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BLACK & VEATCH

Renewable Energy Transmission Initiative Phase 1A Draft Report

Black & Veatch

Plenary Stakeholder Group Meeting

March 26, 2008

Introductions

Ryan Pletka

Tim Mason

Ric O'Connell

Kevin Joyce

Today's Objective

Review the highlights of the Phase 1A *Draft* Report with the Stakeholder Steering Committee

Agenda

- Introduction / Overview
- Resource Assessment
  - Resource Potential
  - Economics
  - Resources to Consider in Phase 1B
- Key Methodological Issues
  - Base Case
  - Resource Valuation
  - CREZ Development
- Phase 1B Scope of Work and Schedule

Introduction

RETI Phase 1

- Objective: Identify Competitive Renewable Energy Zones
- Phase 1A:
  - Deliverables
    - List of sources – Jan. 22
    - March 14 Report
      - Assumptions
      - Methodology
      - Resource screening for Phase 1B
- Phase 1B:
  - Project & CREZ identification and characterization

Stakeholder Feedback and Input

- 14 March - Draft Phase 1A Report
- 26 March – Plenary Stakeholder Group Meeting
- 28 March – Comments Due
  - Stakeholder Steering Committee Representatives or CEERT **and**
  - Clare Laufenberg Gallardo CLaufenb@energy.state.ca.us
- 11 April – Revised Phase 1A Report
- 16 April – Stakeholder Steering Committee consideration of Report

Phase 1A Draft Report – March 14

- Executive Summary
- Introduction
- Methodology
- Assumptions
- Technology Characterization
- Resource Screening
- Phase 1B Scope of Work

255 pages, available at www.energy.ca.gov/reti

Phase 1A Work Group Members

- Instrumental in reviewing initial proposals and concepts that found their way to the draft report

Spokesperson - Mike DeAngelis, SMUD	
Steven Kelly – IEP	Anne Gillette - CPUC
Linda Brown – SDG&E	Gregg Morris – Biomass
John McCaull – Geothermal	Rainer Aringhoff - Solar
Joe Bertotti – Counties	Clare Laufenberg – CEC
Gary Allen – SCE	Dariush Shirmohammadi - Wind

Thanks!

