NARUC

Winter Committee Meetings

Committee On Energy Resources & the Environment

Distribution System Evolution
Planning, Platforms & Operations

Paul De Martini

February 16, 2016

Caltech
Resnick Institute

This presentation draws from *"Distribution Systems in a High Distributed Energy Resources Future"*, Report No. 2 in Lawrence Berkeley National Lab's Future Electric Utility Regulation (FEUR) series.

This report was supported by DOE's Office of Electricity Delivery and Energy Reliability - National Electricity Delivery Division. More information and reports in the FEUR series can be found at: FEUR.lbl.gov

Objectives & Attributes for Distribution

Clarity of purpose in relation to modernization and DER integration is essential

Reliability	Safety	Cyber-physical Security	Affordability	Environment	Finance-ability	Flexibility
Impact Resistance	Public Safety	Threat Detection & Mitigation	System Performance	GHG Reduction	Utility Credit Rating	Accommodate Tech Innovation
Minimal Recovery	Workforce Safety	Access Control & Data Protection	OpEx Management	Criteria Pollutants	DER Asset Finance	Accommodate New Busn Models
Operational Risk Management	Fail Safe Modes	Physical Security	Asset Optimization	Nexus w/Gas, Water & Transp.	Venture Capital Funding	Open & Interoperable

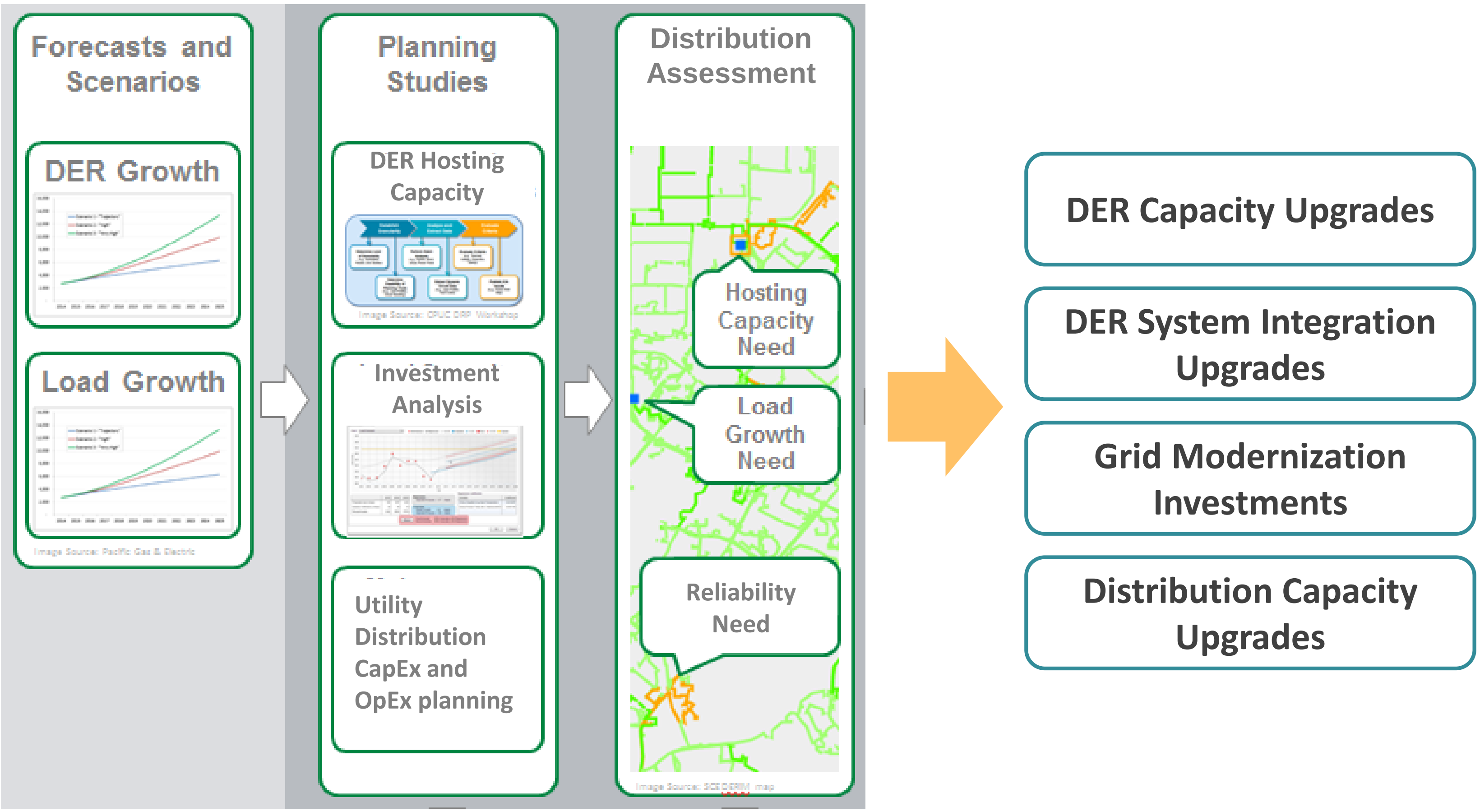
- Clear policy objectives on elements such as above (**examples in blue)** are needed to align system planning and operational decisions as well as DER development
- From these objectives a related set of attributes (**examples in green**) for the system can be clearly defined with specific outcomes in terms of metrics
- This allows development of flexible architectures and functional designs to evolve a distribution system over a logical sequence aligned with timing of customer needs/uses and net system value.

Stage 1 & 2 Transition Functions

Distribution Functions	Stage 1	Stage 2	Stage 3
1. Planning			
A. Scenario based, probabilistic distribution engineering analysis	✓	✓	✓
B. DER Interconnection studies with new criteria	✓	✓	✓
C. DER Hosting capacity analysis	✓	✓	✓
D. DER Locational value analysis		✓	✓
E. Integrated T&D planning		✓	✓
2. Operations			
A. Design-build and ownership of distribution grid	✓	✓	✓
B. Switching, outage restoration & distribution maintenance	✓	✓	✓
C. Physical coordination of DER schedules		✓	✓
D. Coordination with ISO at T-D interface		✓	✓

Distribution Planning

Initial focus on assessing distribution system's capability to support customer adoption of DER and related changes in net load shapes and dynamics

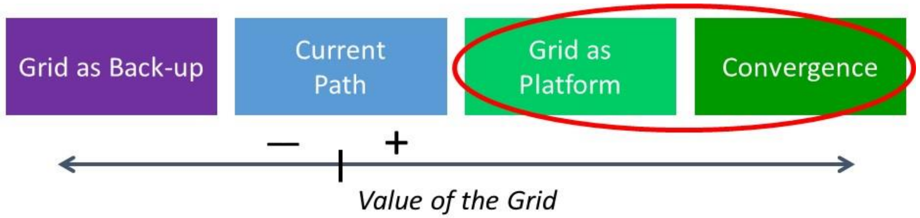


Graphic adapted from SolarCity

Distribution Grid as a Platform

Modernization investments lay foundation for future

Potential for grid to evolve into a platform is dependent on near-term investments that create immediate benefits irrespective of the pace of DER adoption



Current Path

- Aging infrastructure replacement and reliability improvements are increasing DER hosting capacity
  - Replacing 4kv with 12/21kV
  - Standardizing on fewer, but slightly larger, equipment/wire sizes
  - Replacing electromechanical protection with digital devices

Grid modernization

- No regrets investments lay foundation for future and provide immediate benefits
  - Advanced distribution management systems
  - Distribution sensing, visualization and analytics
  - Field switch/device automation
  - Higher bandwidth/lower latency operational communications networks

Graphic source: More Than Smart

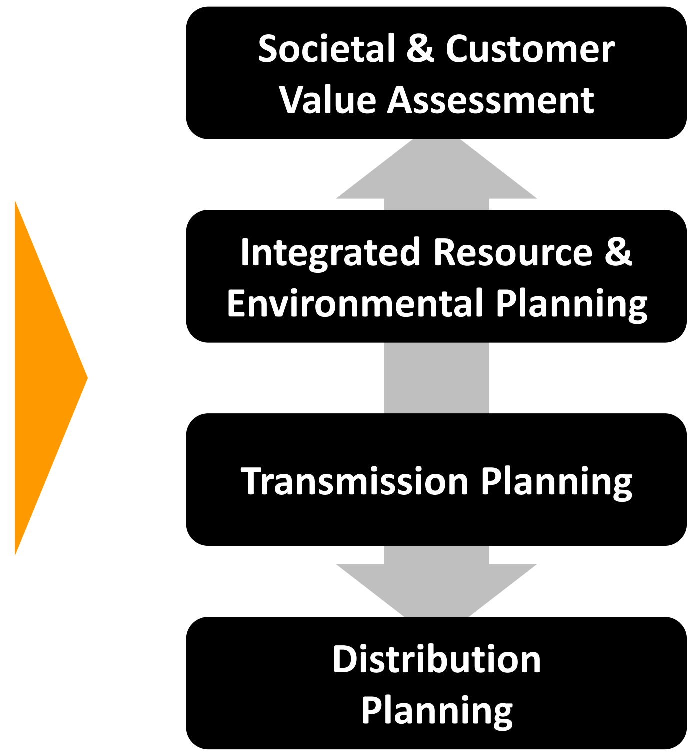
Locational Net Value of DER

Requires alignment of several planning processes in & outside utility

Many of the benefits do not flow through a utility cost structure and rate cases

	Value Component
Wholesale	Bulk Power System Benefits
	System Energy Price
	Wholesale Energy
	Resource Adequacy
	Flexible Capacity
	Wholesale Ancillary Services
	RPS Generation & Interconnection Costs
	Transmission Capacity
	Transmission Congestion + Losses
	Wholesale Market Charges
Distribution	Subtransmission, Substation & Feeder Capacity
	Distribution Losses
	Distribution Power Quality + Reactive Power
	Distribution Reliability + Resiliency
	Distribution Safety
Customer & Societal	Customer Choice
	Emissions (CO_2, Criteria Pollutants & Health Impacts)
	Energy Security
	Water & Land Use
	Economic Impact

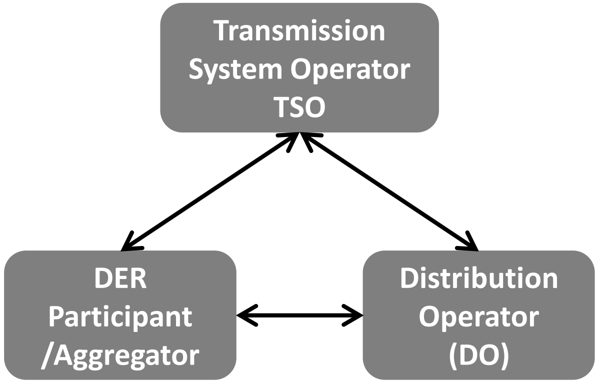
Table source: More Than Smart



Initial T-D Operational Coordination

For areas with DER participating in wholesale markets

- **Growth of DER creates operational challenges at the transmission-distribution interface**
  - Transmission system operator (TSO) "sees" DER as if they're located at the T-D substation => TSO has no visibility of impact of its DER dispatches on the distribution system
  - Utility distribution operator (DO) must manage the system with numerous diverse DER, some acting autonomously, some responding to TSO dispatches, some able to provide DO services
- **Requires physical coordination of the grid through schedule and operational coordination between TSO and DO with DER participant/aggregator**
  - 3-way communication between TSO, DO & DER
  - Real-time visibility of DER on distribution grid
  - Physical schedules and dispatch coordination
  - Operating procedures to manage TSO dispatches of multiple DER/Aggregators in the same local distribution area
  - Coordination of multi-use DER services to support distribution system



Source: More Than Smart

Caltech
Resnick Institute

http://resnick.caltech.edu

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Growth of Distributed Resources and Evolution of the Distribution System

Lorenzo Kristov, Ph.D.
Principal, Market & Infrastructure Policy

NARUC 2016 Winter Meetings
February 16, 2016

Ideas in this presentation are offered for discussion purposes only, and do not reflect the views or policies of the California ISO.

Distributed energy resources will and should become a major element of the "grid of the future."

- Distributed Energy Resources (DER) are proliferating and will affect nearly all aspects of the electric system
  - "DER" = all energy resources connected at distribution level, on customer side or utility side of the customer meter
  - Plus communications & control systems to combine or aggregate DER and optimize their use
- DER growth is driven by bottom up demand & adoption
  - Customers want flexibility, control, ability to participate in wholesale market, resilience to disturbances
  - Local jurisdictions pursue synergies among municipal services, enact climate action plans, extend access to renewable energy
  - Powerful new technologies make it all feasible & economic
- Rates of DER growth are different in different states, but all states will be affected within the next decade
  - Better to plan proactively to maximize customer benefits

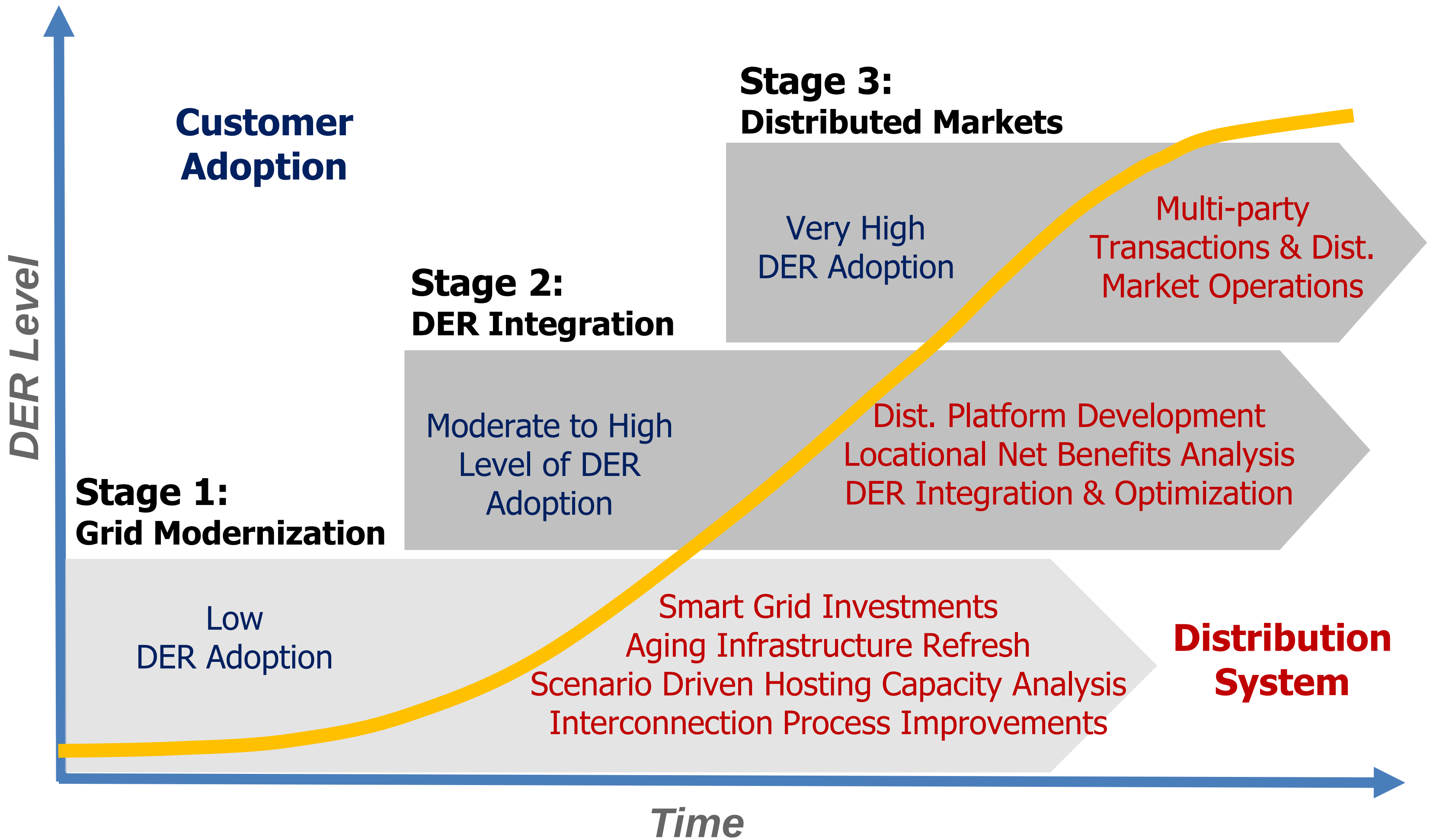
DER growth is shaping an “unstructured” path of evolution for the electric industry.

