas not progressing as described in the Blue Map scenario?				





## Objective 2

# Enhanced Metrics Framework

### Questions:

- What metrics are most meaningful and indicative of progress, and can they form a real-time set of leading indicators that would signal need for action?
- What are the elements of an effective, integrated framework for monitoring, evaluating and communicating progress on key technologies?
- What lessons can be learned from the private sector, or from public-private partnerships in monitoring progress on technology development and commercialization?
- What approaches are most effective in communicating results to inform decision-making, feed into the prioritization or restructuring of research investments and related policies, and achieve desired outcome?



# Sample Questionnaire

## Objective #2

Objective #2: Enhanced Metrics Framework				
<p>A. What metrics are most useful in assessing progress? Score the relative utility of each metric below, using the scale: [1 = low utility; 2 = moderate utility; or 3 = high utility].</p> <p>B. Assess the current situation, as represented by the metric's data, regarding progress toward Blue Map goals: [1 = inadequate; 2 = adequate; or 3 = more than adequate].</p>				
Metric		A. Utility of the Metric as an Input to Assessing Progress (circle one) <sup>†</sup>	B. Adequacy of Current Situation (circle one) <sup>††</sup>	Comments (additional room for comments on back of form)
Resources	Public R&D Investment	1 2 3	1 2 3	
	Private R&D Investment	1 2 3	1 2 3	
Technology Readiness	Performance (reliability, efficiency, lifespan, etc)	1 2 3	1 2 3	
	Capital cost (upfront equipment and installation costs)	1 2 3	1 2 3	
	Unsubsidized LCOE (includes	1 2 3	1 2 3	

<sup>†</sup> Relative usefulness of the metric as an indicator of technical progress, or an input to assessing deployment progress.  
<sup>††</sup> Adequacy of the circumstances (as represented by the metric) to promote progress toward the ETP BLUE Map goals by 2050.



**IV. INTEGRATIVE SUMMARY  
ON  
STATUS AND PROSPECTS  
WITH  
DEVELOPMENT OF EGRD  
RECOMMENDATIONS**



# Workshop Outputs

## IV. Workshop Outputs

- A. Integration of:
  - 1. Quantitative Inputs
  - 2. Qualitative Inputs
- B. Synthesis of:
  - 1. Situational Context
  - 2. Discussion Points and Messages
- C. Development of Recommendations:
  - 1. Accelerating Technology Programs
  - 2. Enhancing Metric Frameworks
- D. Workshop Report
  - 1. Drafting of Report
  - 2. EGRD Review and Approval



# Summary of Experts Assessments

Strategic Goal	Key Element of Strategy	Corresponding IEA Technologies & Roadmaps	Contributions to Goals ETP 2010 Blue Map Scenarios (Sum to 2050)	Units	Blue Map Deployment Tracks				Likelihood of Goal Attainment† (Expert Eval and Metrics)					Policy Adequacy‡			
					2007	2015	2030	2050	Very Unlikely	Unlikely	Maybe	Likely	Very Likely				
1 Energy Efficiency	1.3	Industry	Final Energy Reduction		EJ	0.00	11.8	32.2	56.5		✓					3	
	1.2	Buildings	Final Energy Reduction		EJ	0.00	6.66	30.6	63.1		✓					2	
	1.1	Transportation	Final Energy Reduction		EJ	0.00	3.23	27.3	66.3				✓			3	
2 Fossil Energy and CCS	2.1	Fossil-Based Fuels and Power with CCS	Electricity: Fossil w/CCS		T kWh/yr	0.00	0.03	1.65	6.56			✓				1	
	2.2	Carbon Capture	(Embedded in 2.1)	N/A	N/A	N/A						✓				1	
	2.3	Geological Storage	Carbon Storage	N/A	GtCO2 Cum	0.00			145			✓				1	
	2.3	High Efficiency Low Emission (HELE) Coal	Electricity: HELE Fossil	N/A	T kWh/yr	N/A						✓				3	
3 Renewable Energy	3.1	Renewable Energy and Fuels	Electricity: Solar PV (incl. Rooftop)		T kWh/yr	0.00	0.06	0.53	2.47		✓					4	
	3.2		Electricity: CSP		T kWh/yr	0.00	0.02	0.40	2.49			✓					3
	3.3		Electricity: Wind Power		T kWh/yr	0.17	1.32	2.78	4.92			✓					2
	3.4		Electricity: Hydro		T kWh/yr	3.08	3.73	4.94	5.75					✓			5
	3.5		Electricity: Geothermal		T kWh/yr	0.06	0.11	0.31	1.01		✓						3
	3.6		Biomass (incl. w/ CCS)		T kWh/yr	0.26	0.38	1.48	2.46				✓				4
	3.7		Biofuels		EJ	N/A	3.40	10.10	32				✓				4
4 Fission and Fusion	4.1	Nuclear Fission	Electricity: Nuclear Fission		T kWh/yr	2.72	3.29	5.36	9.61			✓				2	
	4.2	Nuclear Fusion	Electricity: Fusion Energy	N/A	T kWh/yr					✓						TBD	
5 Hydrogen and Fuel Cells	5.1	Hydrogen	Hydrogen		EJ	0.00			8.37			✓				1	
	5.2	Fuel Cells	Fuel Cells	N/A	% of Vehicle Sales	0%	0%	3%	20%			✓				1	
6 Cross-Cutting	6.1	Electric Grid and Infrastructure	Peak Load Reduction	N/A	% Reduction	N/A	0%	6%	10%			✓				2	
	6.2	Grid Storage	Grid Storage Required for Intermittants	N/A	GW	100*			122-189		✓					2	
	6.3	Batteries for Vehicles	EV/PHEV Roadmap	N/A	EV/PHEV Sales	0.012*	1.48					✓				4	

† Very Likely (90-100%); Likely (60-90%); Maybe (40-60%); Unlikely (10-40%); Very Unlikely (0-10%)

‡ Adequacy of existing policy to address known barriers

\* 2010 Value, EV/PHEV Sales in Millions

Note: Contributions to Goals Estimated for gray rows



# Recommendations of IEA Progress Report, April 2011\*

- Increase public investment in innovation through support for research and development (R&D), as well as large-scale demonstration.
- Implement smarter energy policies, including removing non-economic barriers and providing transparent, predictable and adaptive incentives for cleaner options.
- Facilitate the uptake of clean energy technologies into energy systems by supporting integration of technologies such as smart grids.
- Phase out subsidies for fossil fuels.
- Establish a price on CO<sub>2</sub> emissions.



# Technical Recommendations for Public R&D Planners

**To Be Determined  
In EGRD Discussions**



# Related Policy Recommendations

**To Be Determined  
in EGRD Discussions**