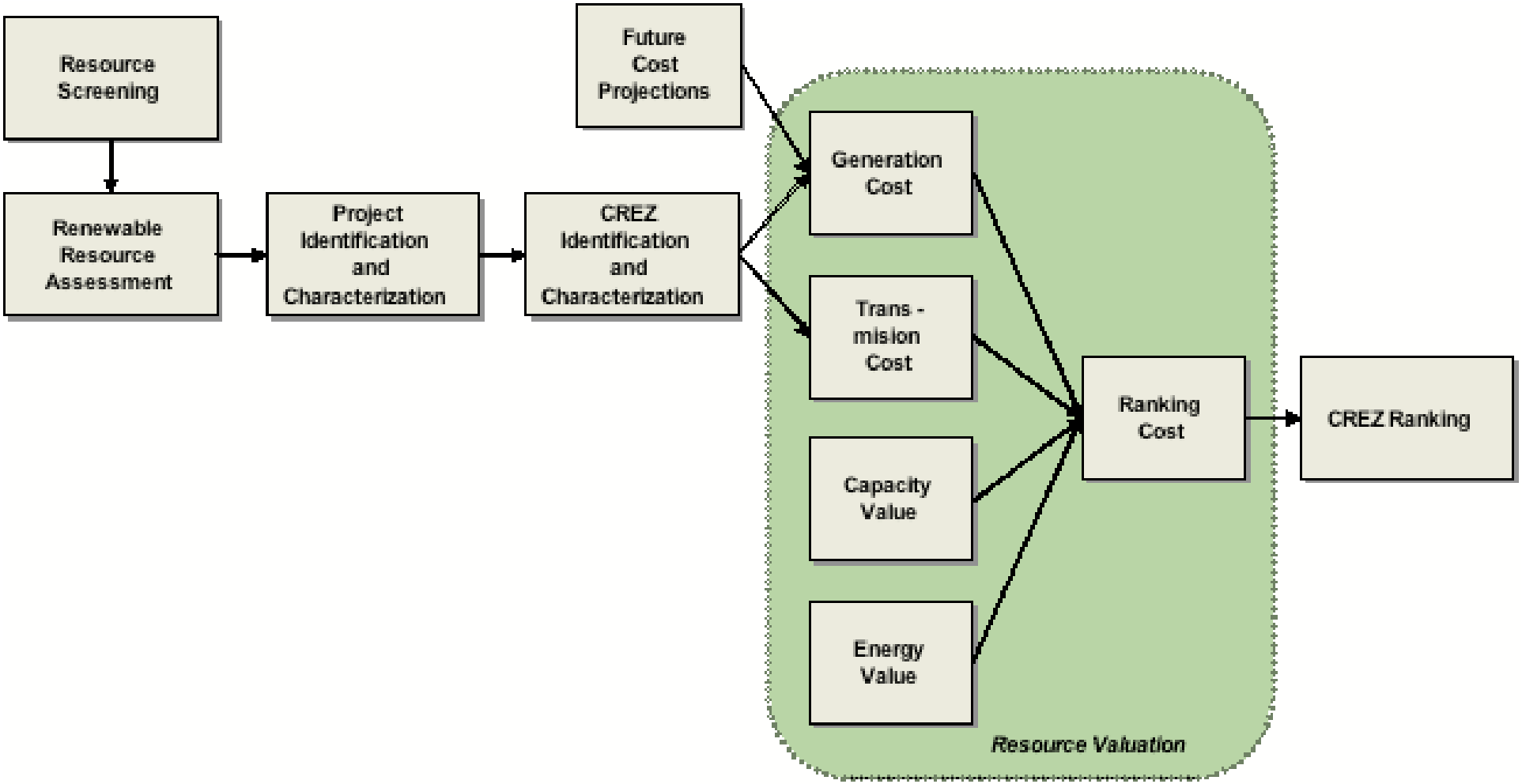
They have saved all of us time by volunteering

Stakeholder Feedback and Input

- Assumptions
- Methodology
- Resource Assessment
- Results…

…build consensus and momentum for Phase 1B

Overview of Methodology



Resource Assessment and Technology Characterization

Phase 1A Draft Report – March 14

- Executive Summary
- Introduction
- Methodology
- Assumptions
- **Technology Characterization**
- **Resource Screening**
- Phase 1B Scope of Work

Biomass
Landfill Gas
Digester Gas
Hydro
Geothermal
Marine Current
Wave
Solar Thermal
Solar PV
Wind

What are Technology Characteristics?