- Structured => incremental changes to business as usual
- Unstructured => major paradigm shift or discontinuity
  - Existing paradigm = dominance of central power generation & one-way distribution system energy flows
  - New paradigm features
    - Substantial local supply to meet local demand
    - Multi-directional, reversible flows on distribution system
    - New challenges for distribution operations & planning
    - DER can provide services to D and T grid operators
    - Potential for low-cost, reliable islanding & “grid defection”
  - Unstructured evolution requires a whole-system approach
    - Consider interactions & impacts at all levels from regional interconnection down to end-use customer
    - Design T & D systems to operate reliably while accommodating diverse resource mixes in local areas

Role of local jurisdictions is largely unrecognized in industry planning for the "grid of the future."

- Policy makers, regulators, utilities, DER developers & advocates tend to think entirely in terms of individual decisions & behaviors of individual customers (old paradigm)
- Cities, counties, local government agencies (e.g., water, waste) are becoming highly motivated, capable innovators
    - Climate action plans, clean energy goals, local economic development
    - Tailor local energy programs to fit local customer mix, climate zone, geography/topology, economic opportunities & needs
    - "Convergences" between electricity network and other municipal services – water supply, wastewater treatment, waste management, local transport, high-speed internet
    - Partnerships between cities/counties and distribution utilities
- Bottom-up adoption means regulators become facilitators, to enable customers to meet their needs, rather than driving system change through top-down policy

Evolution can be manageably addressed in stages.



Suggestions for regulators and policy makers in the early stage of DER growth

- Consider the current stage of DER growth in your jurisdiction, how DER growth could support other policy objectives, and what DER stage you want to move toward
- Assess how current regulations inhibit or promote DER growth
  - Interconnection rules, procedures and costs
  - Available information about the distribution system (where to locate)
  - Integrate regulatory siloes
- Establish new distribution system planning studies
  - Estimate DER “hosting” or “integration” capacity
  - Identify where DER could substitute for infrastructure investment
  - Evaluate benefits of flattening local load profiles
- Identify & initiate “no regrets” investments
  - Situational awareness; T-D interface coordination
- Engage local governments to be full participants in developing policies, regulations & forecasts for the future electric system

Thank you.

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ELECTRIC POWER RESEARCH INSTITUTE

An Integrated Approach to Distribution Planning

Maximizing the Benefits and Minimizing the Impacts of DERs in an Integrated Grid

Committee on Committee on Energy Resources and Environment:

NARUC Winter Committee Meeting

Washington D.C.
February 16, 2016

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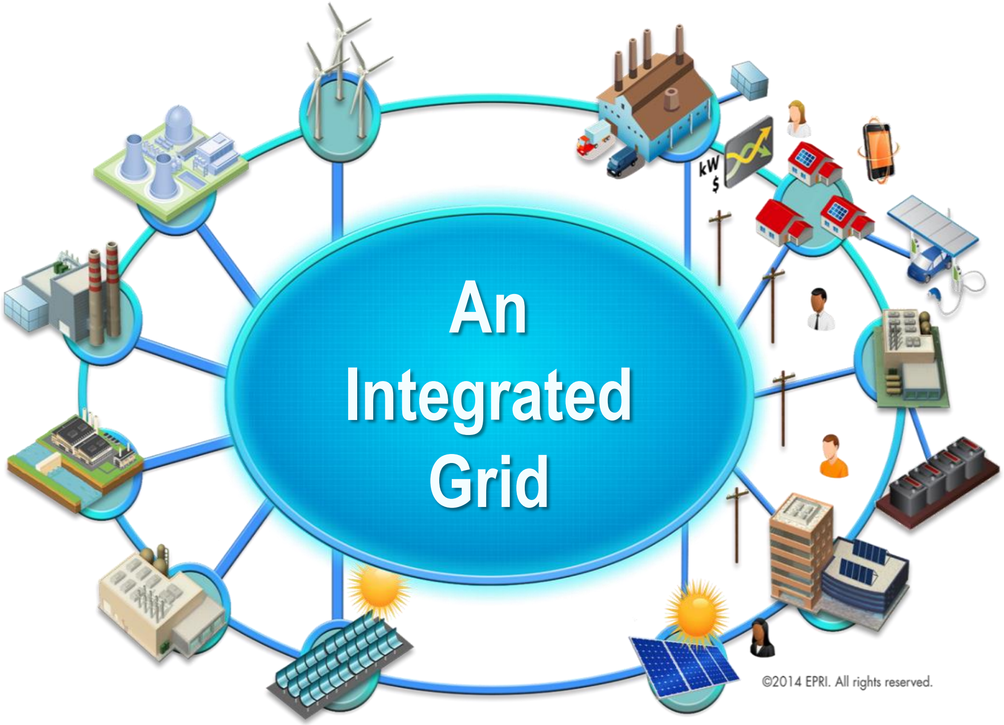
An Integrated Grid Framework

- The electric power system is changing with the rise of distributed energy resources (DER).
- To fully realize the value of these distributed resources, and to provide power quality and reliability, a deliberate and beneficial integration is needed.
- Widespread deployment of DER needs to be incorporated into both grid planning and operational processes.
- This in mind, EPRI has developed a comprehensive benefit-cost framework aimed at better informing strategic decision-making by all power system stakeholders.



The Integrated Grid: A Benefit-Cost Framework, EPRI, Palo Alto, CA. 3002004878, 2015.

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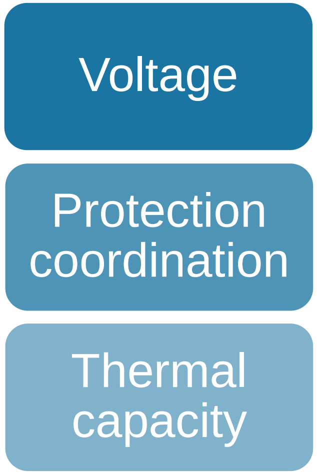
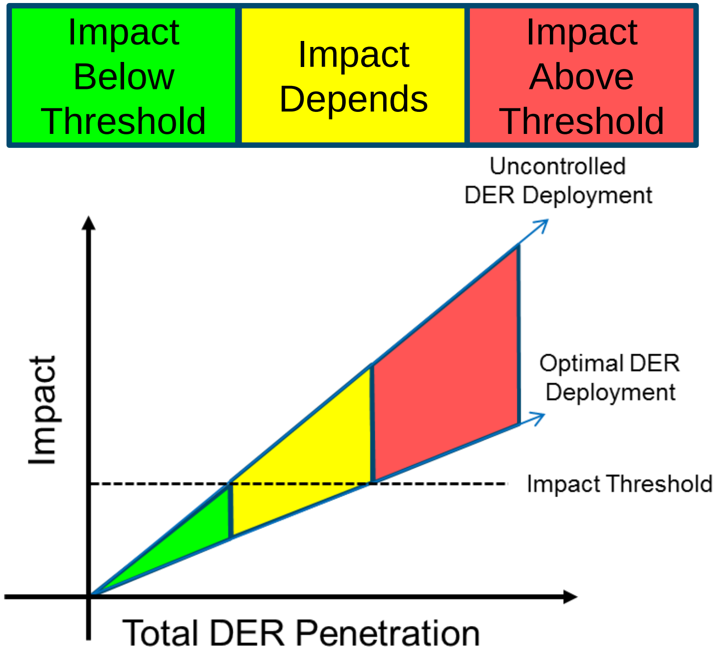
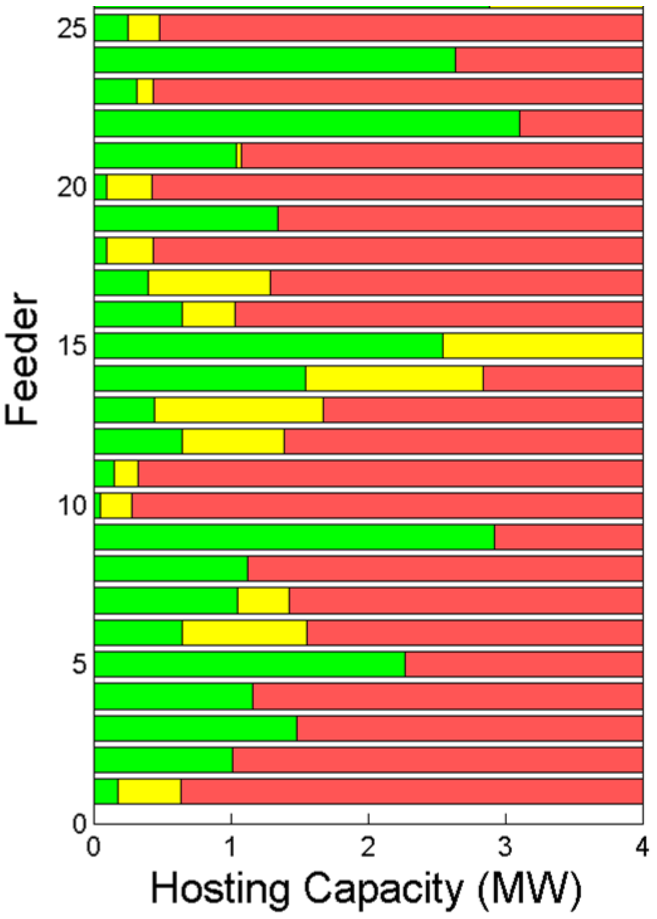
Distribution System has Unique Response to DER

What matters most?

- DER technology and impacts
- DER size and location
- Feeder construction and operation







DER Technology and Impacts

DER Size and Location

Feeder Construction and Operation

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Most Change is Occurring at the "Edge" of the Grid

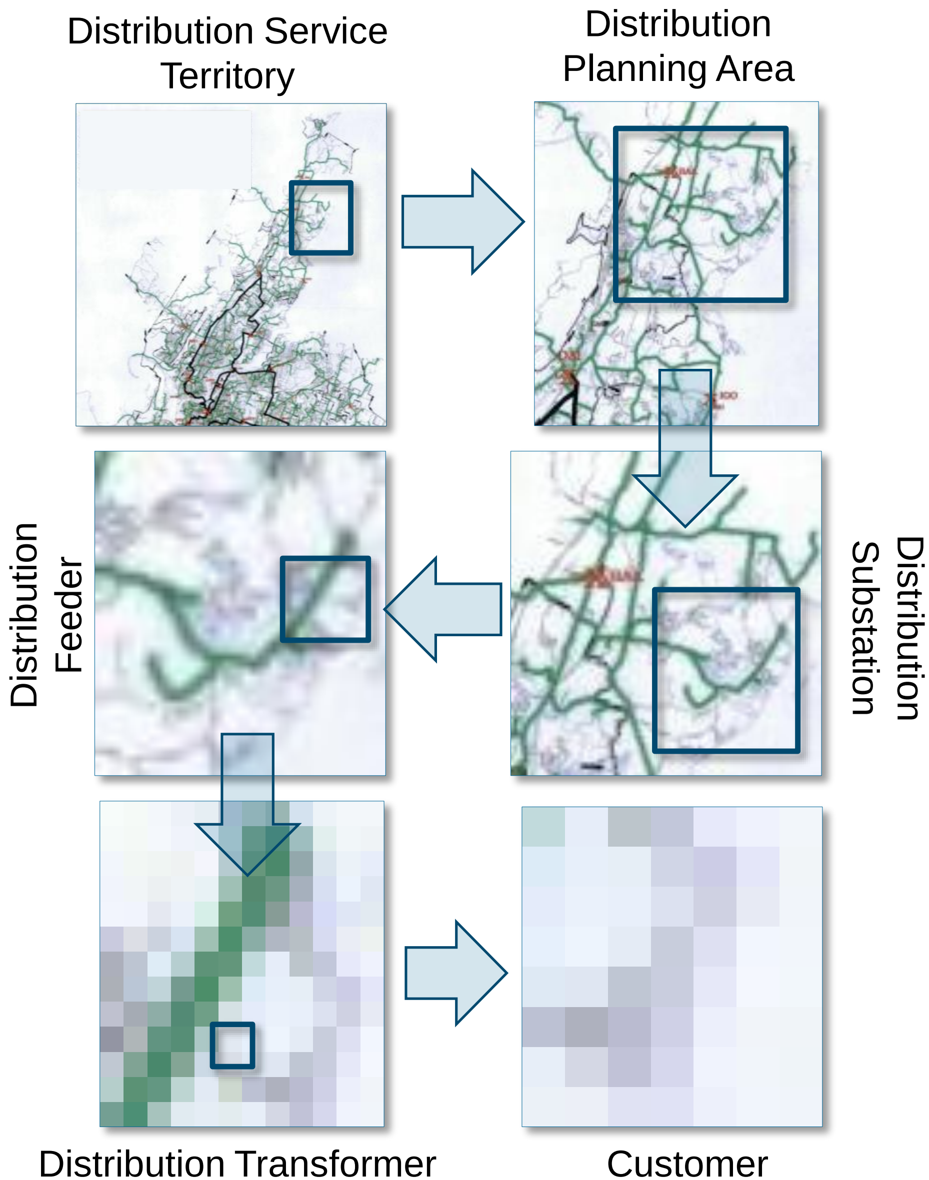
Issue

- Large "scale" of distribution service area
  - 100's to 1000's of feeders
- DER connecting at edge of grid
  - Utility has least amount of visibility/control @ "edge"

Solution

- Improved modeling and analysis methods that capture "breadth" and "depth" of distribution impacts

