Flexible Electricity Systems

Integrated Energy Systems of the Future

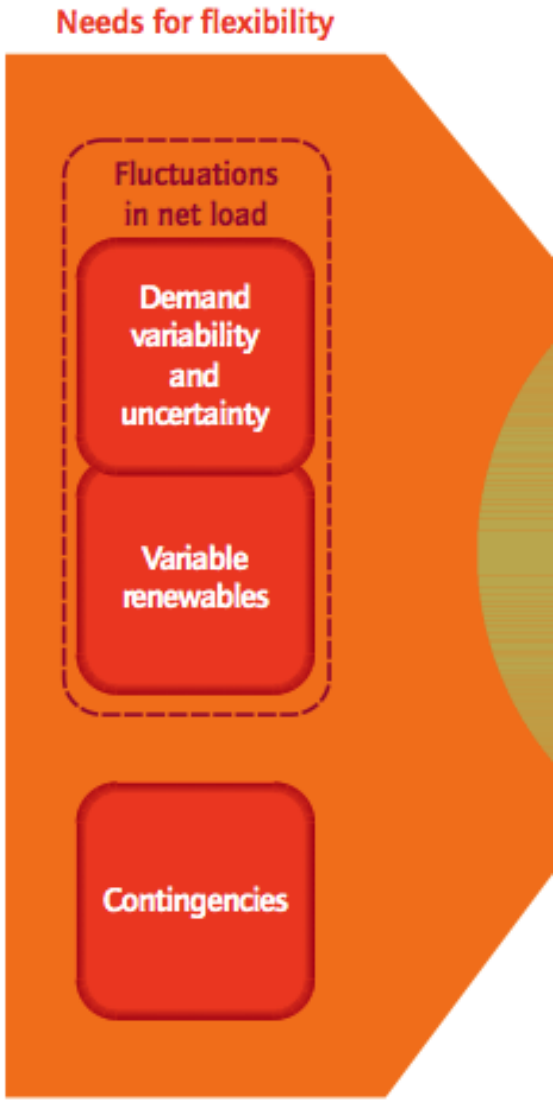
7, 8 November, 2011

How does the electricity system work?

- **Three key elements:**
  - **Energy – MWh's**
    - We need to ensure that we have enough fuel to deliver the total amount of electricity over the course of the year
  - **Capacity – MW's**
    - Ensure we have enough generation, transmission and distribution to meet highest demand over the course of a year for every point and load throughout the electricity system
  - **Flexibility - +/- MW's/minute**
    - Ensure the system can modify electricity production or consumption in response to variability, expected or otherwise.

All three elements must be adequately satisfied for the system to operate!

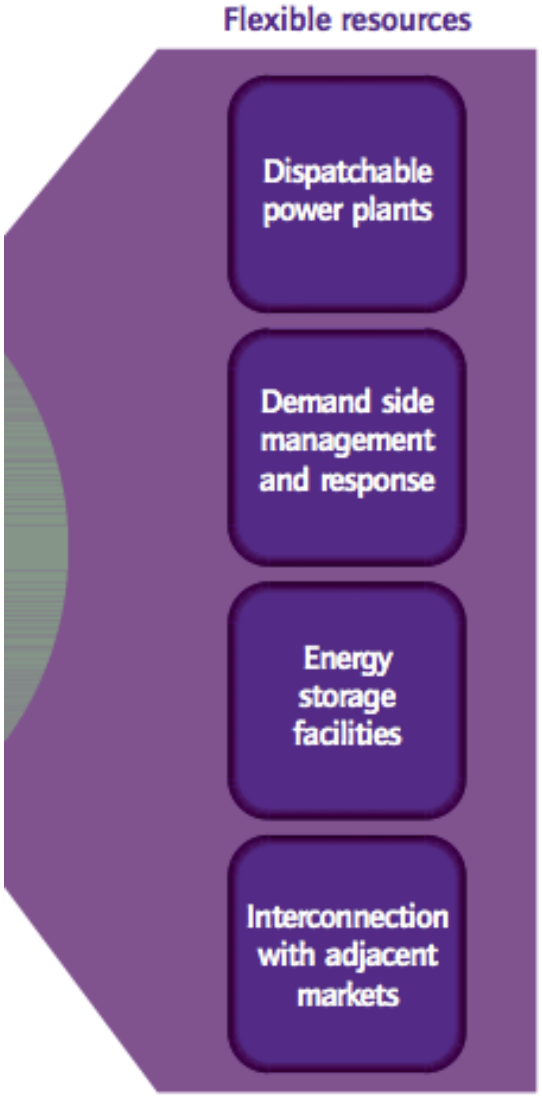
Why do we need Flexibility?