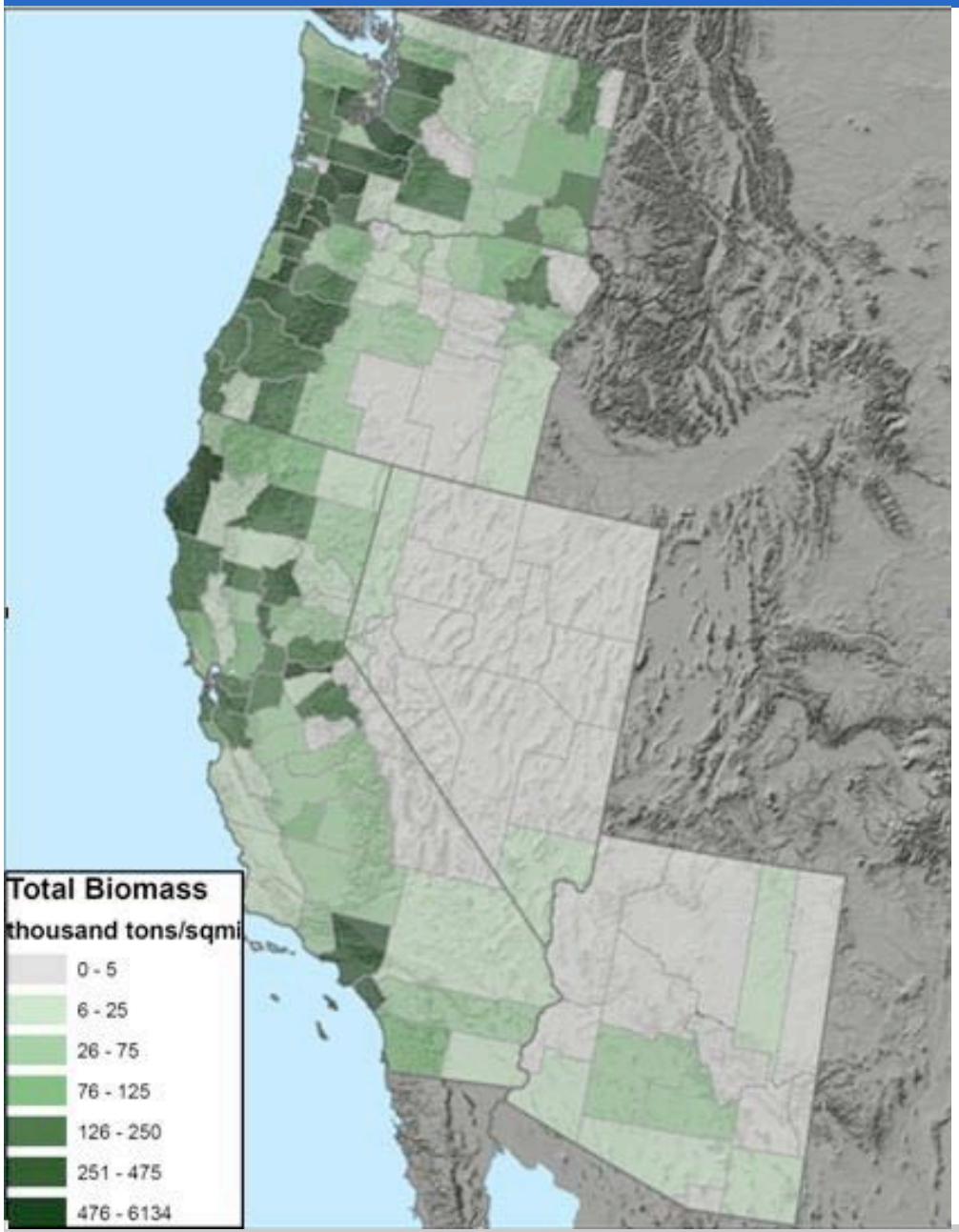
- Major distinguishing assumptions that determine project economics
- Cost and performance information derived from recent Black & Veatch projects and public sources
- ***Typical, representative information provided***
- Characteristics can vary widely
  - Project Size
  - Project location
  - Labor type
  - Air quality requirements
  - Fuel variations

Goal of Technology Characterization

- Phase 1A:
  - Provide broad indication of general technology costs
  - Used to screen entire technology categories
- Phase 1B:
  - Develop project-specific estimates
  - Used for developing and ranking CREZs
  - The specific estimates in Phase 1B should be relatively consistent with Phase 1A ranges

General Resource Assessment Approach

- Rely on publicly available estimates
- Assessments vary in detail and quality
- Generally represent technical potential
- Some are site specific (hydro, landfill gas)
- Attempt to use assessments that apply across entire region (US data)
  - But do not ignore better state-specific estimates
- **A starting point for Phase 1B**



Biomass

- Used NREL (2005) and other data sources
  - Tons per county by residue type
  - Agricultural, forest, mill, and urban wood residues
  - Sustainably harvested materials only
- Converted tons to potential MW

Biomass Assessment Results

	Existing Capacity (MW)	Potential for Additional Capacity (MW)
Arizona	0	180
Baja California	–	–
British Columbia	540	2,560
California	700	4,160
Nevada	1	42
Oregon	1,000	425
Washington	340	1,615
Total	**2,581**	**8,980**

17.7% of California Load

Biomass Assumptions

- Combustion-based technology (stoker / fluidized bed)