…**embrace** and **plan** accordingly



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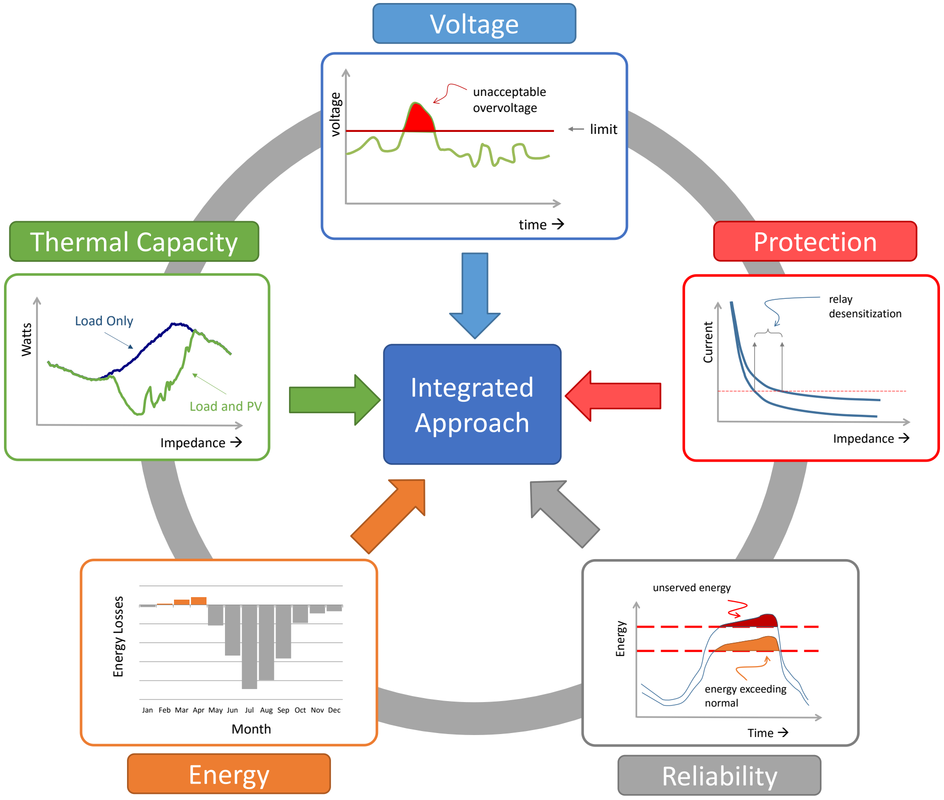
EPRI's Integrated Approach for Distribution Planning with DER

- **Step 1: Minimize Cost of DER**
  - Identify feeder hosting capacity
  - Avoid driving new capital upgrades with DER
  - Maintain voltage, protection, thermal capacity,and reliability standards
- **Step 2: Maximize Benefit of DER**
  - Identify locational value of DER
  - Defer or avoid planned capital upgrades
  - Improve system efficiency
  - Enhanced power quality, reliability, and resiliency



Components for determining optimal type and location of DER

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Minimizing Impact: Hosting Capacity

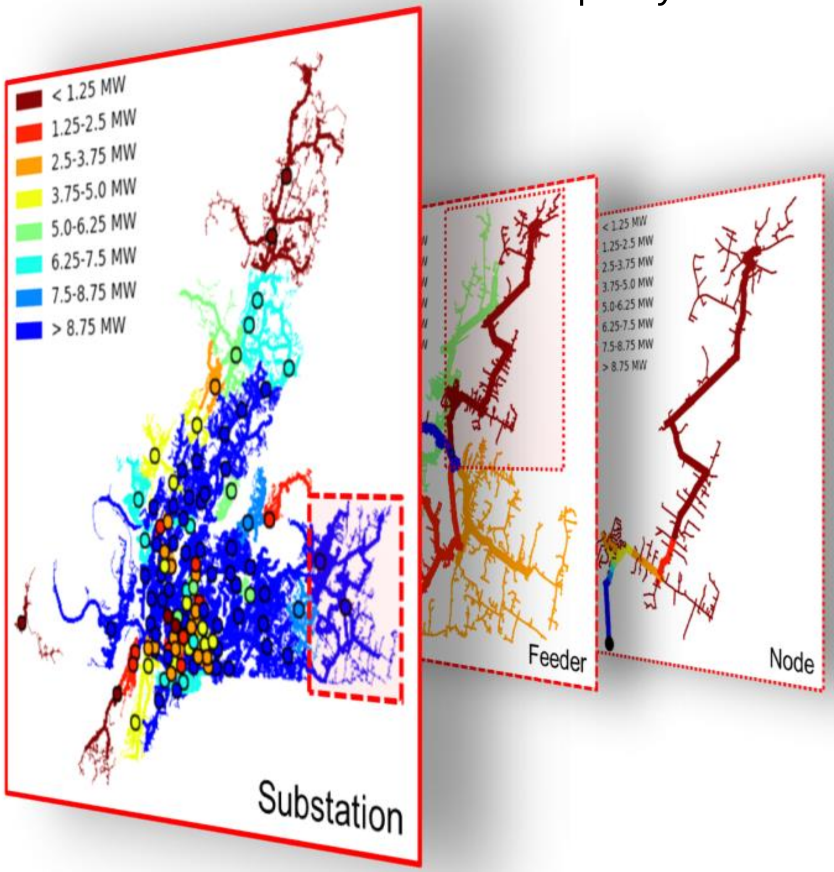
What Does Hosting Capacity Tell Us?

- Where DER can be accommodated without requiring upgrades
- Mitigations needed to accommodate higher penetrations
- Mapping of DER impacts across system

What is Needed?

- Effective distribution models of service area
- Integration of hosting capacity methods into existing planning tools

Sample Distribution-Wide Hosting Capacity Results



[EPRI White Paper: Integration of Hosting Capacity Analysis into Distribution Planning Tools. 3002005793]

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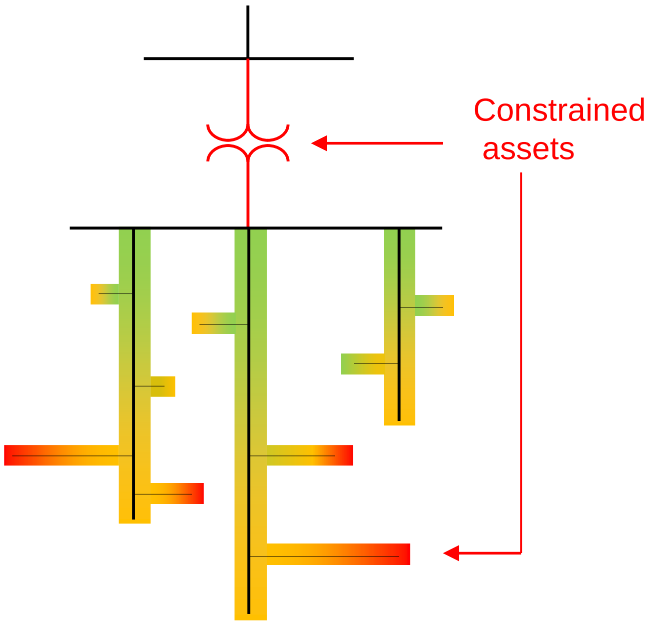
Maximizing Benefit: Locational Value of DER

What Does Locational Value Tell Us?

- Where and when grid services are needed
- What services DER can provide
- Informs strategic planning (new infrastructure investment or asset upgrade deferral)

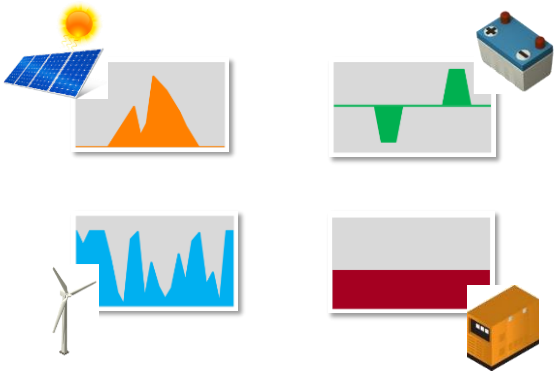
Where…



What Is Needed?

- Improved modeling of existing distribution assets
- Improved modeling and characterization of DER limitations/capabilities

What…



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Summary

- Hosting capacity and locational value are key components to effective and robust DER planning approach
- Improved distribution modeling is a key component
- Not all distribution areas are modeled at present

- EPRI's Industry Involvement
  - Working with utilities and vendors to implementing new methods within existing planning tools
  - Enabling distribution planners to perform distribution system-wide assessments without sacrificing necessary details

[EPRI Paper: It's All in the Plans: Maximizing the Benefits and Minimizing the Impacts of DERs in an Integrated Grid", Power and Energy Magazine, March/April 2015]

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References

- *The Integrated Grid: A Benefit-Cost Framework*, EPRI, Palo Alto, CA. 3002004878, 2015.
- Smith, J., Rylander, M., Rogers, L., Dugan, R., “It’s All in the Plans: Maximizing the Benefits and Minimizing the Impacts of DERs in an Integrated Grid”, Power and Energy Magazine, March/April 2015.
- Distribution Feeder Hosting Capacity: What Matters When Planning for DER?. EPRI, Palo Alto, CA: 2015. 3002004777
- Integration of Hosting Capacity Analysis into Distribution Planning Tools. EPRI, Palo Alto, CA: 2016. 3002005793

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Shared Renewables and Community Solar

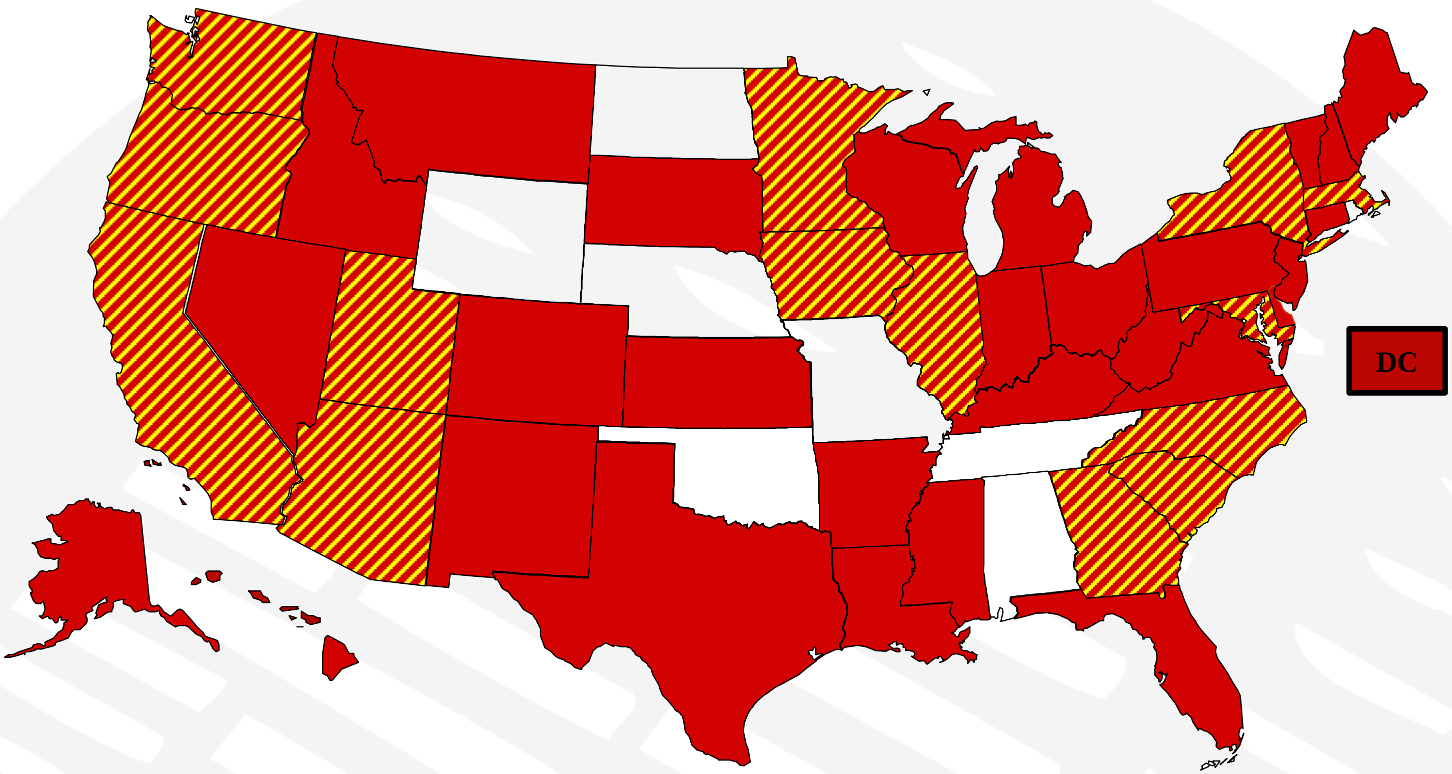
Sara Baldwin Auck
Director, Regulatory Program

February 16, 2016
NARUC Winter Committee Meeting

Interstate Renewable Energy Council

- Independent, non-partisan, national non-profit organization founded in 1982
  - Non-industry voice and non-lobbying
- Our focus: Expand access to reliable, affordable clean energy *for all consumers*
- **Workforce Program:** Ensure a qualified, job-ready clean energy workforce
  - Solar Career Map
  - National Coordinator, Grid Engineering for Accelerated Renewable Energy Deployment (w/ EPRI, SEPA, US DOE)
- **Credentialing Program:** Develop national education/training standards, best practices, and credentials
  - National Administrator, Solar Instructor Training Network (US DOE)
  - ANSI-Accredited National Standards Developer
- **Regulatory Program:** State regulatory engagement on distributed energy resource policies
  - Model rules, national best practices, policy innovations

IREC's National Regulatory Engagement



IREC Regulatory Activity 2007-2015

IREC Current Regulatory Engagement

IREC is represented by the lawfirm Shute, Mihaly & Weinberger, LLP

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Shared Renewable Energy
(a.k.a. community solar)

- IREC Model Rules for *Shared Renewable Energy Programs*
- Shared renewable energy programs enable multiple customers to share the benefits from one renewable energy system via their individual utility bills.
- Separate policy from Virtual Net Metering

Other Models – Not Shared Renewables

•Investment-based models (cash return)