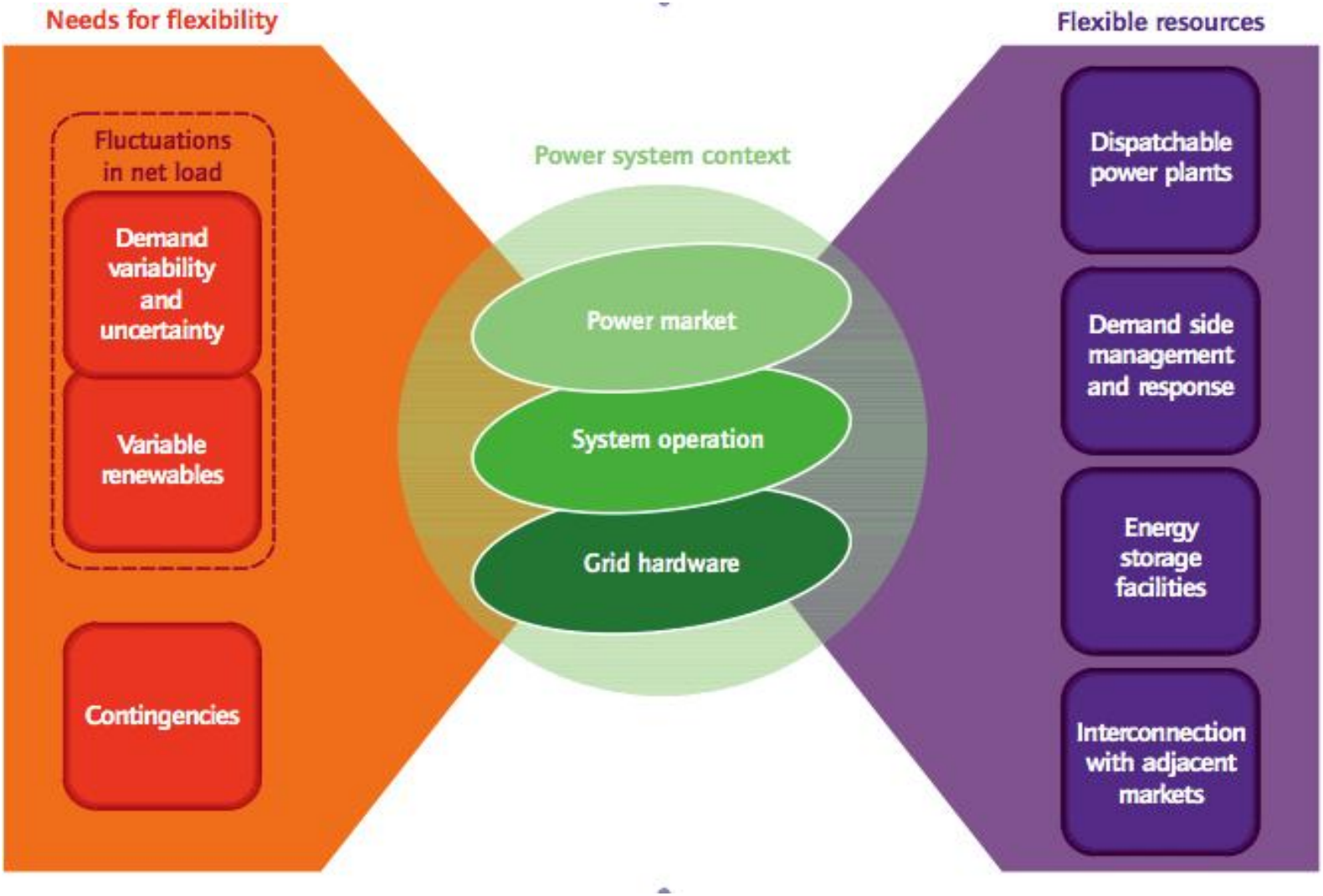
- Demand variability and uncertainty
- Variable renewables
- Contingencies

What are the resources for flexibility?

- Generation
- Demand side
- Storage
- Interconnection



The power system context:

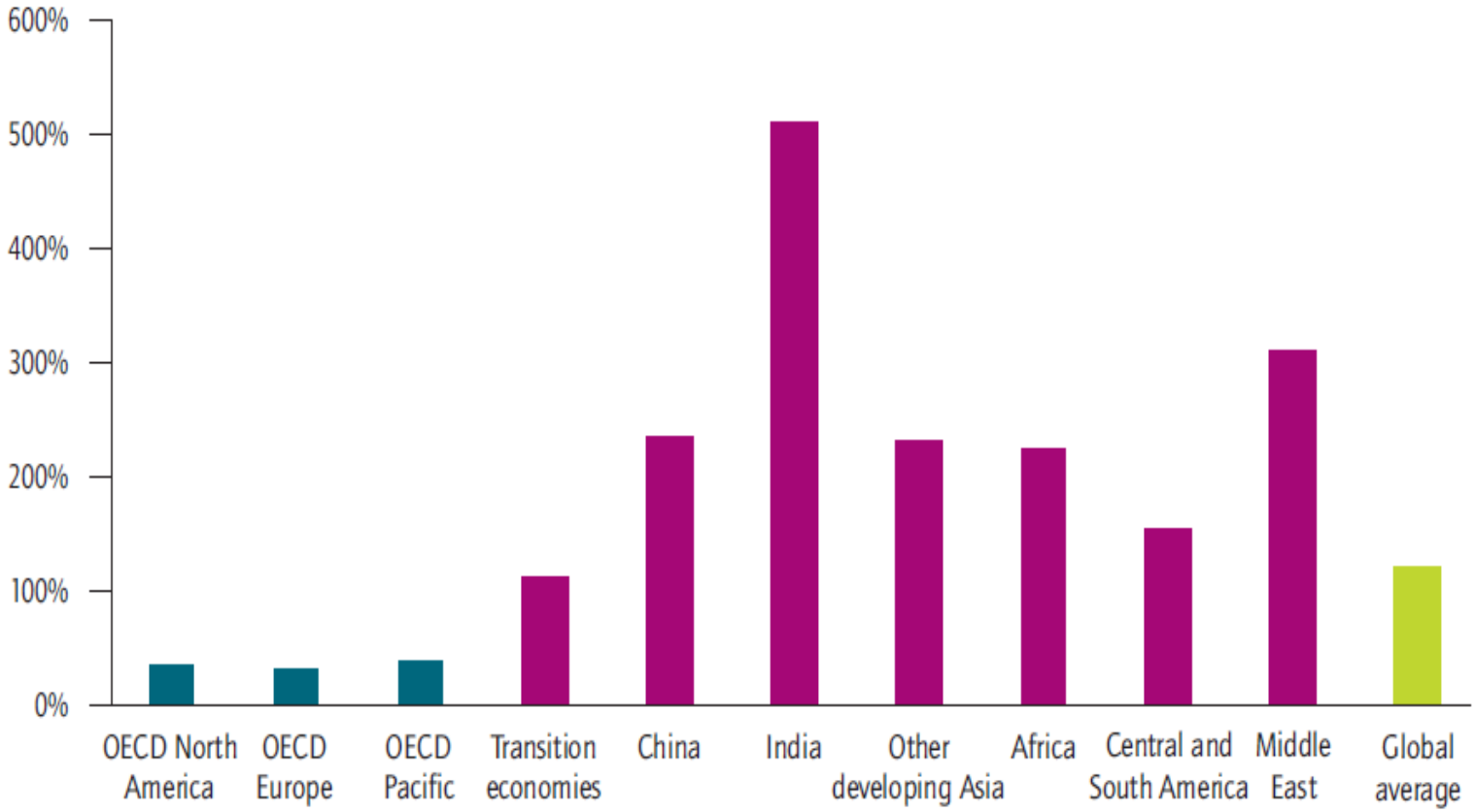


Source: Chandler, H., Harnessing variable renewables: A guide to the Balancing Challenge, 2011

The electricity system works fine? Why is this important?