Performance	
Net Plant Capacity (MW)	35
Net Plant Heat Rate (HHV, Btu/kWh)	14,500
Capacity Factor (percent)	80
Economics	
Total Project Cost ($/kW)	3,000 to 5,000
Fixed O&M ($/kW-yr)	83
Variable O&M ($/MWh)	11
Fuel Cost ($/MBtu)	0 to 3
Levelized Cost of Energy ($/MWh)	67 to 150

Anaerobic Digestion

	Potential Capacity (MW)
Arizona	8 – 18
Baja California	–
British Columbia	50
California	85 – 293
Nevada	0
Oregon	10 – 13
Washington	18 – 203

- Manure and food waste resource
- Based on several sources
- Not recommended for Phase 1B due to small project size and limited potential

Anaerobic Digestion Assumptions

Performance	
Net Plant Capacity (MW)	0.150
Capacity Factor (percent)	80
Net Plant Heat Rate (Btu/kWh)	13,000
Economics (2007$)	
Total Project Cost ($/kW)	4,000 to 6,000
Variable O&M ($/MWh)	17
Fuel Cost ($/MBtu)	1 to 3
Levelized Cost ($/MWh)	100 to 168

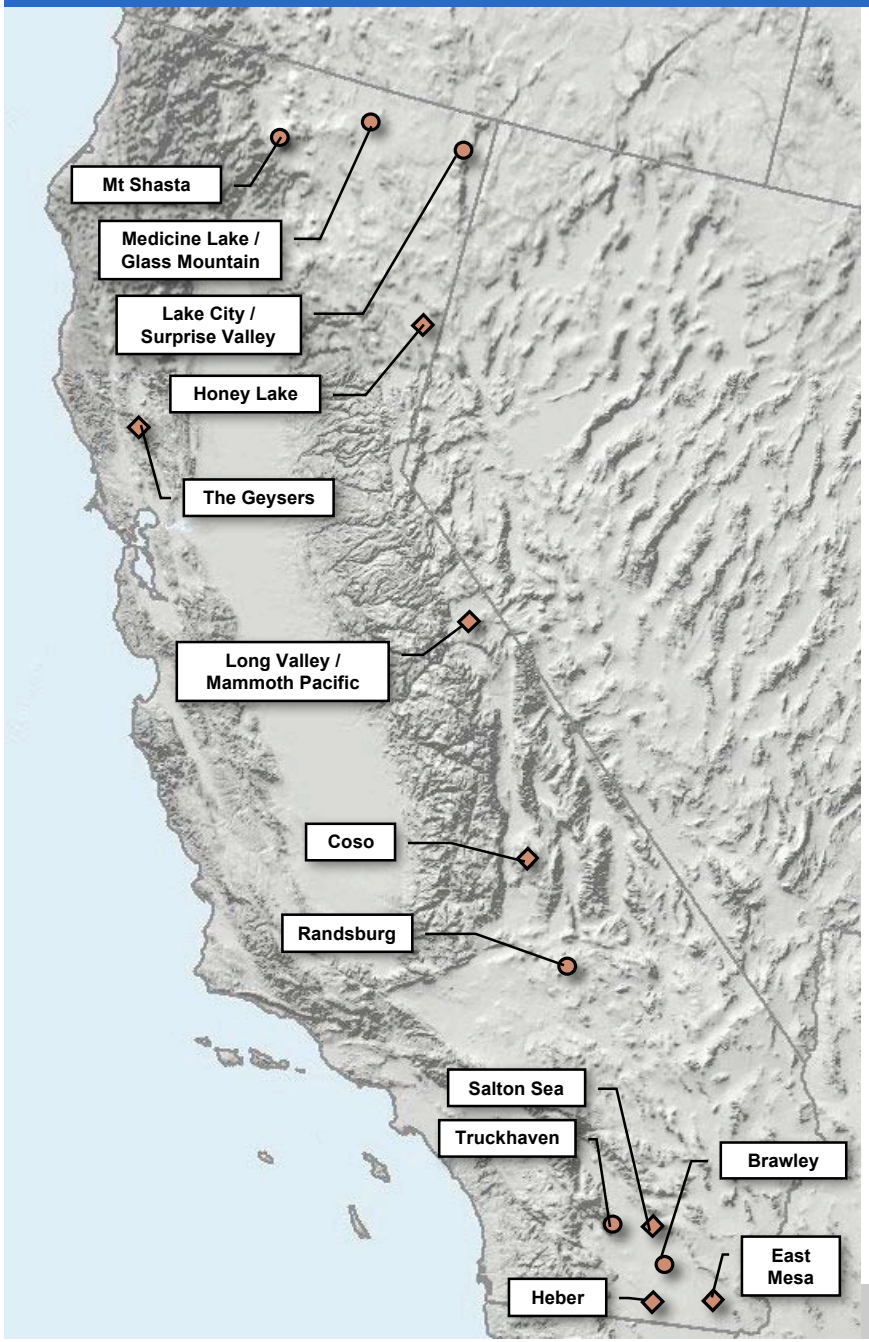
Landfill Gas Assessment Results

	Potential Capacity (MW)	
	All Projects	**> 3 MW**
Arizona	10	0
Baja California	–	–
British Columbia	22	Unknown
California	139	102
Nevada	6	0
Oregon	23	19
Washington	17	9
Total	217	130

- Not recommended for Phase 1B due to small project size and limited potential