•Green Tariff – REC/premium pricing programs

•Community bulk-purchase

•Crowd-funded projects

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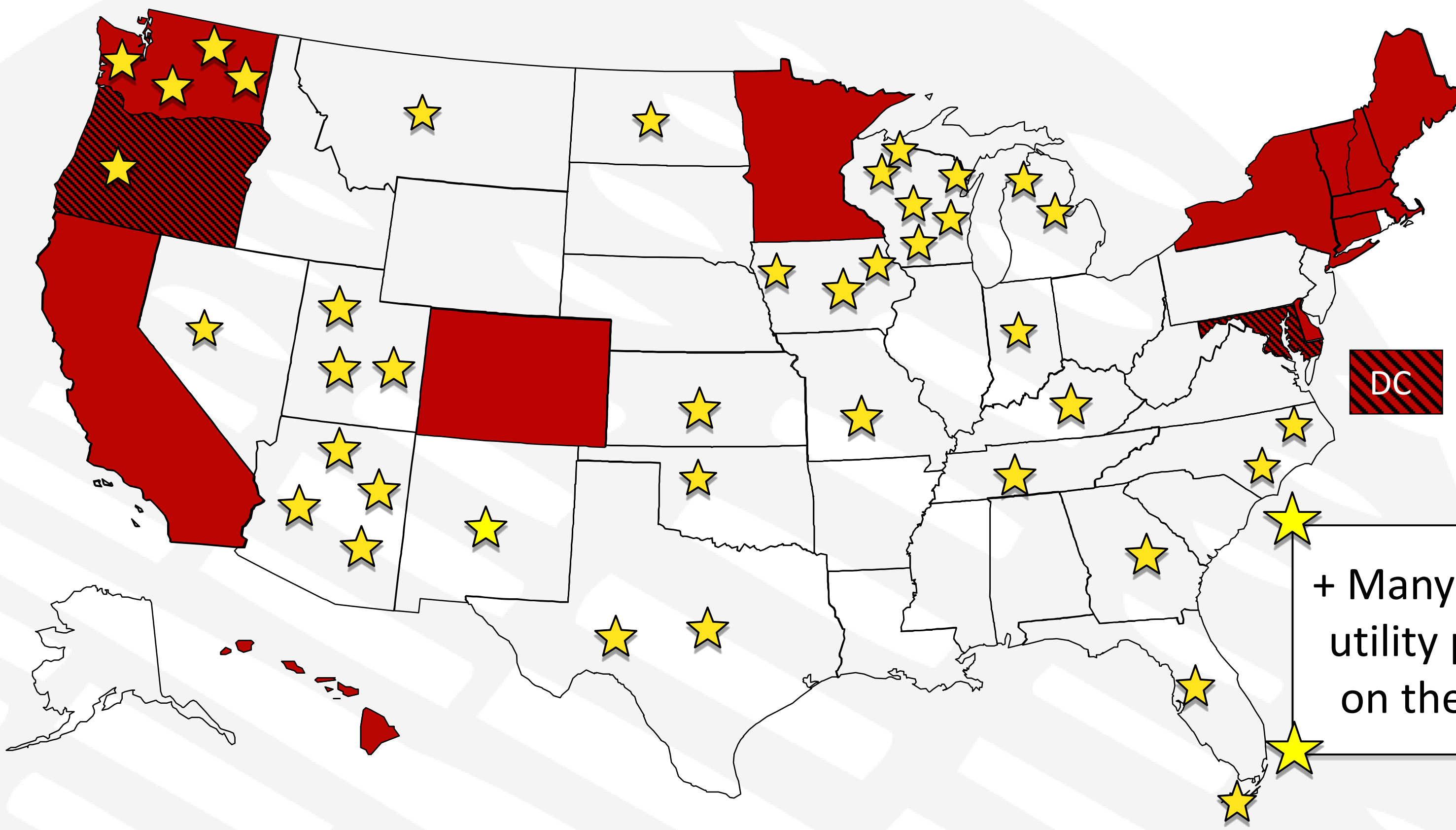
National Shared Renewables Landscape



+ Many voluntary utility programs on the horizon

- Statewide Enabling Policies or Programs
- Proposed policy/program
- Voluntary bill-credit Programs

Based on IREC research as of September 2015, www.irecusa.org

IREC Interstate Renewable Energy Council

Statewide Shared Renewable Programs

- California Green Tariff Shared Renewables (GTSR) and Enhanced Community Renewables (ECR)
- California Virtual Net Metering (VNM)
- Delaware Community Solar (CS)
- Colorado Community Solar Gardens (CSG)
- Massachusetts Virtual Net Metering (VNM) and Community Solar
- Minnesota Community Solar Gardens (CSG)
- New York Community Distributed Generation (CDG)

Others:

- Connecticut Virtual Net Metering
- Group Net Metering programs: Vermont, New Hampshire

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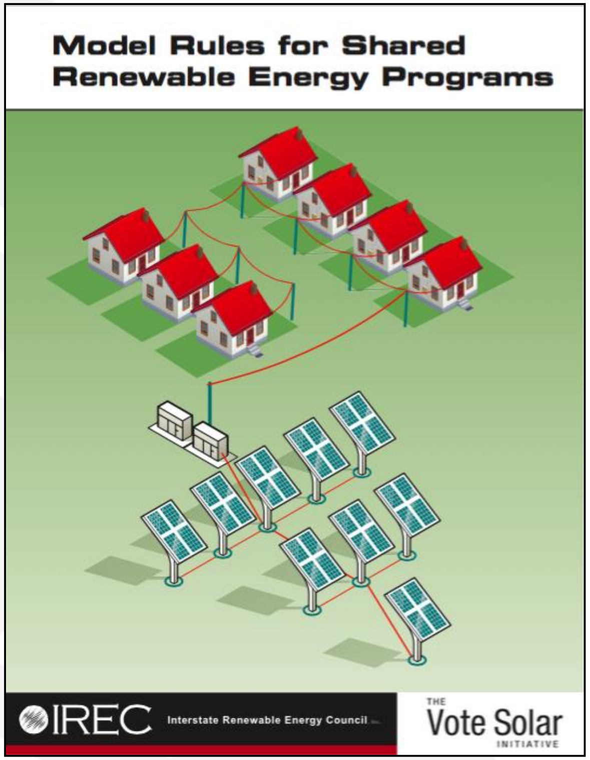
Core Program Design Elements

- ❖ Ownership & Administration
- ❖ Size
  - ✓ Program Cumulative Capacity
  - ✓ System/Facility Size
- ❖ Allocating the benefits of participation
  - Bill Credit
  - REC Ownership
  - Valuation of the energy produced
- ❖ Location
- ✓ Participation
  - ✓ Min. Term length
  - ✓ Number of participants
  - ✓ Eligibility requirements
- ✓ Portability and transferability of subscriptions
- ✓ Unsubscribed energy



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Additional Considerations

- ✓ Simplicity
- ✓ Comprehensibility
- ✓ Consumer protections, disclosures, transparency
- ✓ Low-income customer participation

***New IREC Report Coming Soon** – Shared Renewable Energy for Low-to-Moderate Income Customers: Policy Guidelines and Model Rules*

IREC
Interstate Renewable Energy Council

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State	Program	Year Launched	Installed Capacity	Program Capacity Limit	System Capacity Limit	Bill Credit—kWh or $	Bill Credit--Value	Siting Requirements?	LMI Component?
CA	GTSR/ECR	2015	0 MW (ECR)	600 MW	3 MW (ECR)	$	Compilation of statute-mandated costs and credits	Same municipality or county, or within ten miles of the customer's address	Yes
CO	**CSG**	**2011**	Fully subscribed	2011-13 = 18 MW 2015-16 = 6.5-30 MW/yr	2 MW	$	Total Aggregate Retail Rate = base energy, demand charges and other riders; excludes T&D, customer charge, DSM, RESA	Same or adjacent county	Yes
DE	**CS**	**2011**	N/A	5% of a utility's aggregated customer monthly peak demand	Up to 2 MW	unclear	Same feeder = full retail rate; different feeders = supply service charge	Same utility service territory	No
MA	**VNM**	**2009**	N/A	9% of system peak load (4% private, 5% public)	Up to 2 MW (up to 10 MW for gov't)	$	All but Class III = full retail rate; Class III = energy, transmission, transition	Same utility service territory	No
MN	CSG	2014	40 kW	None	1 MW	$	Full retail rate plus REC adder (res. CSG rate = $0.14 or $0.15 per kWh, depending on the project size)	Same or adjacent county; co-location limitations	No
NY	CDG	2015	N/A	(NY NEM caps currently lifted)	2 MW	kWh unless demand-metered, then $	Full retail rate	Phase 1 = "Opportunity Zones" and 20% low-income projects; Phase 2 = unrestricted	Yes

Facility Ownership

- Direct ownership—customer(s) own
- Third-party ownership—project developer owns
- Utility ownership
  - CO, MN allow for utility ownership
  - Restructured markets (ownership would need to be done through affiliate)
- Policy Considerations
  - ➢ Financing options available for facility
  - ➢ Benefits to customers of competitive offerings

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Program Administration

- Utility
- Third party
- Participants (rare, see VT group billing)

***

- ➢ Program Design, Billing
- ➢ Marketing/Advertising/Outreach
- ➢ Communications
- ➢ Participant Interface
- ➢ Facility Maintenance

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Program Capacity, System Capacity

State	Program	Year Launched	Installed Capacity	Program Capacity Limit	System Capacity Limit
CA	GTSR/ ECR	2015	0 MW (ECR)	600 MW	3 MW (ECR)
CO	CSG	2011	Fully subscribed to date	2011-13 = 18 MW 2015-16 = 6.5-30 MW per year	2 MW
DE	CS	2011	N/A	5% of a utility's aggregated customer monthly peak demand	Up to 2 MW
MA	VNM	2009	N/A	9% of system peak load (4% private, 5% public)	Up to 2 MW (up to 10 MW for gov't)
MN	CSG	2014	40 kW	None	1 MW
NY	CDG	2015	N/A	(NY NEM caps currently lifted)	2 MW

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Allocating Benefits (How)

- By check
  - Can raise tax and security concerns
- By bill credit mechanism
  - Relatively easy to administer
  - Can avoid security and tax concerns
  - Familiar to participants and utilities
  - kWh credit or dollar credit
- REC Ownership
  - IREC recommends REC stays with customer unless otherwise specified and clarified via contractor

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Valuation method (what)

- Embedded-cost-based approach—participants' retail rates
  - Generation, transmission and/or distribution
  - Can get complicated with TOU rates and non-kWh components, e.g., demand charges

- Value-based approach—value of solar rate
  - Costs = lost revenue, admin. costs, incentives
  - Benefits = avoided generation costs, avoided line losses, capacity benefits, avoided T&D costs, avoided environmental compliance costs, other benefits, etc.

IREC Model Rules provide language for both approaches

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State	Program	Bill Credit—kWh or $	Bill Credit--Value
CA	GTSR/ECR	$	The bill credit rate: credits (generation credit and solar value adjustment) and charges (generation cost, indifference adjustment, grid charges, resource adequacy charges, and administrative charges).
CO	CSG	$	Total Aggregate Retail Rate (TARR)= base energy, demand charges and other riders; <u>excludes</u> T&D, customer charge, DSM, RESA Res Credits = the Subscriber's share (% of total) times the utility's Total Aggregate Retail.
DE	CS	unclear	Same feeder = full retail rate; different feeders = supply service charge
MA	VNM	$	All but Class III = full retail rate; Class III = energy, transmission, transition
MN	CSG	$	Full retail rate plus REC adder (res. CSG rate = $0.14 or $0.15 per kWh, depending on the project size)
NY	CDG	kWh unless demand-metered, then $	Full retail rate

Facility Location

- Location requirements depend on goals and priorities
- Remote projects vs. visible, local projects
- Urban vs. rural customers
- Programs could encourage locations that maximize grid benefits or provide other benefits (i.e., local economic development)
  - Grid information? Hosting capacity?
  - NY Opportunity Zones
- Interconnection standards
  - Minnesota Community Solar Gardens Example

State	Program	Siting Requirements?
CA	GTSR/ECR	Same municipality or county, or within ten miles of the customer's address
CO	CSG	Same or adjacent county
DE	CS	Same utility service territory
MA	VNM	Same utility service territory
MN	CSG	Same or adjacent county; co-location limitations
NY	CDG	Phase 1 = "Opportunity Zones" and 20% low-income projects; Phase 2 = unrestricted

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Guiding Principles & Policy Goals are Key to Program Design

1. Expand renewable energy access to a broader group of energy consumers
2. Produce tangible economic benefits on customers' utility bills
3. Remain flexible enough to account for energy consumers' preferences
4. Be additive to and supportive of existing renewable energy programs, and not undermine them

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Additional Resources

- IREC Model Rules for Shared Renewable Energy
  - www.irecusa.org
- IREC Shared Solar Catalog
  - www.irecusa.org/2015/11/shared-solar-program-catalog-3/
- US DOE/White House Community Solar Partnership
  http://energy.gov/eere/solarpoweringamerica/national-community-solar-partnership
- US DOE Solar Market Pathways
  - www.solarmarketpathways.org
- National Renewable Energy Laboratory
  - www.nrel.gov
- Shared Solar: Current Landscape, Market Potential, and the Impact of Federal Securities Regulation
  - http://www.nrel.gov/docs/fy15osti/63892.pdf

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Thank you

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Community Solar from the Participants' Perspective

Dan Chwastyk
Solar Electric Power Association

February 16, 2016

About SEPA

SEPA is an educational non-profit (501 c3)

Our unique mission is aimed at supporting utilities integration of solar, and other distributed energy resources, through educational events, research publications, & tailored consultations

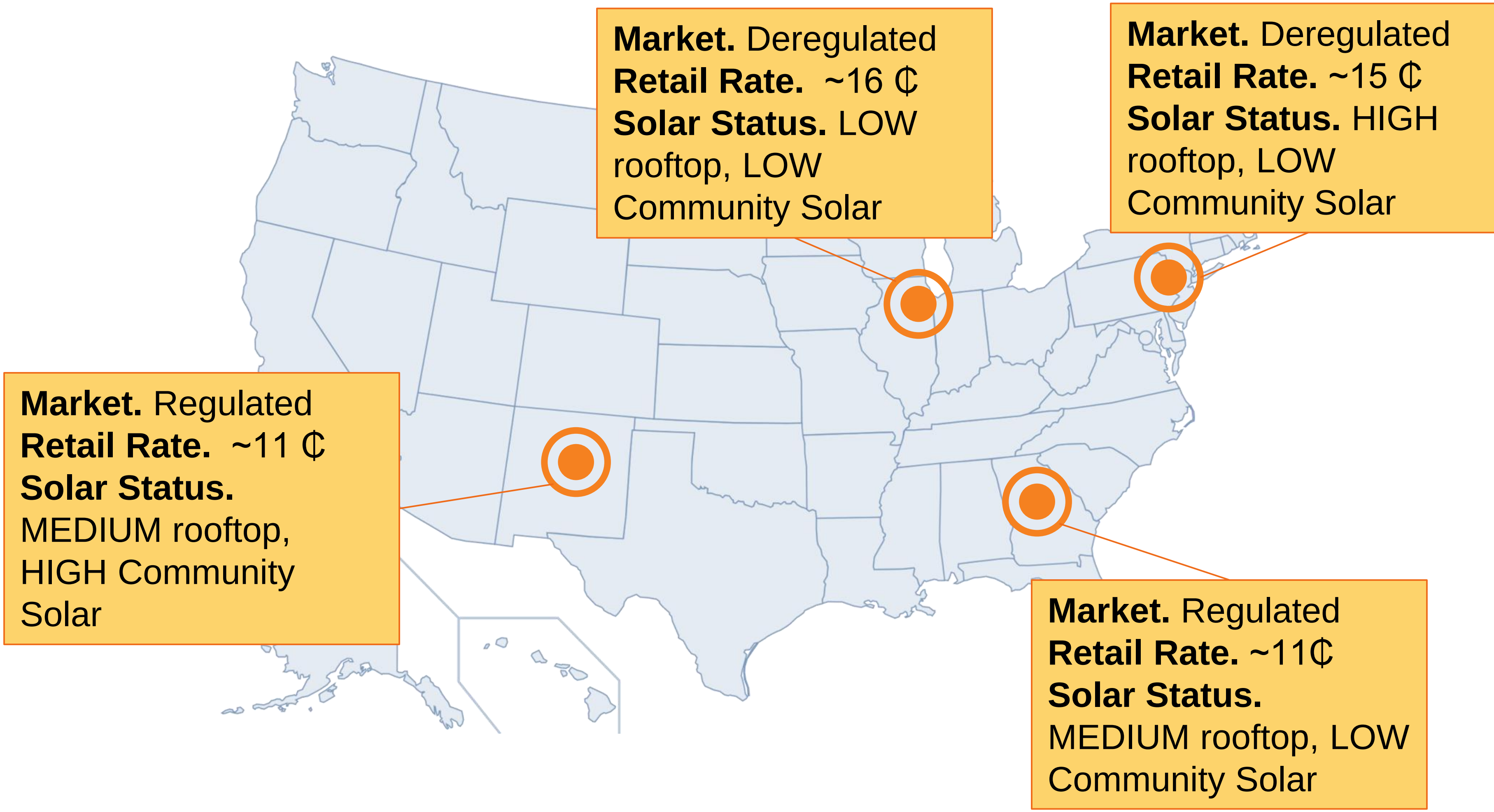
Membership

530+ Utility

475+ solar industry & stakeholder

> 90% of installed solar capacity

Focus group


Market. Deregulated
Retail Rate. ~16 ₵
Solar Status. LOW rooftop, LOW Community Solar
Market. Deregulated
Retail Rate. ~15 ₵
Solar Status. HIGH rooftop, LOW Community Solar
Market. Regulated
Retail Rate. ~11 ₵
Solar Status. MEDIUM rooftop, HIGH Community Solar
Market. Regulated
Retail Rate. ~11₵
Solar Status. MEDIUM rooftop, LOW Community Solar

Expectations

SEPA

Participants would largely prefer community solar over rooftop solar.