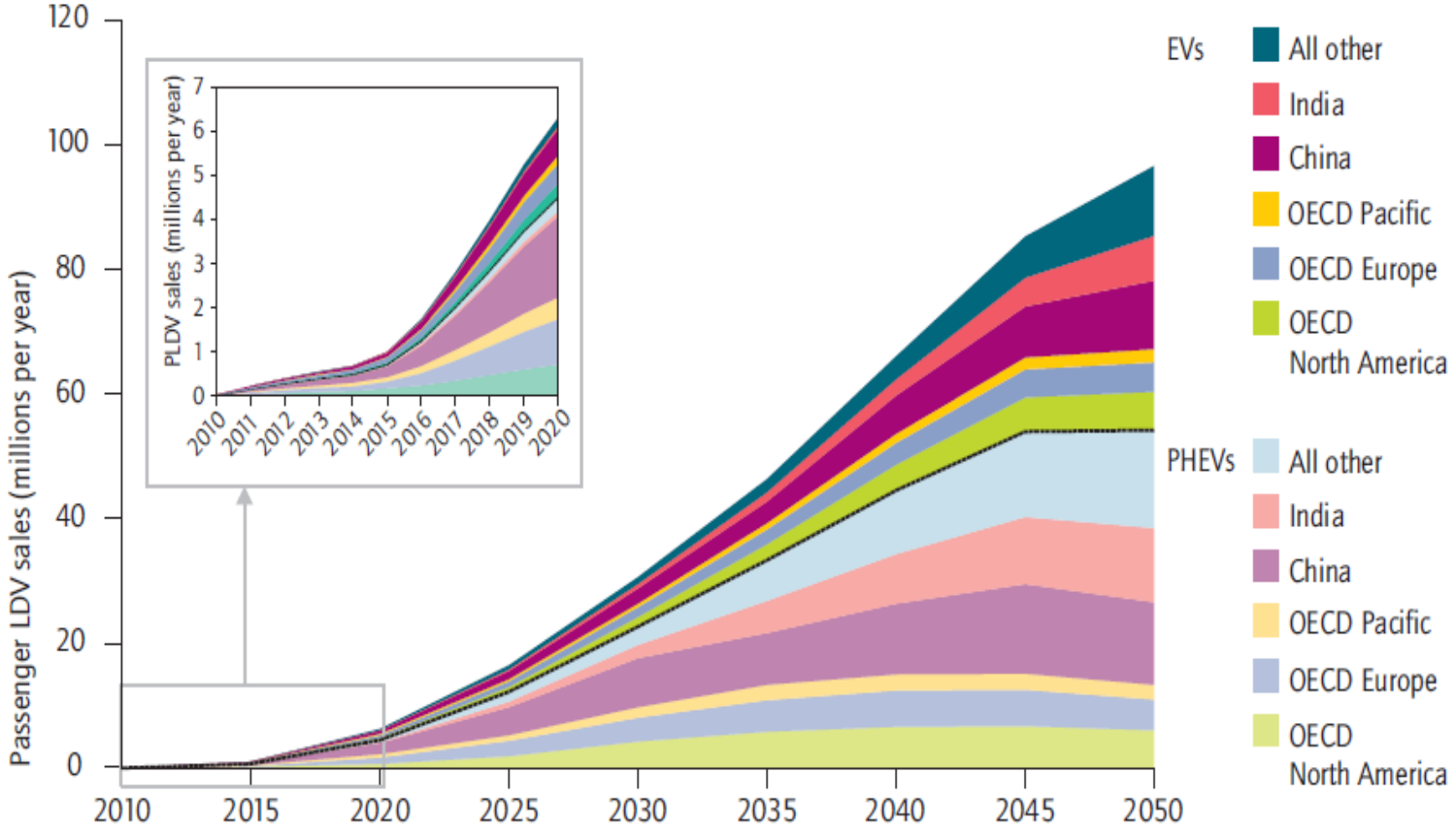
Let's take a look at the future:

Electricity Demand Growth: 2007 - 2050



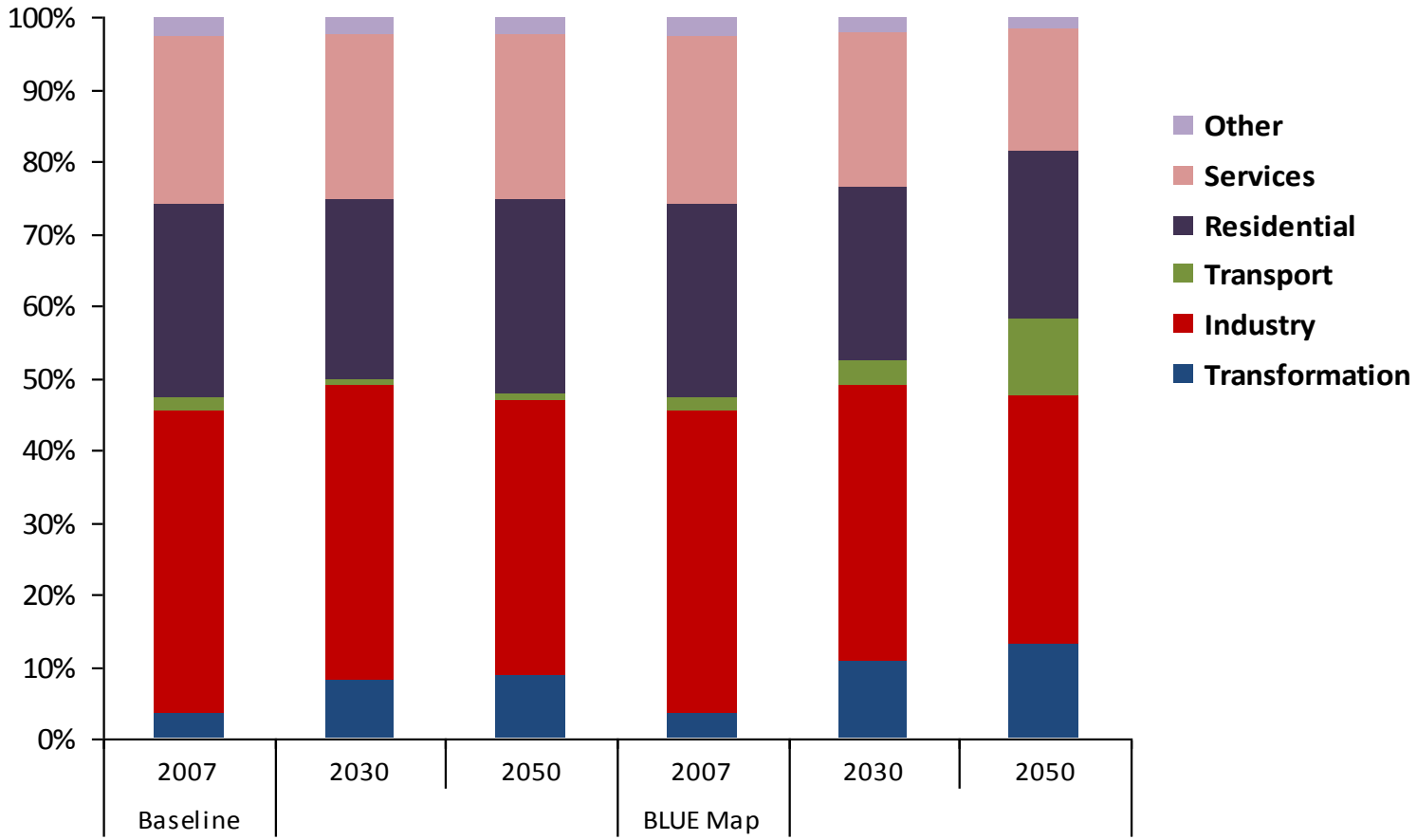
Peak demand may increase faster than overall demand !