Landfill Gas Assumptions

Performance	
Net Plant Capacity (MW)	5
Heat Rate (Btu/kWh)	13,500
Capacity Factor (percent)	80
Economics (2007$)	
Total Project Cost ($/kW)	1,200 to 2,000
Variable O&M ($/MWh)	17
Fuel Cost ($/MBtu)	1 to 2
Levelized Cost ($/MWh)	50 to 80



Geothermal

- Geothermal assessment performed by GeothermEx
- California and Nevada estimates based on past GeothermEx work
- Estimates for other regions rely on multiple data sources

Geothermal Assessment Results

	Installed Capacity (Gross MW)	Additional Capacity (Gross MW)
Arizona	0	50
Baja California	730	80
British Columbia	0	610
California	1,884	2,375
Nevada	297	1,488
Oregon	0	380
Washington	0	50
Total	**2,911**	**5,033**

11.0% of California Load

Geothermal Assumptions

Performance	
Net Plant Capacity (MW)	30
Capacity Factor (percent)	70 to 90
Economics (2007$)	
Total Project Cost ($/kW)	3,000 to 5,000
Variable O&M ($/MWh)	25 to 30
Levelized Cost ($/MWh)	54 to 107

Marine Current

- Resource assessment methods still in their infancy
- Energy flux method generally used
- Based on literature review of several sources, which varied widely
- Not an assess-ment of the entire coast, but it is believed the best sites have been identified