Cost matters, but solar ownership is a premium electricity product.

Participants would be hesitant to work with their utility on a customer product.

Participants would want their solar arrays to be nearby and visible to achieve the halo effect of ownership

Focus Group Findings

SEPA

Expectation: Participants would largely prefer community solar over rooftop solar.

Evidence:

"This sounds great, but unfortunately I don't own my home." *(Denver renter)*

"They should make the panels smaller so I can fit more on my roof and sell more electricity." *(NJ homeowner)*

Most renters and business decision-makers – and about half of homeowners – preferred community solar to rooftop solar options… BUT, significant education on solar fundamentals and community solar model was necessary.

Focus Group Findings

✓ $

Expectation: Cost matters, but solar ownership is a premium electricity product.

Evidence:

> *"I feel like it would be cheaper. It can decrease your electric bill as well."* (Denver renter)

> *"I want to purchase as much as possible so I can make as much as possible."* (NJ homeowner)

Saving money was always the first reason and by far the most cited reason to participate in community solar.

Focus Group Findings

Expectation: Participants would be hesitant to work with their utility on a customer product.

Evidence:

> *"Knowing a utility company's involved would kill it for me. I know that once they get involved in this the costs will go up and it will all just go to admin."* (Ft. Lee business)

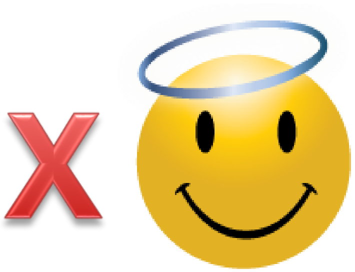
> *"My utility has been in the power business for 100 years. I pay whatever but that's just the way it's always been. But for me to call up another place like that, I'd be a little leery."* (Chicago homeowner)

Participants were interested in working with whom they trusted most.

Focus Group Findings

SEPA

Focus group finding



Expectation: Participants would want the solar array to be nearby and visible to achieve the halo effect

Evidence:

> *"It reminds me of an electrical substation. I sure as hell don't want a substation in my backyard"* (Denver Homeowner)
>
> *"I'd pay more NOT to see it."* (NJ Renter)

Visibility is less important: solar panels are not a "badge of honor" for most mainstream energy consumers.

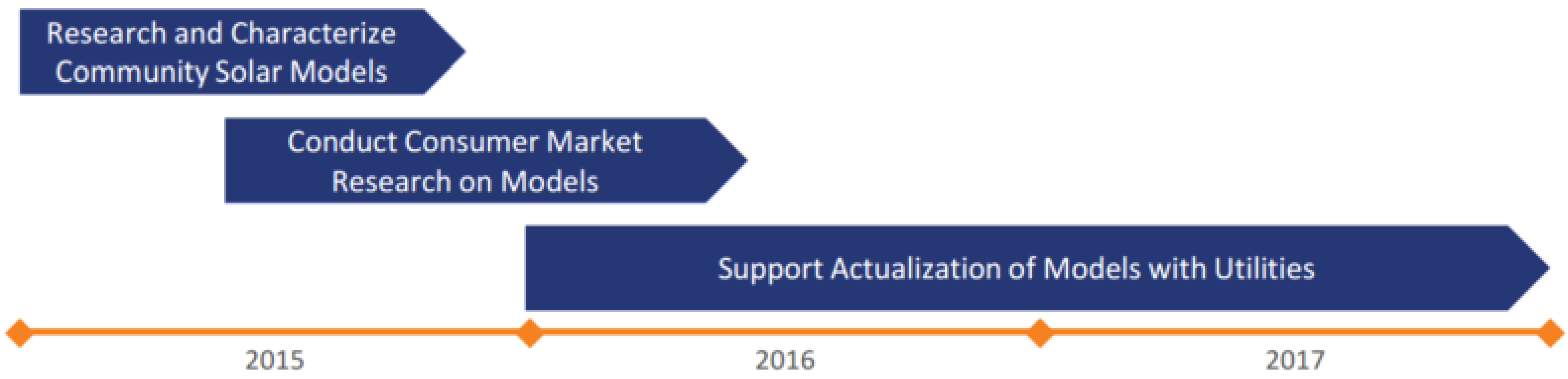
Sacramento Municipal Utility District Solar Shares Program

Price	Premium price, with no expectation of lifetime savings for participants
Siting	Solar array is visibly sited in service territory
Customer Manager	Utility administers the program and handles customer relationships

SolarShares is heavily subscribed and enjoys a **90%+** satisfaction score from participants

Customer Research Timeline

SEPA



- Survey 2,000 residential and 200 commercial decision makers (Now)
- Conduct analysis and report development (March)
- Present findings at Community Solar Workshop at SEPA's Utility Solar Conference (April)

Thank You

Thank you for your time today!

Dan Chwastyk
Utility Strategy Manager
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(202)660-0861

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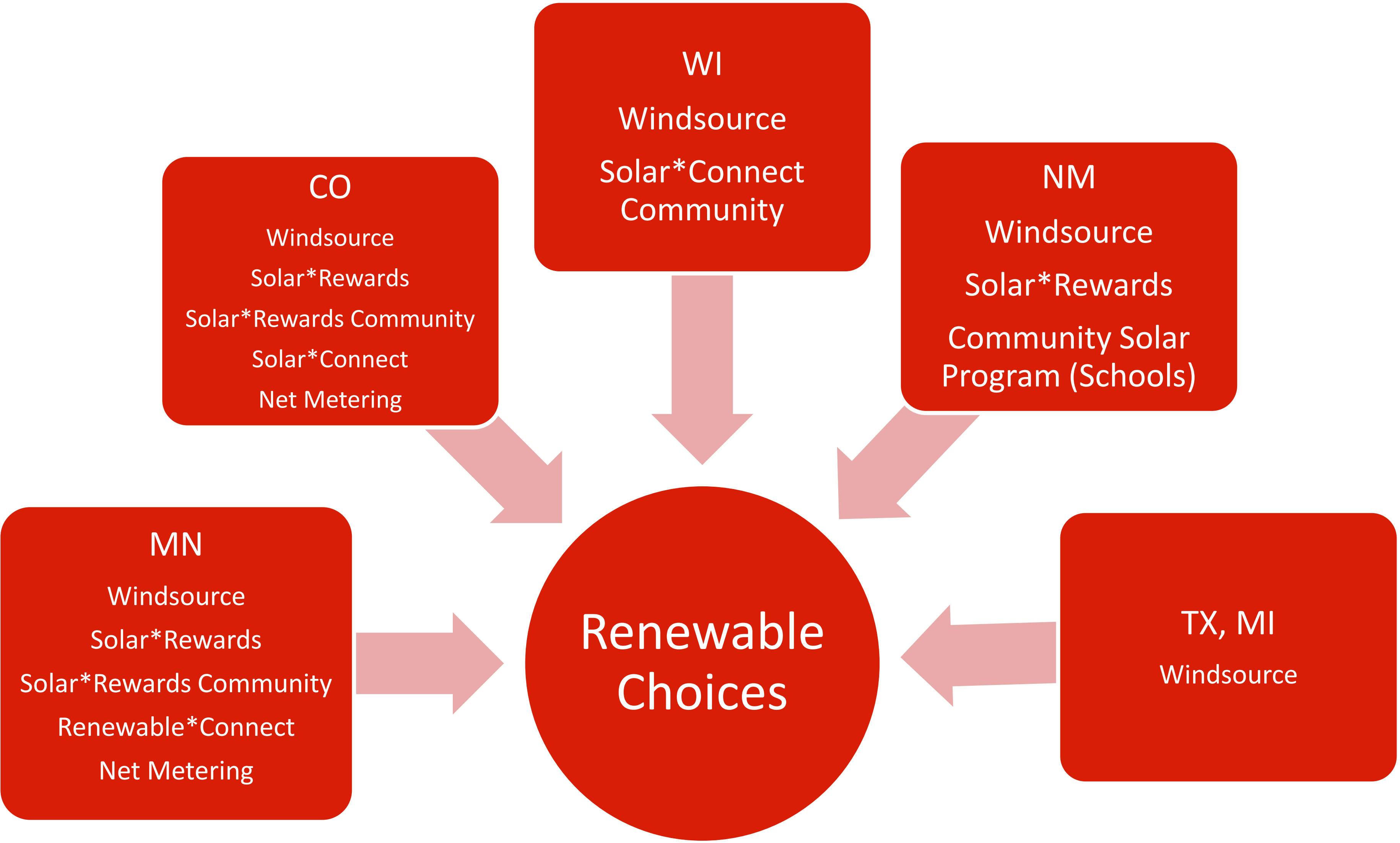
CUSTOMER CHOICE PROGRAMS



PROGRAM COMPARISON | XCEL ENERGY PERSPECTIVE

	Solar*Rewards Community (CO)	Solar*Rewards Community (MN)	Solar*Connect Community (WI)
Program Origin	Legislation	Legislation	Xcel proposal
Xcel Energy Role	Program Administration	Program Administration	Program Administration Customer Acquisition Subscriber Management Marketing Sales
3rd Party Role	Customer Acquisition Subscriber Management Marketing Sales Construction/Operation	Customer Acquisition Subscriber Management Marketing Sales Construction/Operation	Customer Acquisition Marketing Sales Construction/Operation
Program Launch (First gardens online)	2013	2015	Late 2016

PROGRAM COMPARISON | SUBSCRIBER PERSPECTIVE

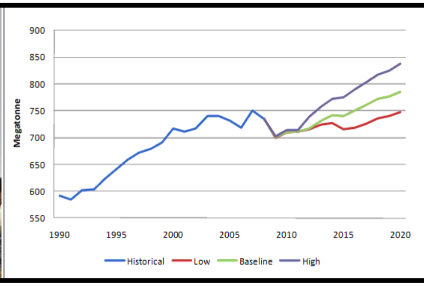
		Solar*Rewards Community (CO)	Solar*Rewards Community (MN)	Solar*Connect Community (WI)
Subscription basis		Capacity	Capacity	Capacity
Garden Size		2 MW	1 MW, but . . .	1 MW
Max Subscription		120% of customer load 40% of single garden	120% of customer load 40% of garden	100% of customer load 40% of a single garden
Current Size of Program	Operational	16.6 MW	1 MW	0 MW
	In Development	31 MW	1,155 MW	3 MW
RECs		Retained by Xcel	Developer can choose to retain or sell to Xcel	Retired on customers behalf
Payment method		Ongoing per kWh charge or up-front payment (varies by developer/garden)	Ongoing per kWh charge or up-front payment (varies by developer/garden)	Up-front payment

PROGRAM COMPARISON | NON-SUBSCRIBER PERSPECTIVE

	Solar*Rewards Community (CO)	Solar*Rewards Community (MN)	Solar*Connect Community (WI)
Unsubscribed Energy Value	Average Hourly Incremental Cost	[Avoided cost (> 40 kW) or Retail rate (< 40 kW)] + $0.01/kWh for REC	Bill credit rate
Subscriber Bill Credit basis	Full retail rate, less T&D costs	Full retail rate plus REC payment of $0.02-0.03/kWh	Average generation and fuel costs

COP 21 – a Debrief from Paris

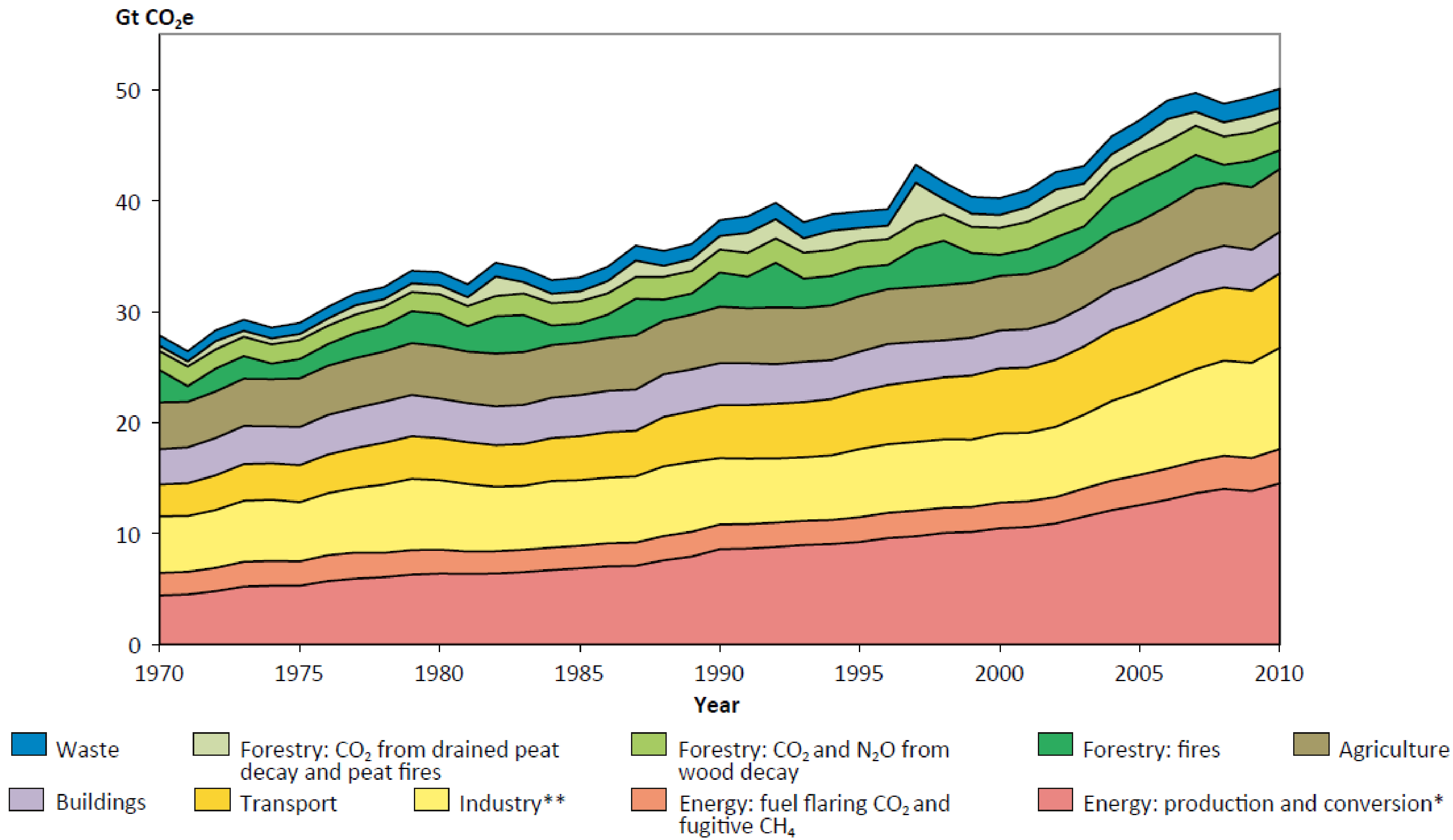
United nations conference on climate change
COP21/CMP11