EV/PHEV Deployment

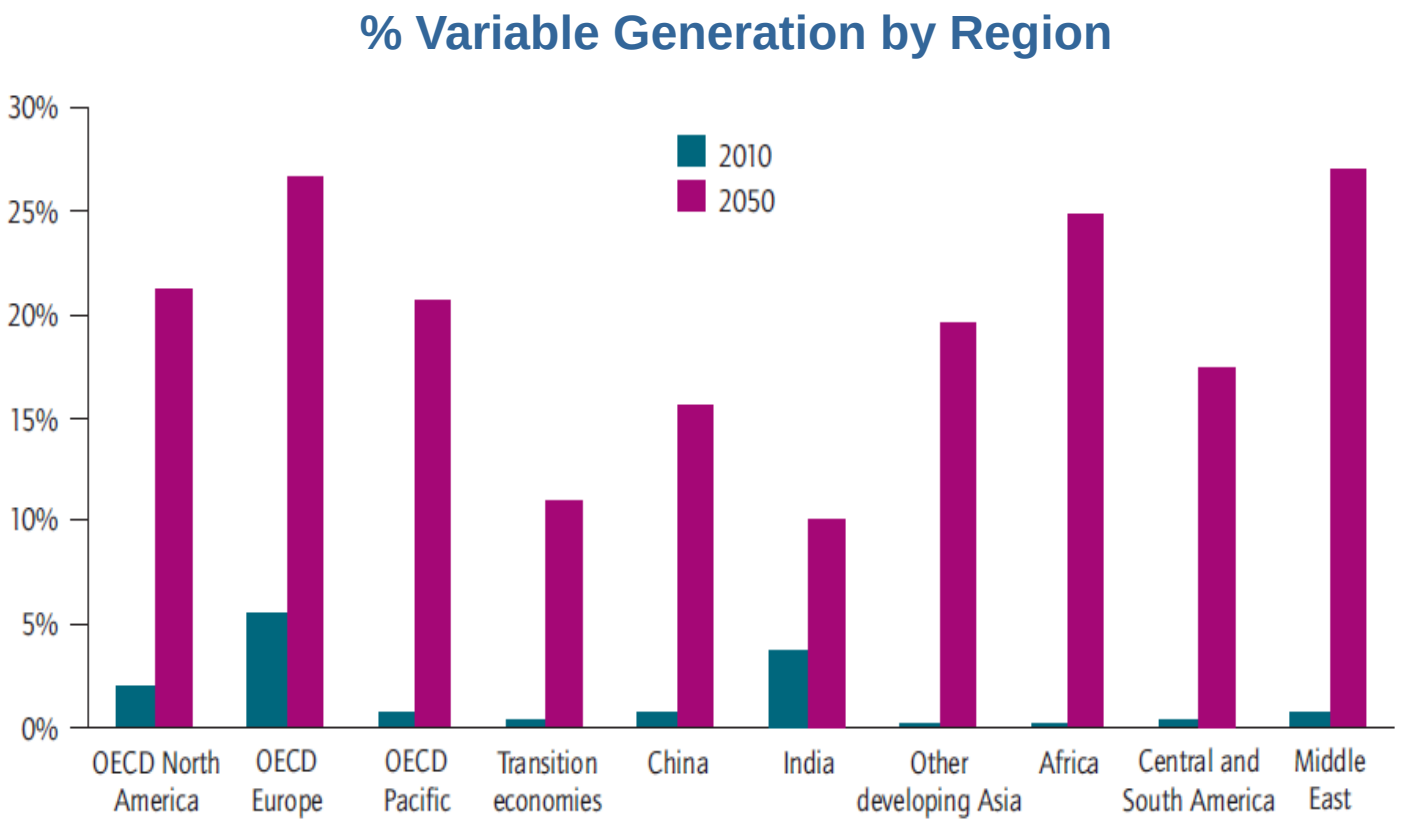


Source: IEA, 2009.

Sectoral Electricity Demand



Deployment of Variable Generation



Discussion topics:

- Flexibility time frames
  - Regulation
  - Load following
  - Scheduling
- Data/analysis associated with given time frames
- DR, Interconnection, Storage, Generation
  - Technology
  - Technology maturity
  - Barriers/ Risks
  - Lock-in and scenarios

Flexible Electricity Breakout

- **Delimitation of discussion**
  - **What we will talk about:**
    - Need for flexibility
    - Flexibility of various generation technologies
    - Other flexibility resources: interconnection, DR, Storage
    - Regulatory considerations for new technology investments in the electricity system and market aspects for flexibility
  - **What we won't talk about:**
    - Generation technologies in detail
    - Overall regulation of the electricity system
    - Overall market operation

Structure of Breakout

- 13:30 – 13:40: Intro
- 13:40 – 14:00: Parallel generation/interconnection discussion
- 14:00 – 14:10: report and discussion
- 14:10 – 14:30: DR
- 14:30 – 14:50:Storage
- 14:50 – 15:30: systems solutions
  - Key consideration (time frame, lock-in, ensure capacity, market structure/regulation)

Outputs from the breakout session

- Key Messages
- Further Analysis needed
- Near term links to other energy systems
- Long term links to other energy systems
- Key Questions for other energy systems
- What is required to encourage these links to be exploited?