Marine Current Assessment Results

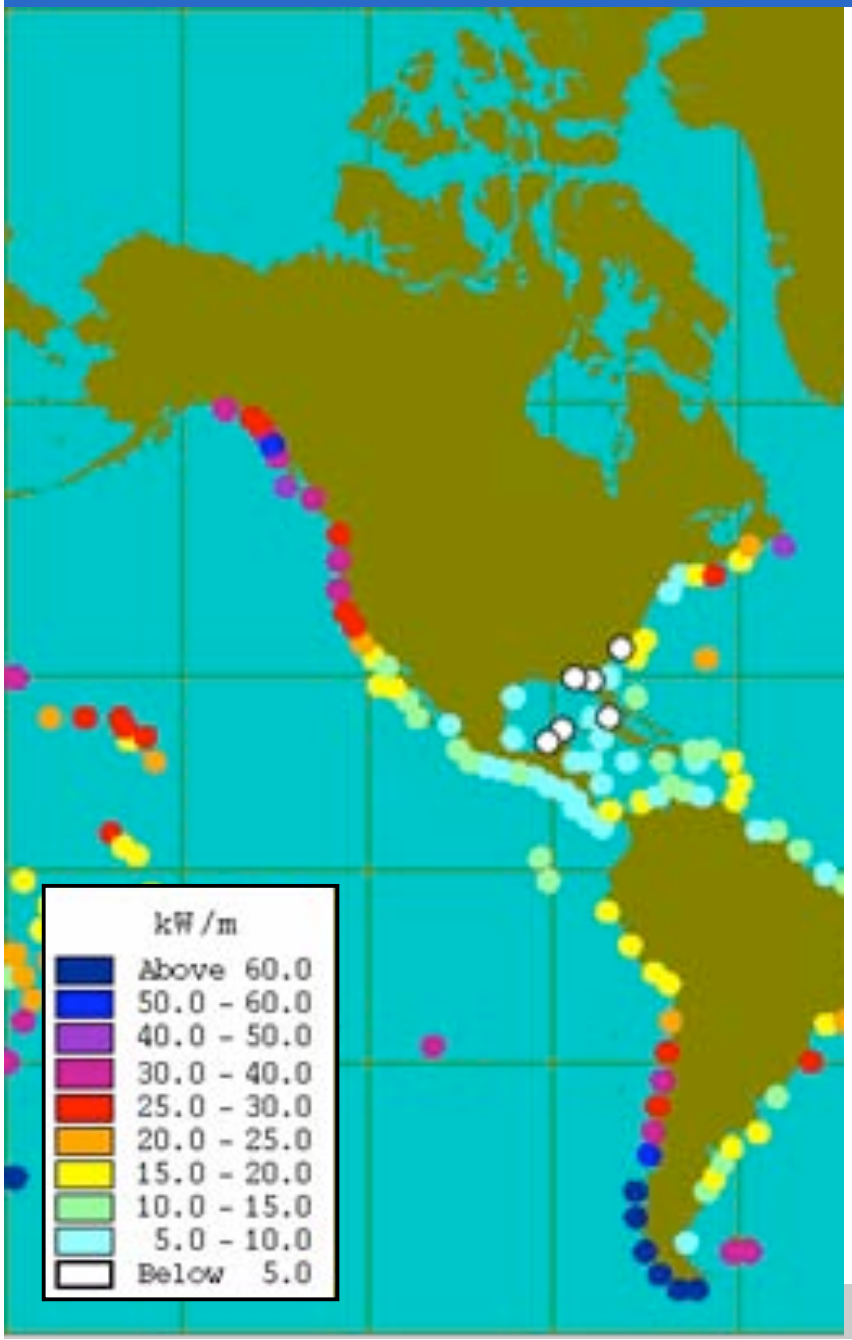
	Potential Rated Capacity (MW)
Arizona	0
Baja California	N/A
British Columbia	1463
California	86
Nevada	0
Oregon	N/A
Washington	36
TOTAL	**1,585***

*note: differs from reportt

- Not recommended for Phase 1B due emerging status of technology

Marine Current Assumptions

Type	Generic offshore
Performance	
Net Plant Capacity (MW)	100
Capacity Factor (percent)	25 to 45
Economics ($2008)	
Total Project Cost ($/kW)	2,200 to 4,725
Fixed O&M ($/kW-yr)	90 to 255
Variable O&M ($/MWh)	Incl. in FOM
Levelized Cost of Energy ($/MWh)	71 to 353



Wave Energy

- As with marine current, resource assessment methods for wave are still preliminary
- Assessment included both total potential available and extractable resource
- Primary and secondary sites considered