Jonathan Pershing
US Department of Energy

NARUC
February 16, 2016

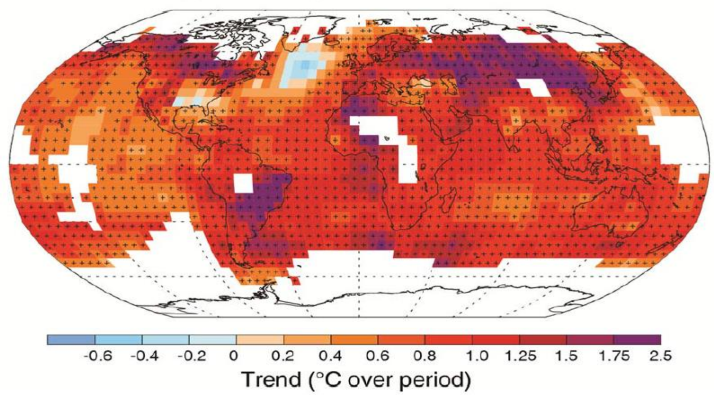
Trend in global greenhouse gas emissions 1970-2010 by sector

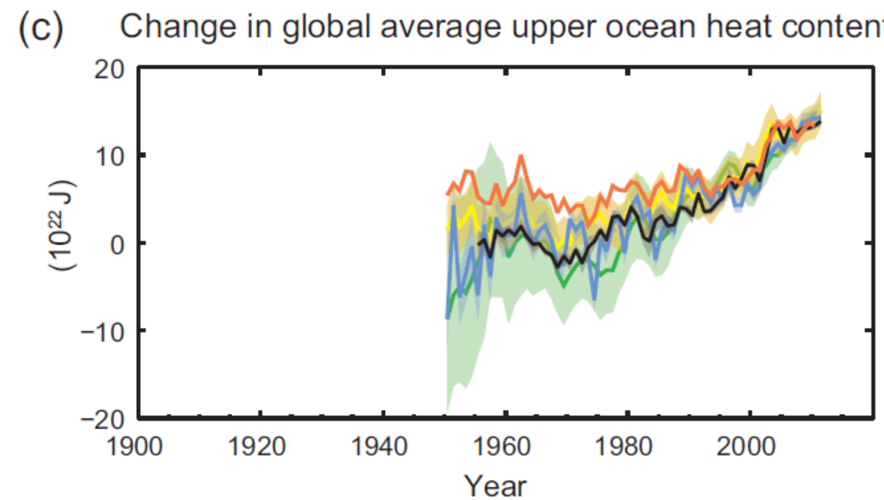


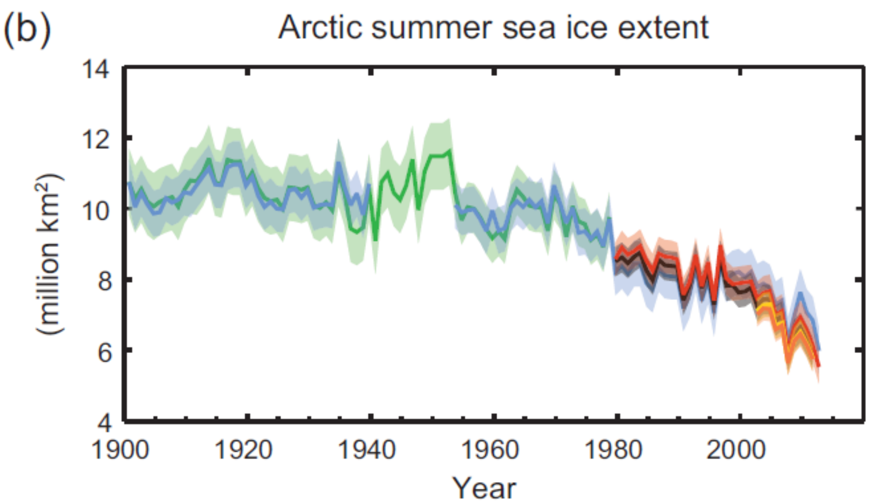
Source: UNEP, Emissions gap report, 2012

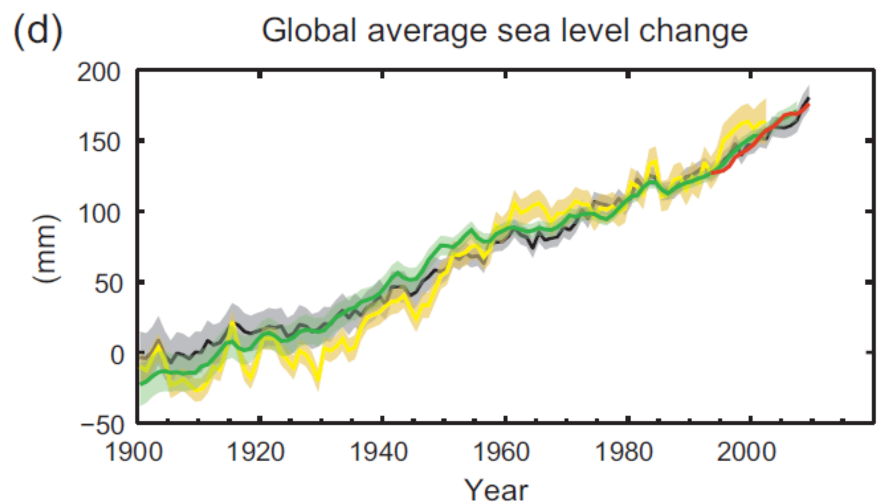
Observed Impacts

Observed Change in Average Temperatures 1901-2012





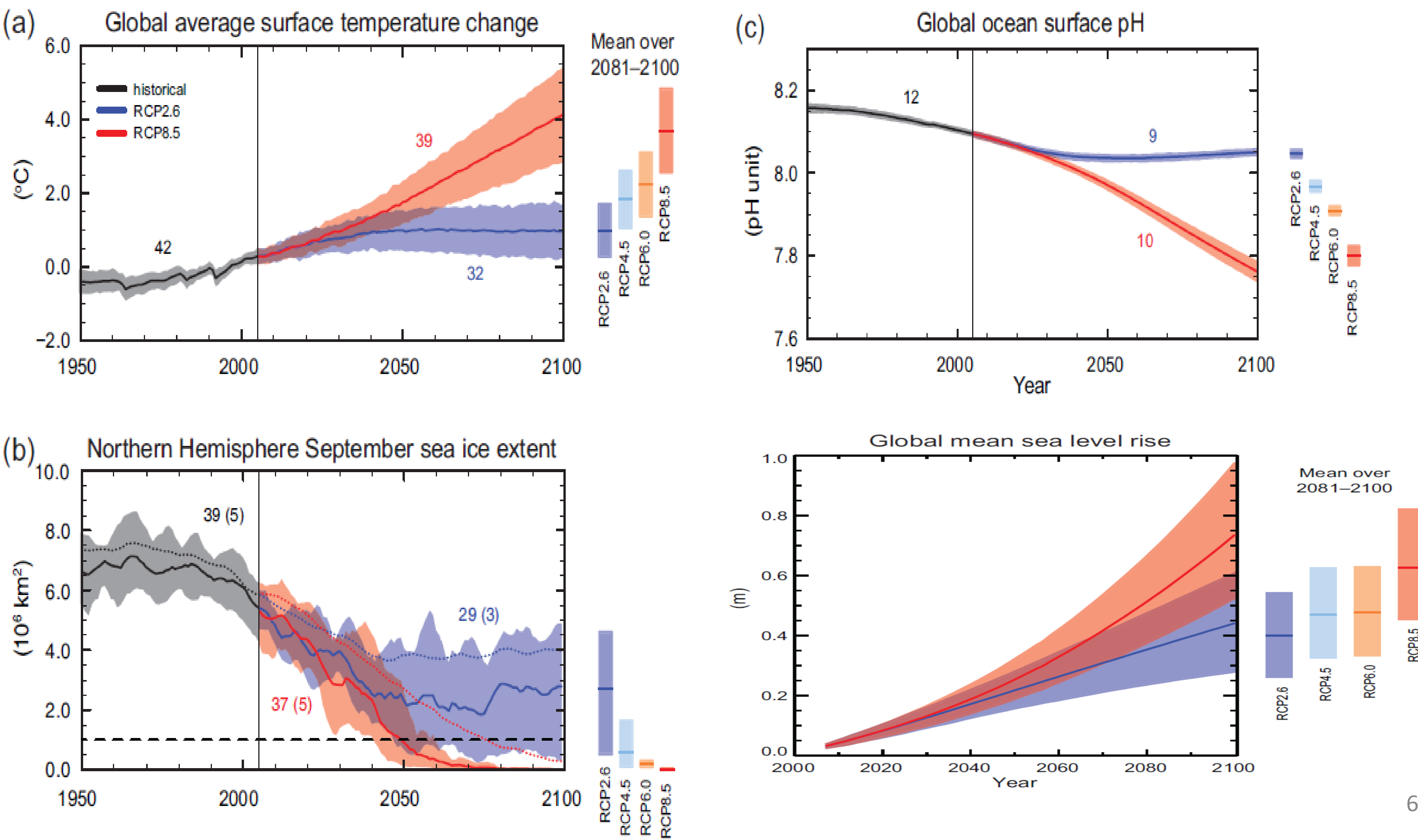




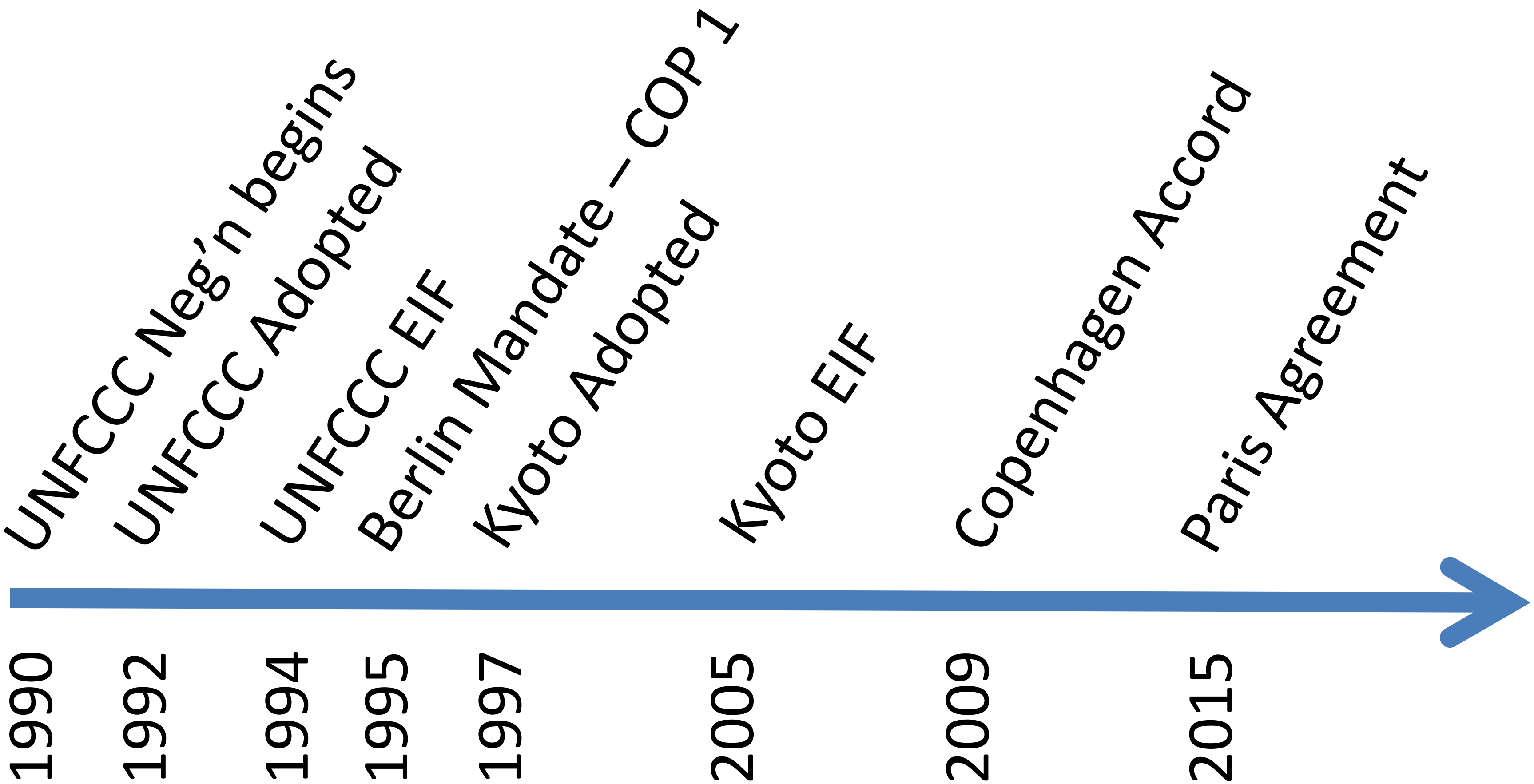
Source: IPCC, 5th Assessment Report, SPM, 2013

Looking Forward

Source: IPCC, 5th Assessment Report, SPM, 2013



Timeline of the Negotiations



Elements of the Paris Agreement

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

The Paris Agreement

- "Aims to strengthen the global response to the threat of climate change … by
  - (a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels,
  - (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience
  - (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development."

- "Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."