Information for the above points needs to be captured in the discussion to report back to plenary sessions

Balancing timeframe

	Response time (lead time)	Duration	**GIVAR flexibility analysis**
Regulation	~ 1 minute	10 minutes	15 min
Load following	~10 to 30 minute	1 hr	1 hours
Scheduling	~ 1 day	6 hrs – **36 hrs**	6 hours 36 hours

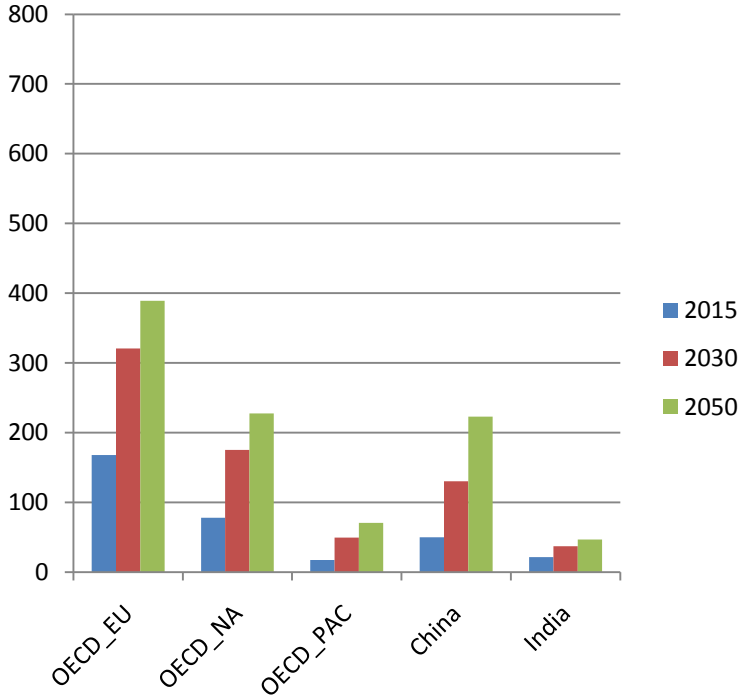
All balancing/ancillary service markets are different, but approach is reasonable for modeling and discussion purposes.

Flexibility requirements

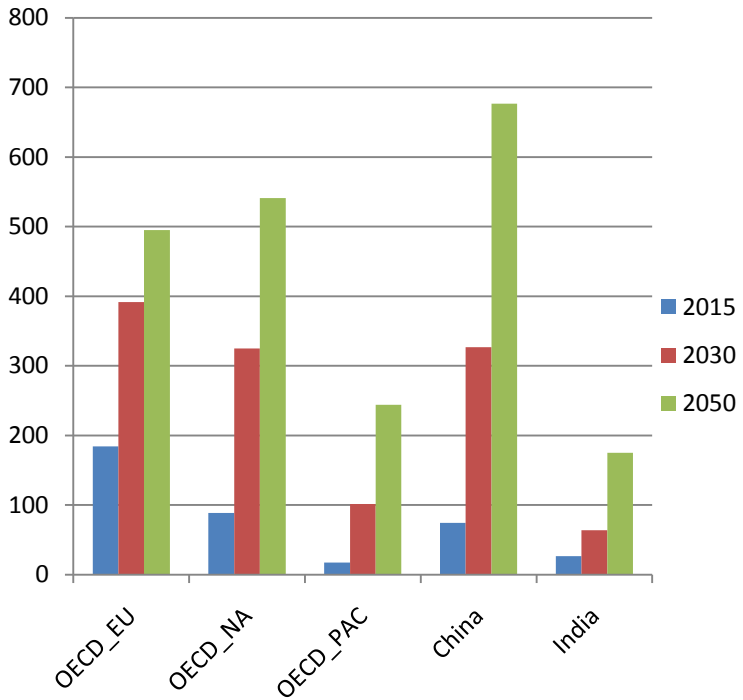
[% of installed capacity]	15 min	1hr	6 hrs	36 hrs
British	3.2	10.0	46.0	85.0
Iberian	3.5	13.0	51.0	70.0
Mexico	3.4	11.0	49.0	85.0
Nordic	3.4	11.0	49.0	85.0
Denmark	6.5	23.0	75.0	90.0
Japan	2.8	8.9	40.0	85.0
US WEST (2017)	2.6	9.4	38.0	80.0
Canada (NBSO area)	3.3	11.0	48.0	90.0
Average	3.2	10.6	45.9	82.9
Average_OECD_EU	4.2	14.3	55.3	82.5
Average_OECD_NA	3.1	10.5	45.0	85.0

*** Source: "Harnessing variable renewables", IEA, 2011**

VarRE Capacity (ETP 2010) [GW]