(Paris Agreement, Article 2)

The Paris Agreement

- "Parties aim to reach global peaking of GHG emissions as soon as possible … and to undertake rapid reductions thereafter … so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century"
- "Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. "
- "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition."
- "Each Party shall communicate a nationally determined contribution every five years"

(Paris Agreement, Article 4)

The Paris Agreement

- Calls for the provision of financial resources *(Article 9)*
  - Developed countries have obligation (while no amount is specified; language calls for a "progression beyond previous efforts")
  - Developing countries are encouraged to provide support voluntarily
  - Funds are to "achieve a balance" between mitigation and adaptation
- Technology *(Article 10)*
  - "Parties…shall strengthen cooperative action on technology development and transfer."
  - "Accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development. Such effort shall be, as appropriate, supported, including by the Technology Mechanism and, through financial means, by the Financial Mechanism of the Convention, for collaborative approaches to research and development, and facilitating access to technology, in particular for early stages of the technology cycle…."

The Paris Agreement

- Arrangements to ensure full transparency *(Article 13)*:
  - biennial reports
  - tracking of NDC implementation progress (including through technical review)
  - full GHG inventories
  - financial support and technology assistance
- Call for a periodic "stocktaking" *(Article 14)*:
  - Assess collective progress towards achieving the purpose of the Agreement and its long-term goals to inform Parties in updating and enhancing … their actions and support
  - First global stocktake in 2023 and every five years thereafter
- Entry-into-force, and final clauses *(Article 17-29)*
  - Open for signature starting April 22, 2016 (Earth Day)
  - Enters into force when ratified by at least 55 parties representing at least 55% of global GHG emissions

INDCs Submitted to Date

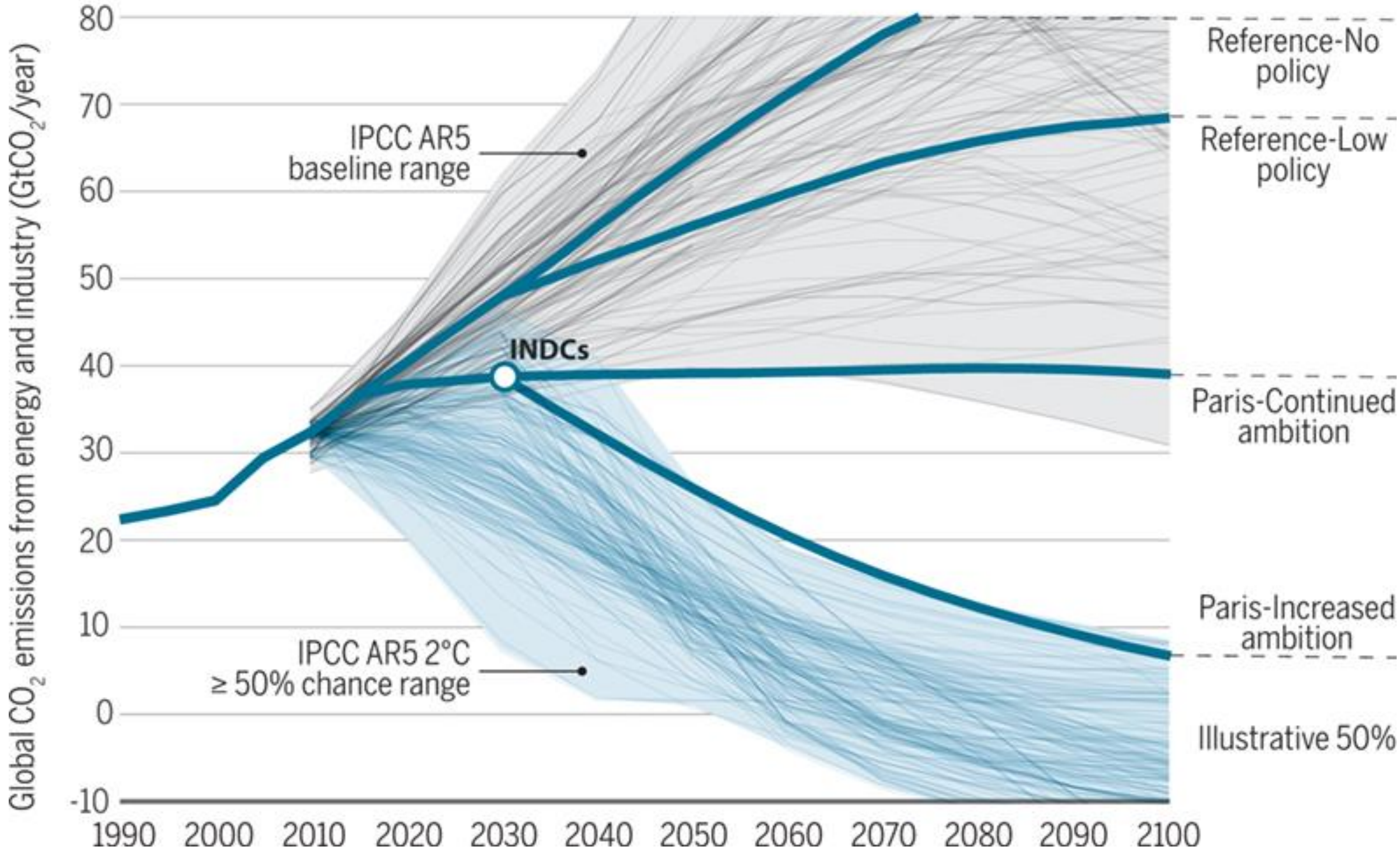
- 160 INDCs, representing 187 countries
- 98.6% of global GHG emissions

Source: WRI. http://cait.wri.org/indc/

INDCs: Copenhagen vs Paris

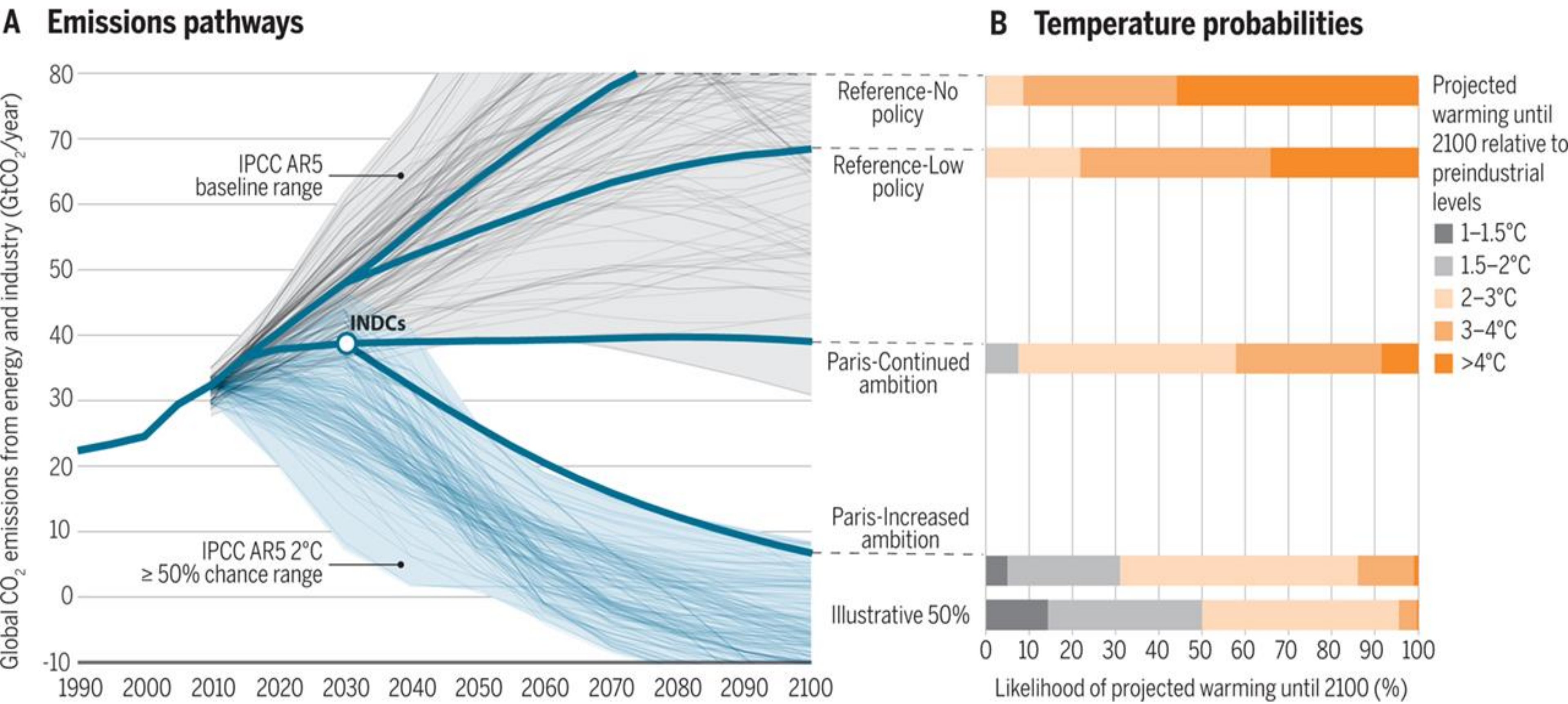
Country	Copenhagen	Paris
Brazil	36 – 39% below BaU by 2020	Reduce greenhouse gas emissions by 37% below 2005 levels in 2025 and 43% below 2005 levels in 2030
China	40-45% reduction in emissions intensity by 2020 below 2005 levels	• Peak CO2 emissions around 2030; • Lower CO2/GDP by 60% to 65% from 2005; • Increase share of non-fossil fuels in primary energy consumption to around 20%; • Increase forest stock volume by around 4.5 billion m^3 from 2005 level.
EU	20 – 30% below 1990 levels by 2020	At least 40% domestic reduction in GHG emissions by 2030 compared to 1990
India	20-25% reduction in emissions intensity below 2005 by 2020	• 33 to 35 % reduction in emissions intensity below 2005 by 2030; • 40 % cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 (with help)
USA	In the range of 17% below 2005 levels by 2020	Economy-wide target of reducing its GHG emissions by 26%-28% below 2005 level in 2025 (and to make best efforts to reduce emissions by 28%.)

INDCs keep the door open to global goals



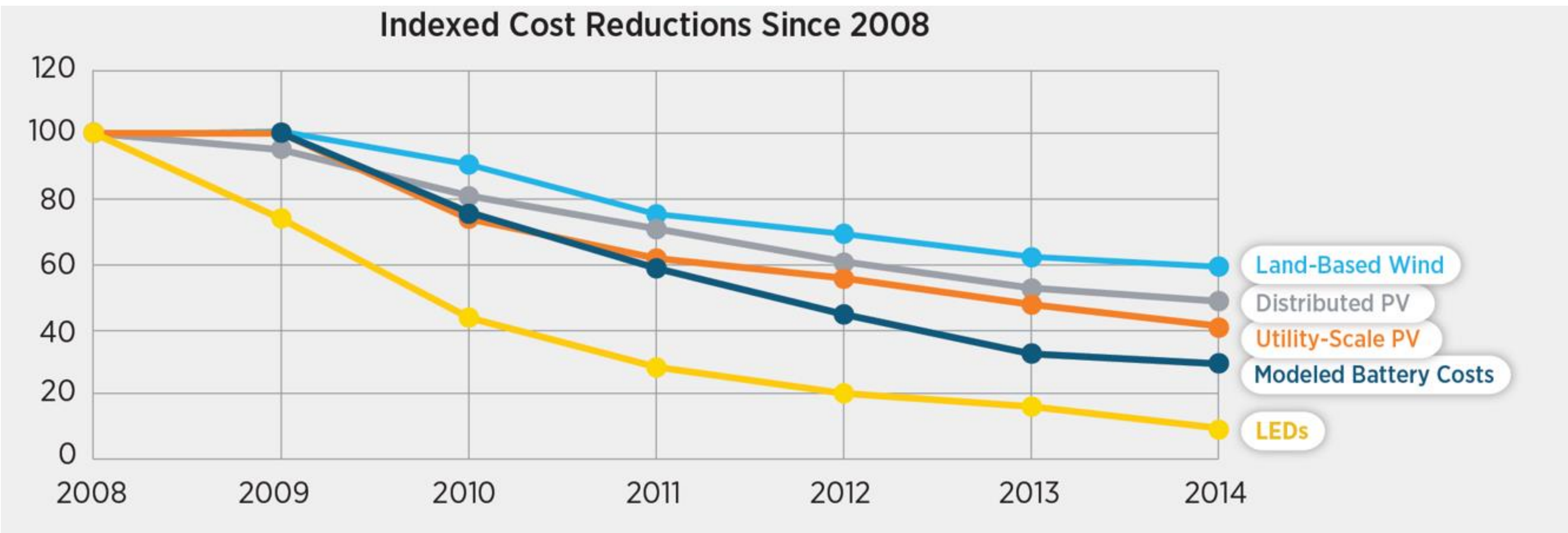
Fawcett et al 2015, Can Paris Pledges Avert Severe Climate Change? *Science*.

Paris ambition dramatically reduces risks of extreme climate change



Fawcett et al 2015, Can Paris Pledges Avert Severe Climate Change? *Science*.

Advancing Technology



Source: US DOE, “Revolution Now”

Mission Innovation

- 20 heads of state
- Countries represent 85-90 % of global R&D investment
- Each country supporting a <u>doubling</u> of its R&D investment over the next five years
- Complemented by a private sector initiative

Breakthrough Energy Coalition


Mukesh Ambani


John Arnold


Mark Benioff


Jeff Bezos


Alwaleed bin Ttalal


Richard Branson


Ray Delio


Aliko Dangote


John Doerr


Bill Gates


Reid Hoffman


Chris Hohn

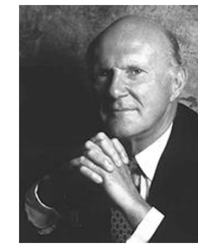

Vinod Khosla


Jack Ma


Patrice Motsepe


Xavier Niel


Hasso Plattner


Julian Robertson


Neil Shen


Simmons & Baxter-Simmons


Masayoshi Son


George Soros


Tom Steyer


Ratan Tata

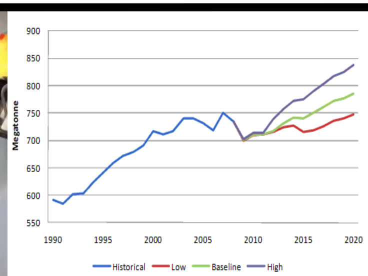

Meg Whitman


Zhang Xin Pan Shiyi


Mark Zuckerberg, Priscilla Chan

- 27 investors & University of California; Collective net worth: $300+ billion
- Commitment to invest in innovation emerging from Mission Innovation pipeline
- Long term, patient and risk tolerant capital

Thanks



900
850
800
750
700
650
600
550
Megatonne
1990
1995
2000
2005
2010
2015
2020
Historical
Low
Baseline
High

ELECTRIC POWER RESEARCH INSTITUTE

Challenges and Opportunities on the Road From Paris

Steven Rose

NARUC Winter Meeting, Washington, DC

February 16, 2016

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COP-21: 195 Nations Adopt Climate Agreement In Paris December 12, 2015

(left to right) ***UN climate chief Christiana Figueres; UN Secretary-General Ban ki-Moon; French Foreign Minister and president of the COP21 meetings Laurent Fabius; French President Francois Hollande***,

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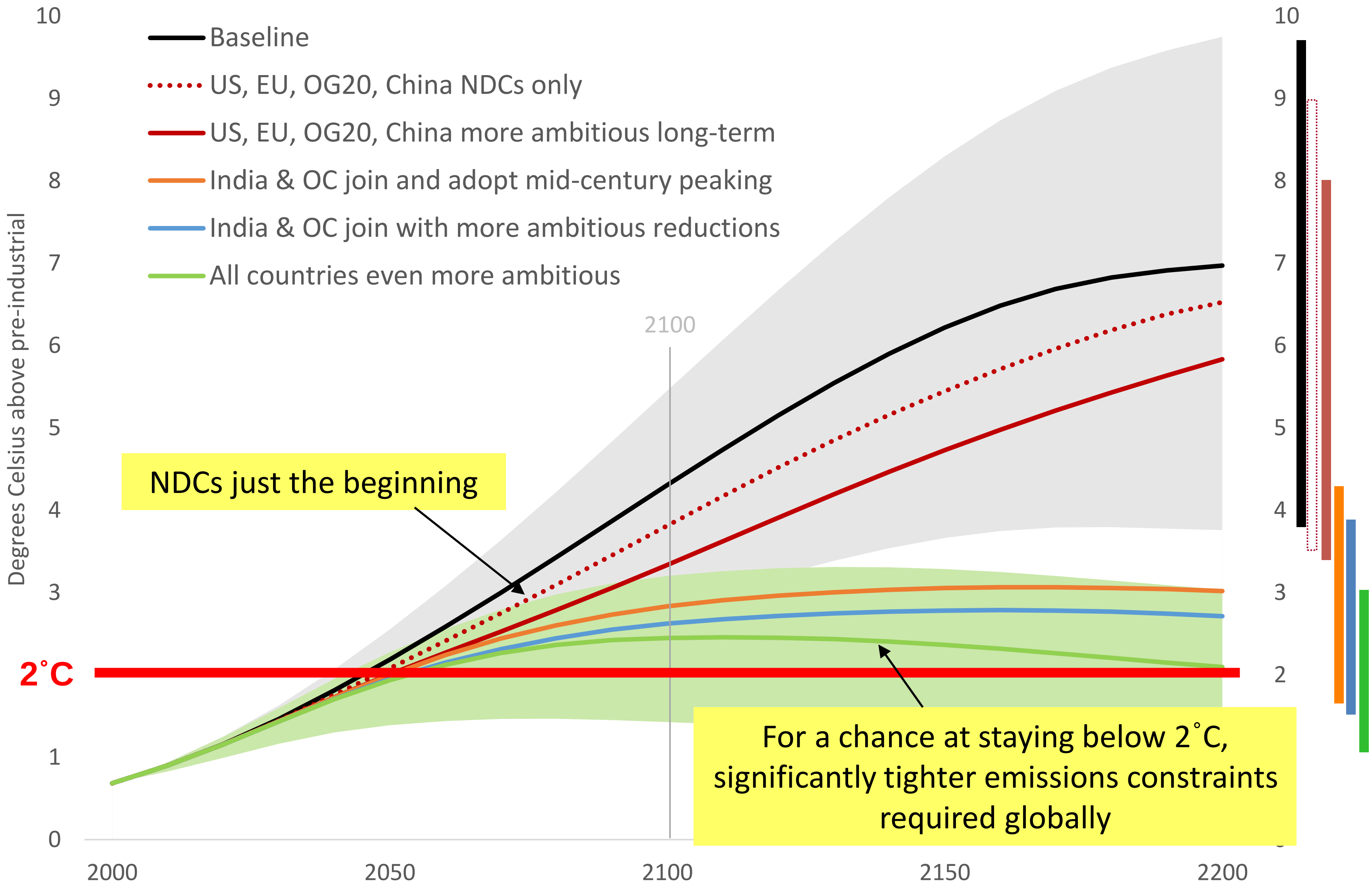
Potential Global Average Temperatures
(with our various long-run policy assumptions)

Plotted lines reflect climate sensitivity = 3°C. Shaded areas & 2200 ranges reflect climate sensitivity uncertainty 1.5 to 4.5°C.



EPRI (2016)

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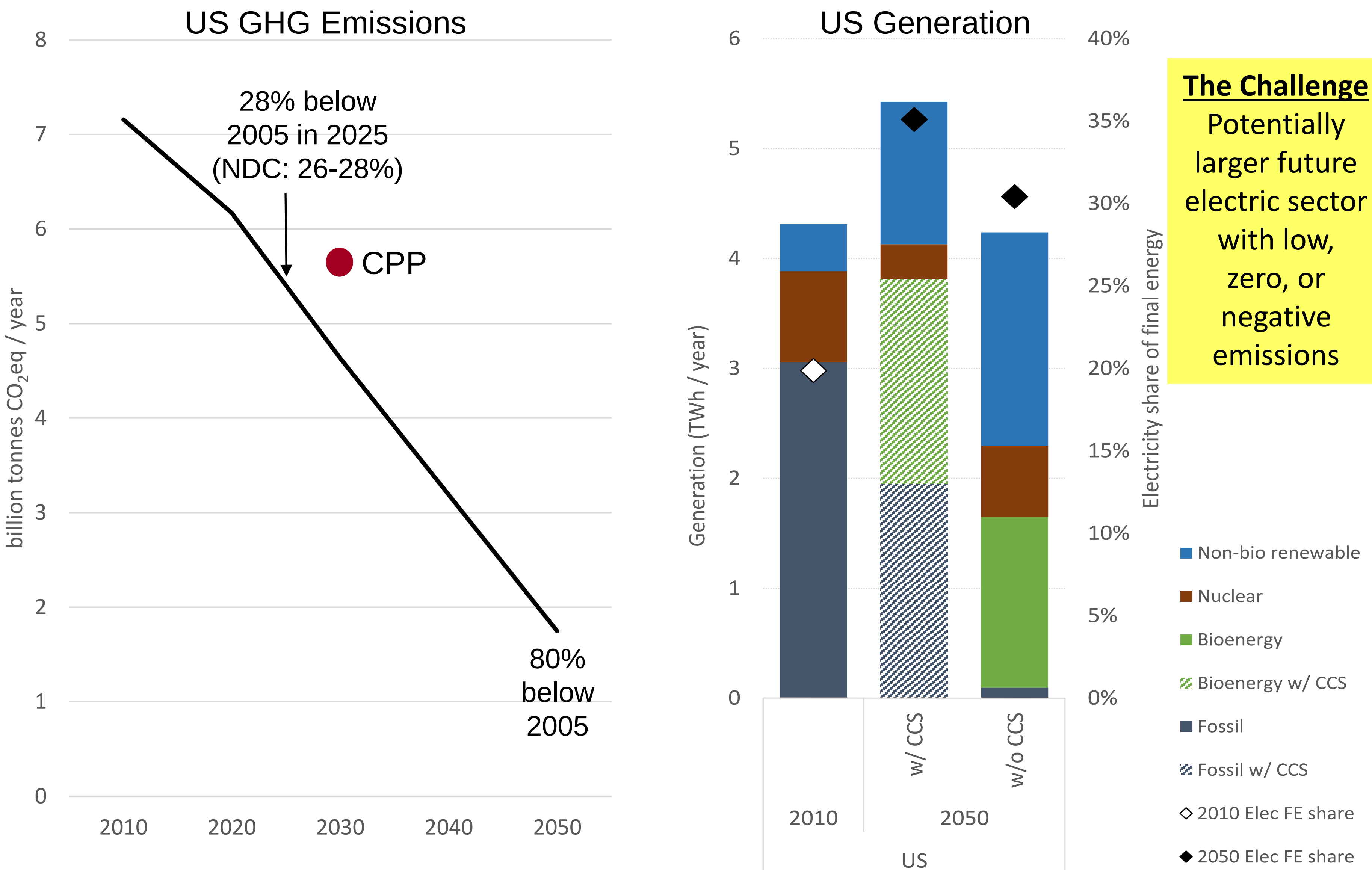
ELECTRIC POWER RESEARCH INSTITUTE

Constraining US GHG Emissions, Transforming Energy



The Challenge

Potentially larger future electric sector with low, zero, or negative emissions

EPRI (2016)

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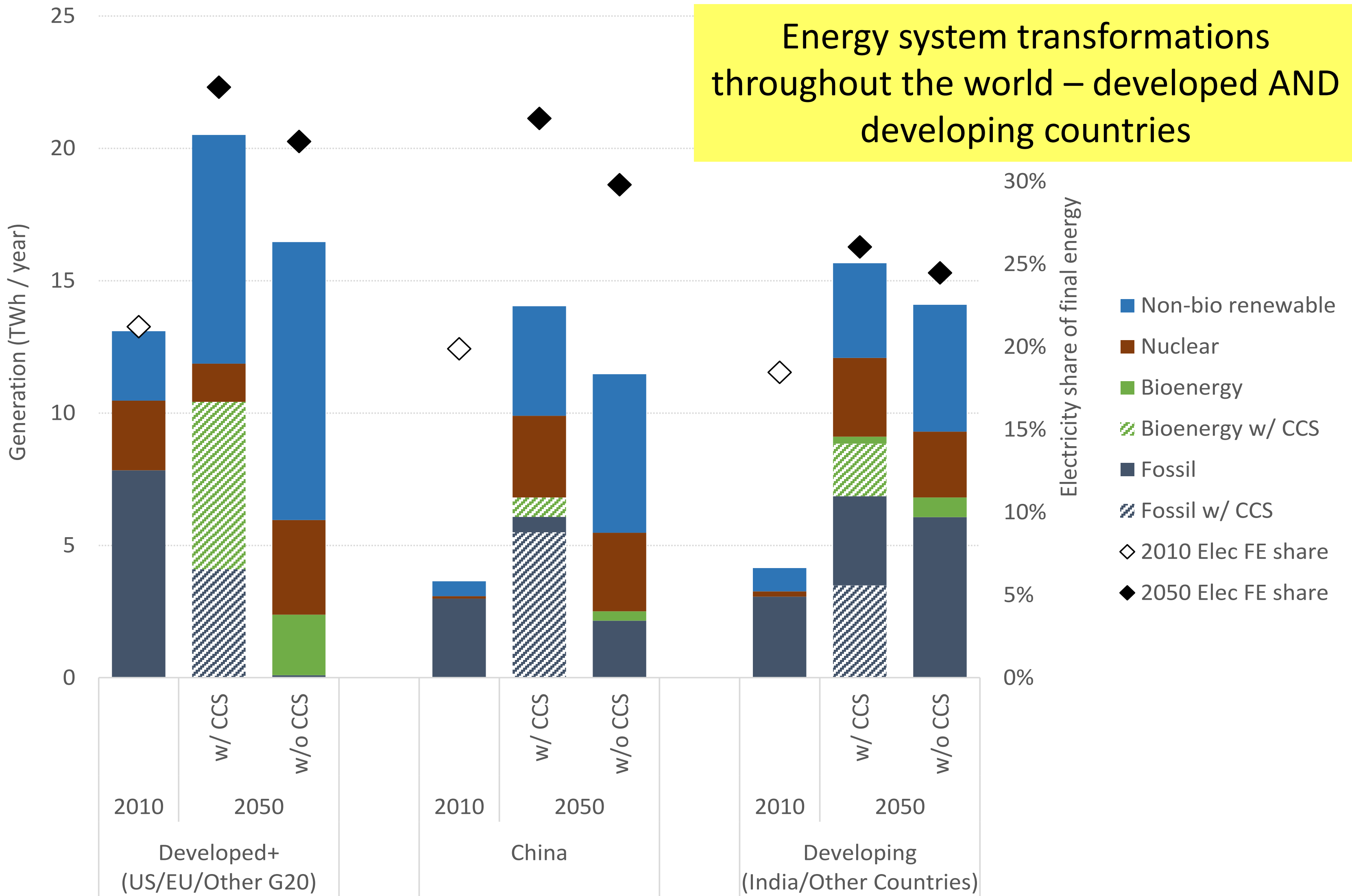
In Every Region, Radically Transform Generation
(Scenario: All countries even more ambitious)



EPRI (2016)

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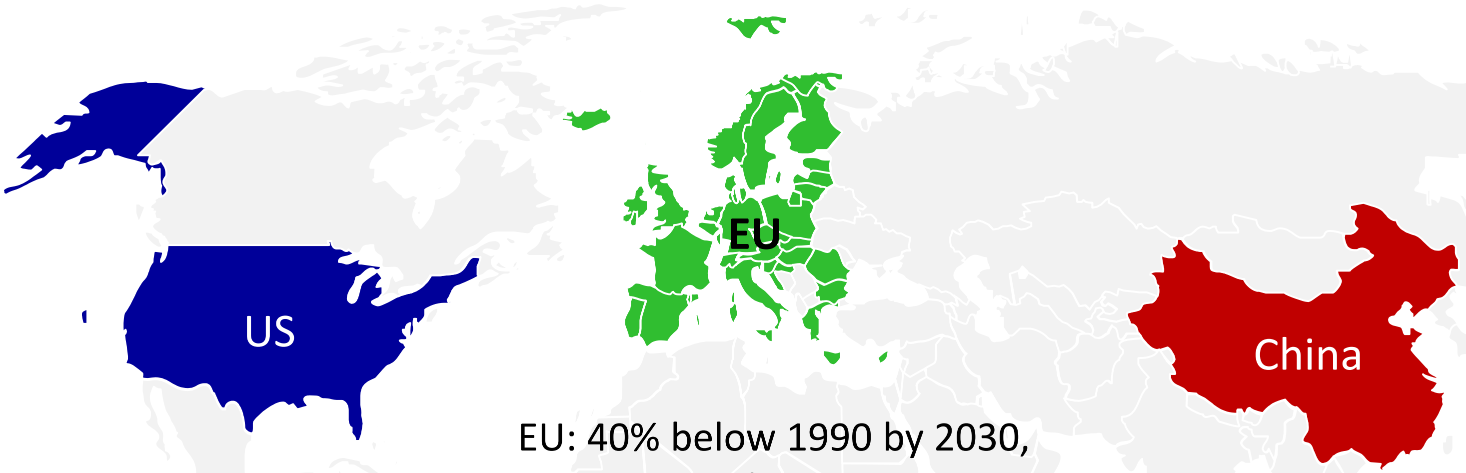
Possible Emissions Trading Partnerships: US-China, US-China-EU



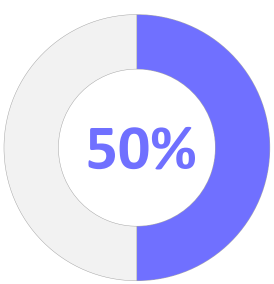
EU: 40% below 1990 by 2030,
80% by 2050

US: 28% below 2005 by 2025,
80% by 2050

China: 2030 peaking with 2050
10% **OR** 35% below 2030 BAU

Preliminary findings:

- **Welfare benefits** for all partners, regardless of ambition, seller or buyer, & partnership
- **US entities potential buyers and sellers**
- **Expanding partnership increases total benefits**, but can affect distribution



2010 emissions

EPRI (forthcoming), preliminary results

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Together…Shaping the Future of Electricity

THANK YOU!

srose@epri.com

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