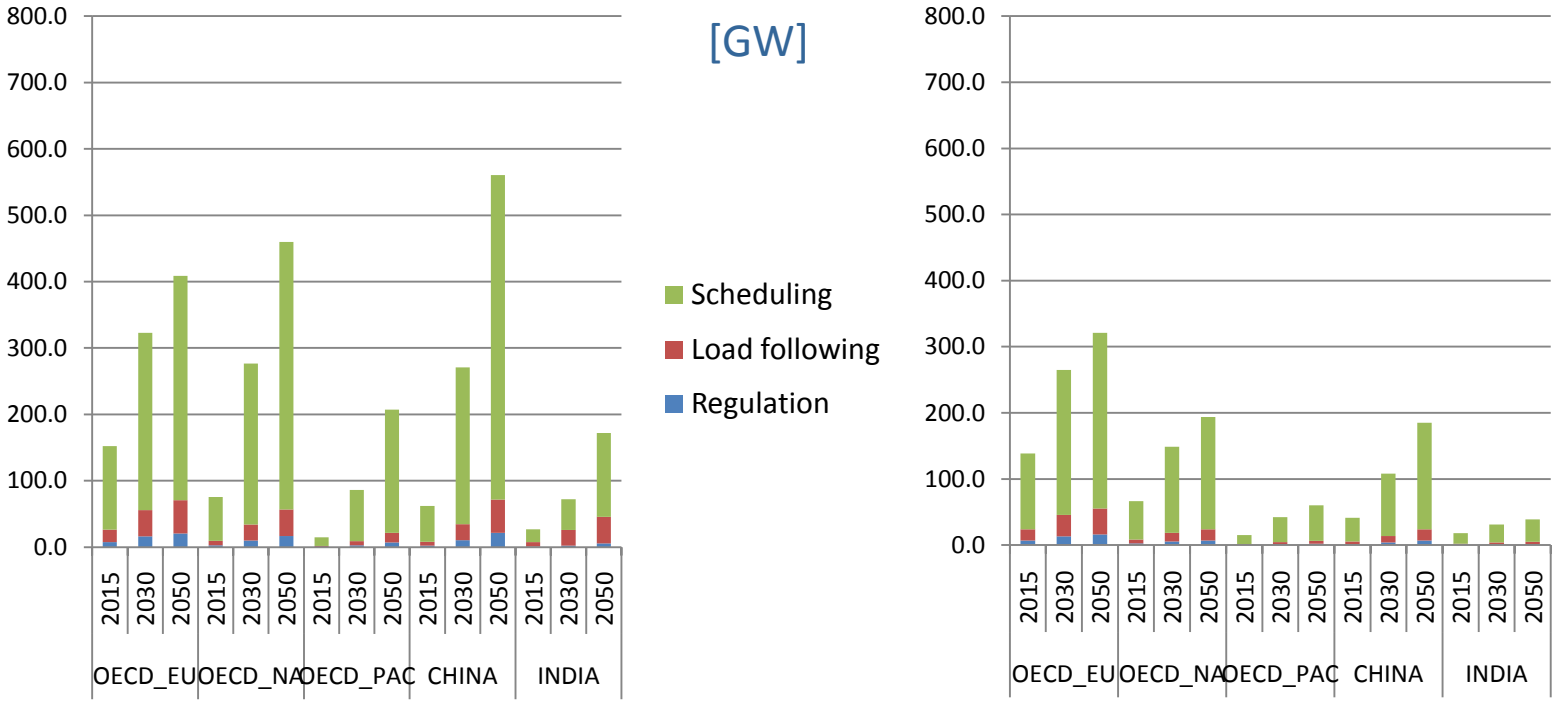
Baseline



Bluemap

Blue map will have higher VarRE deployments out to 2050

Balancing Requirements



Bluemap

Baseline

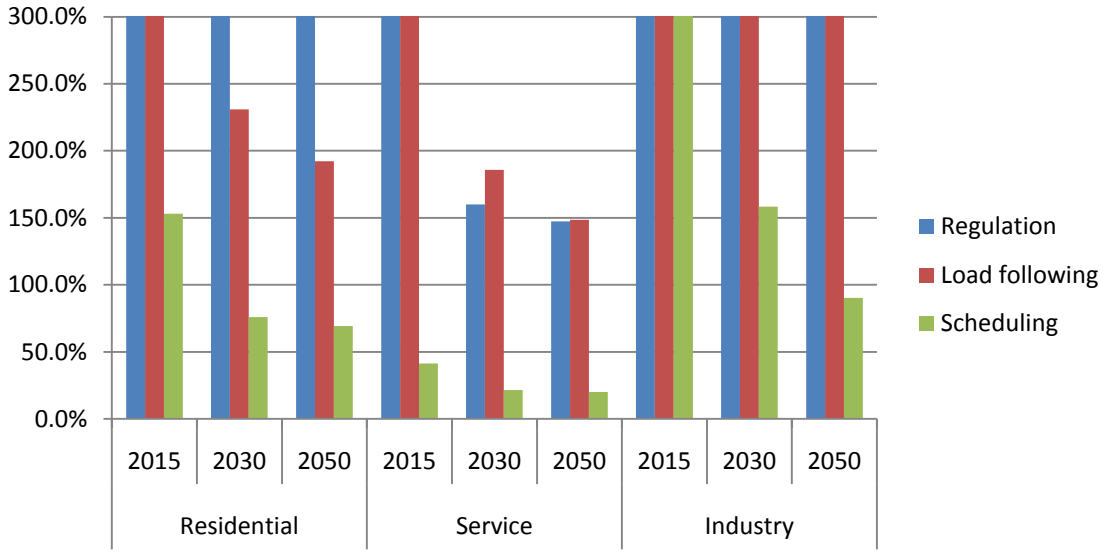
Blue map will have higher Flexibility needs out to 2050

Technology Considerations

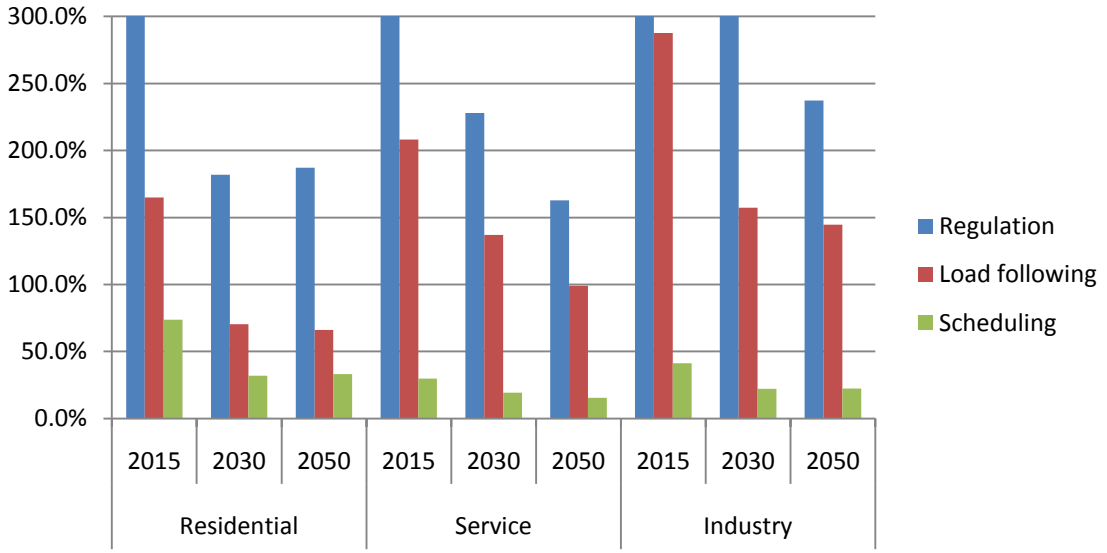
- Roles in providing flexibility
- Maturity (how mature is this technology in providing flexible resources? When will it be available?)
- Time frames (regulation, load following, scheduling)
- Risk factors in choosing this technology for flexibility resources and key considerations
- Environment
- Barriers
- Game changers (what are the potential game changers that could shift things to or from this technology)
- Opportunities for Synergies

Sectoral DR Potential for OECD_EU

Baseline



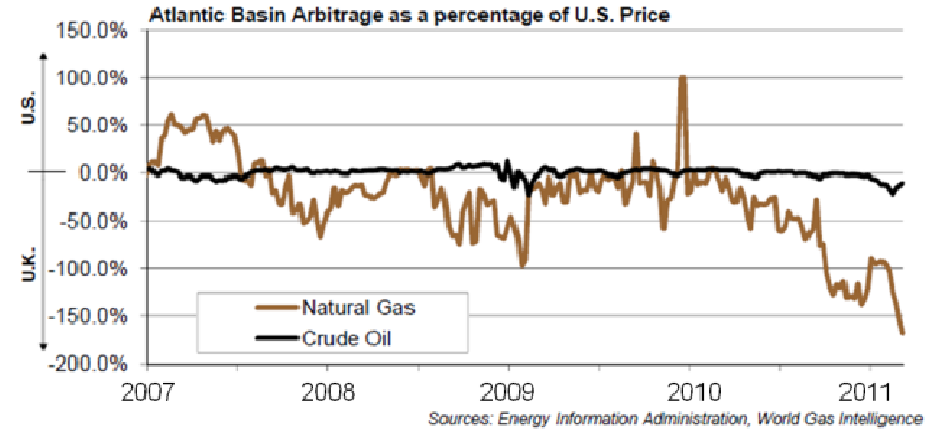
Bluemap

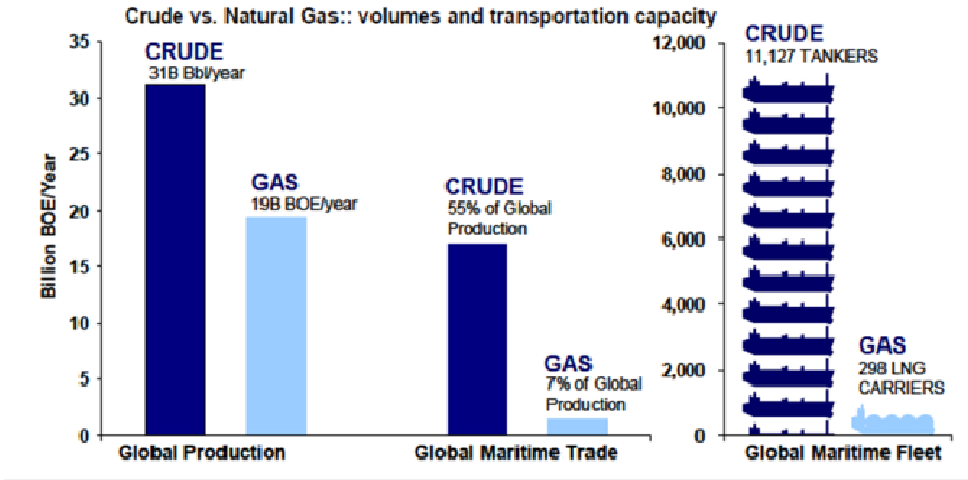


Where is the electricity ship?

Natural Gas is a unique domestic commodity

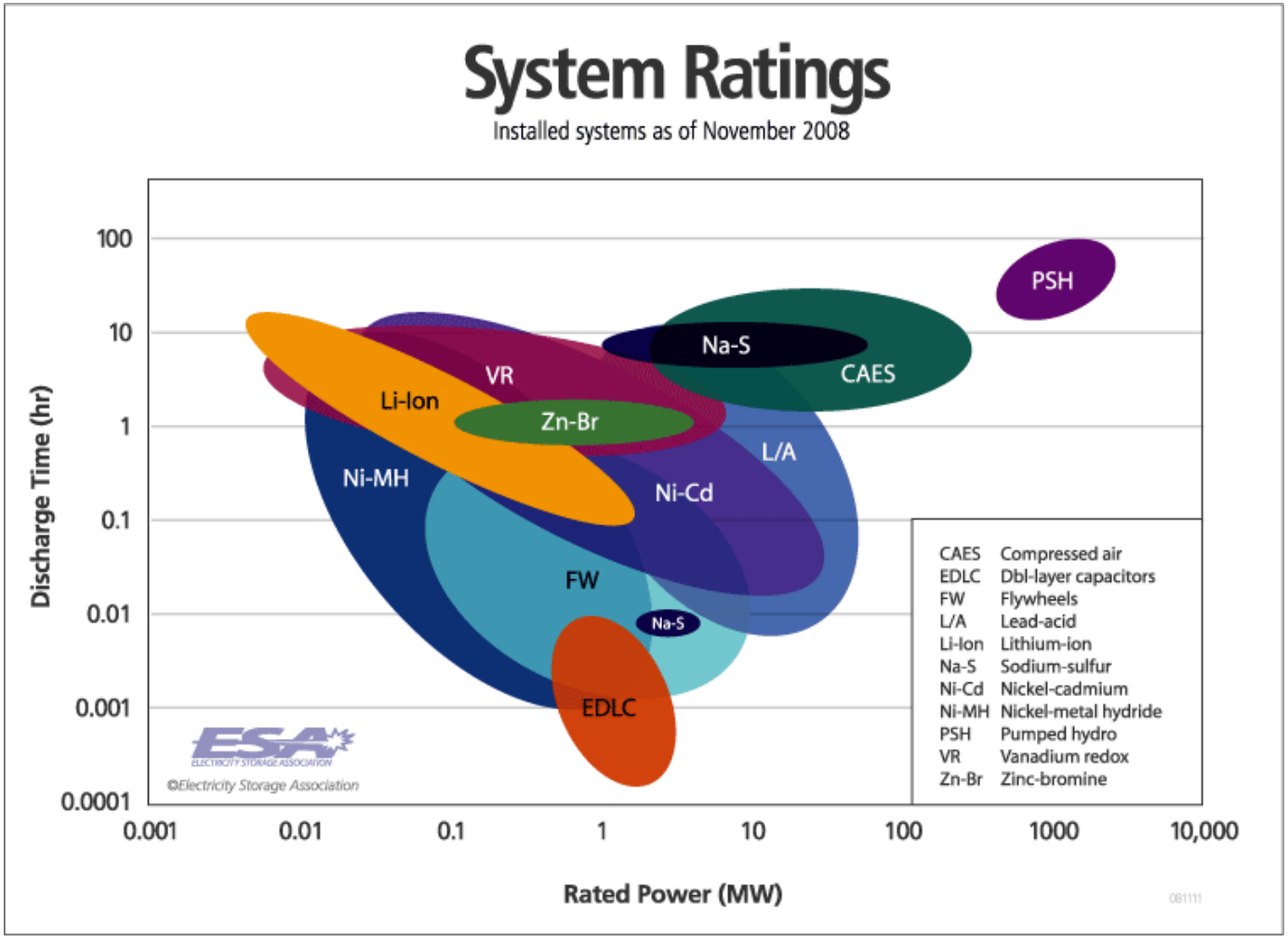
Oil and Natural Gas





Source: presentation by Christopher Smith at 30th USAEE/IAEE Conference, October 2011

Storage – the ultimate game changer?



What's missing?

System approaches

- Combined approaches will be needed – DR + GAS, DR+ Storage + Interconnection. Single solutions are not adequate in the near term? – comments?
- Does the time frame approach provide clarity needed to develop the less mature technologies?
- What scale of "need and resource" assessment is required? Is scenario modeling useful?
- Can we say that fossil generation and existing large scale storage are the only reliable "scheduling" resources?

- We need flexibility now – but we do not have all the technologies (storage, DR)
- Are peakers transitional technology – if yes, how can this be managed?
- Will regulated rates to existing fossil based electricity generation need to change in order to remain in service and ensure resource availability? Long term, or as a reserve as new technologies are tried and tested?

- Are links to heat and hydrogen realistic? What don't we know?

Generation

- **Roles in providing flexibility:**
  - Upward and downward production of electricity.
- **Maturity (how mature is this technology in providing flexible resources? When will it be available?):**
  - Fossil generation (existing and new)
  - Variable renewables
- **Time frames (regulation, load following, scheduling)**
  - What technologies can provide flexibility resources over what time frames?
  - OCGT – all time frames
  - Nuclear – scheduling?
  - Variable renewables – regulation?
- **Risk factors in choosing this technology for flexibility resources and key considerations(consider various generation technologies)**
  - Fuel costs exposure (currently low – will this always be that way), national/regional fuel reserves
  - Operating technology flexibly when not designed for this (both technically and from a market perspective)
  - Long term lock-in may prevent other lower cost technologies and engage customer
  - Other
- **Environment:**
  - Fossil fuel based generation emissions
  - Will CCS be eventually needed for all fossil generation?
  - Reduced VarRE production by ramping down electricity for balancing
- **Barriers:**
  - Existing generation (i.e.: financial stability of existing operation, technical..)
  - New generation (
- **Game changers (what are the potential game changers that could shift things to or from this technology):**
  - Impact on capacity factor of existing generation from other flexibility resource deployment (DR, Interconnection and Storage)
  - Shale gas? Other new fossil fuel availability
  - BANANA, NIMBY?

Interconnection

- **Roles in providing flexibility:**
  - Connects flexibility resource to need, is not a flexible resource in itself.
- **Maturity (how mature is this technology in providing flexible resources? When will it be available?):**
  - Technology is well understood
  - Is there new technology that could change things? DC lines?
- **Time frames (regulation, load following, scheduling)**
  - Dependent on adjacent regions' flexibility resources and coincident of needs(i.e. opposite correlation due to time zones, weather, social)
  - Equally important will be the extent to which the needs of interconnected areas coincide; connected areas will have need of flexibility at different times
- **Risk factors in choosing this technology for flexibility resources and key considerations**
  - BANANA, NIMBY
  - Change in adjoining market structure
  - Change in need for flexible resources in adjoining regions affecting business case for new build and amount of available resource for recipient
  - Size of resource/ near term and long term availability
- **Environment:**
  - Little direct impact
- **Barriers:**
  - Limits - Interconnection allows the shared use of flexible resources to manage variability among adjacent, connected power areas.
  - The impact of DC lines
  - Markets
- **Game changers (what are the potential game changers that could shift things to or from this technology):**
  - Impact on capacity factor from other flexibility resources (DR, Generation and Storage)
- **Opportunities for Synergies:**
  - Supergrid?
  - Connection of varRE in remote locations and then interconnect
  - Can leverage trade of electricty

DR

- Roles in providing flexibility:
  - Increase or decrease in load (peak demand DR only decreases load)
- Maturity (how mature is this technology in providing flexible resources? When will it be available?):
  - Consider residential, service sector, industrial
  - Can existing peak demand programs be leveraged?
- Time frames (regulation, load following, scheduling)
  - See Data
  - Should one sector have more emphasis than others
  - Size of resource
- Risk factors in choosing this technology for flexibility resources and key considerations
  - Can the resource be depended upon?
  - Consumer acceptance (especially at the residential level)
  - Costs – especially communication costs at the residentila levelIncreased cost over conventional infrastrucure (smart meter cost more than electromechanial)
- Environment:
  - Any???
- Barriers:
  - Consumer acceptance
  - Market structures (New entrants needed (aggregators and technology providers – telecom, IT)
- Game changers (what are the potential game changers that could shift things to or from this technology):
  - Huge data hack/ system failure/ loss of data
  - Change in consumer acceptance (positive or negative)
  - Reduction in costs
- Opportunities for Synergies:
  - Supergrid? Need to leverage other neeeds/opportunities for communitaction infructure
- Discussion?
  - Huge resource that is currently being under utilised
  - Has there been too much emphasis on the residential customer and the smart meter
  - Residential versus ICI? Over emphasis on residential?

Storage

- Roles in providing flexibility:
  - Acting as a load and production source as needed
- Maturity (how mature is this technology in providing flexible resources? When will it be available?):
  - Consider mechanical, thermal and electro chemical technologies, hydrogen
  - Technical and cost levels for maturity.
- Time frames (regulation, load following, scheduling)
  - See previous slide
- Risk factors in choosing this technology for flexibility resources and key considerations
  - Is it a simple technology risk?
  - What about small scale storage?
- Environment:
  - Any???
  - Technology specific, (CAES, reservoir hydro?)
- Barriers:
  - Cost, Cost, Cost?
- Game changers (what are the potential game changers that could shift things to or from this technology):
  - Huge breakthrough in cost/size/reliability?
  - Reduction in VarRE deployment?
- Opportunities for Synergies:
  - Key discussion hear around heat/electricity/hydrogen interfaces
- Discussion?
  - Will electricity ever be shipped?