Source: EPRI

Wave Assessment Results

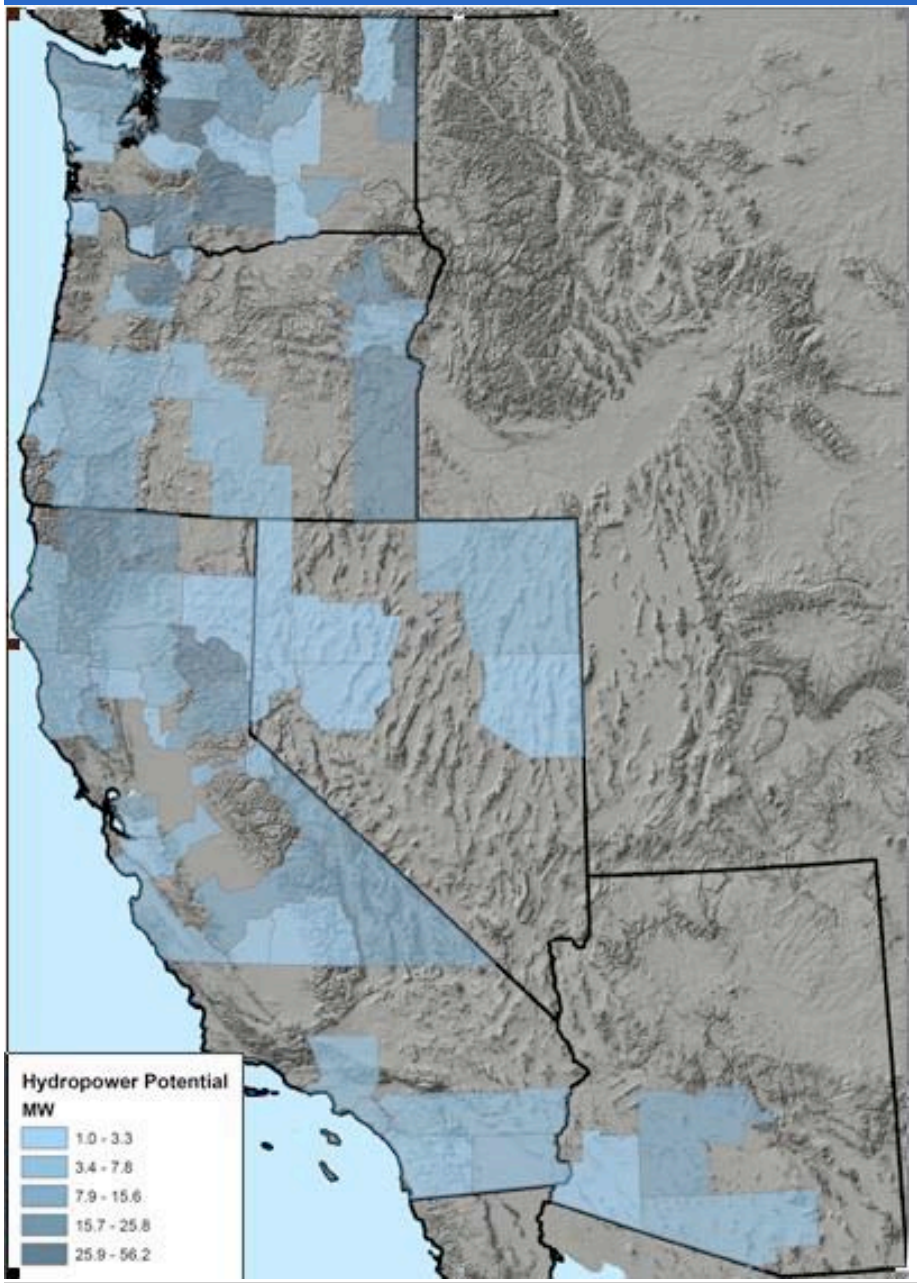
	Potential Rated Capacity (MW) of Primary Sites
Arizona	0
Baja California	N/A
British Columbia	760
California	8,166
Nevada	0
Oregon	3,523
Washington	2,850
TOTAL	**15,299**

- While potential is substantial, not recommended for Phase 1B due emerging status of technology

Wave Assumptions

Type	Generic offshore
Performance	
Net Plant Capacity (MW)	100
Capacity Factor (percent)	25 to 45
Economics ($2008)	
Total Project Cost ($/kW)	2,800 to 5,200
Fixed O&M ($/kW-yr)	150 - 270
Variable O&M ($/MWh)	Incl. in FOM
Levelized Cost of Energy ($/MWh)	105 to 384

- Not recommended for Phase 1B due emerging status of technology



Small Hydro

- Assessment largely based on DOE Idaho National Lab
  - Sites <30 MW
  - Only sites with probability >90% considered (few environmental restrictions)
- Need better data for British Columbia

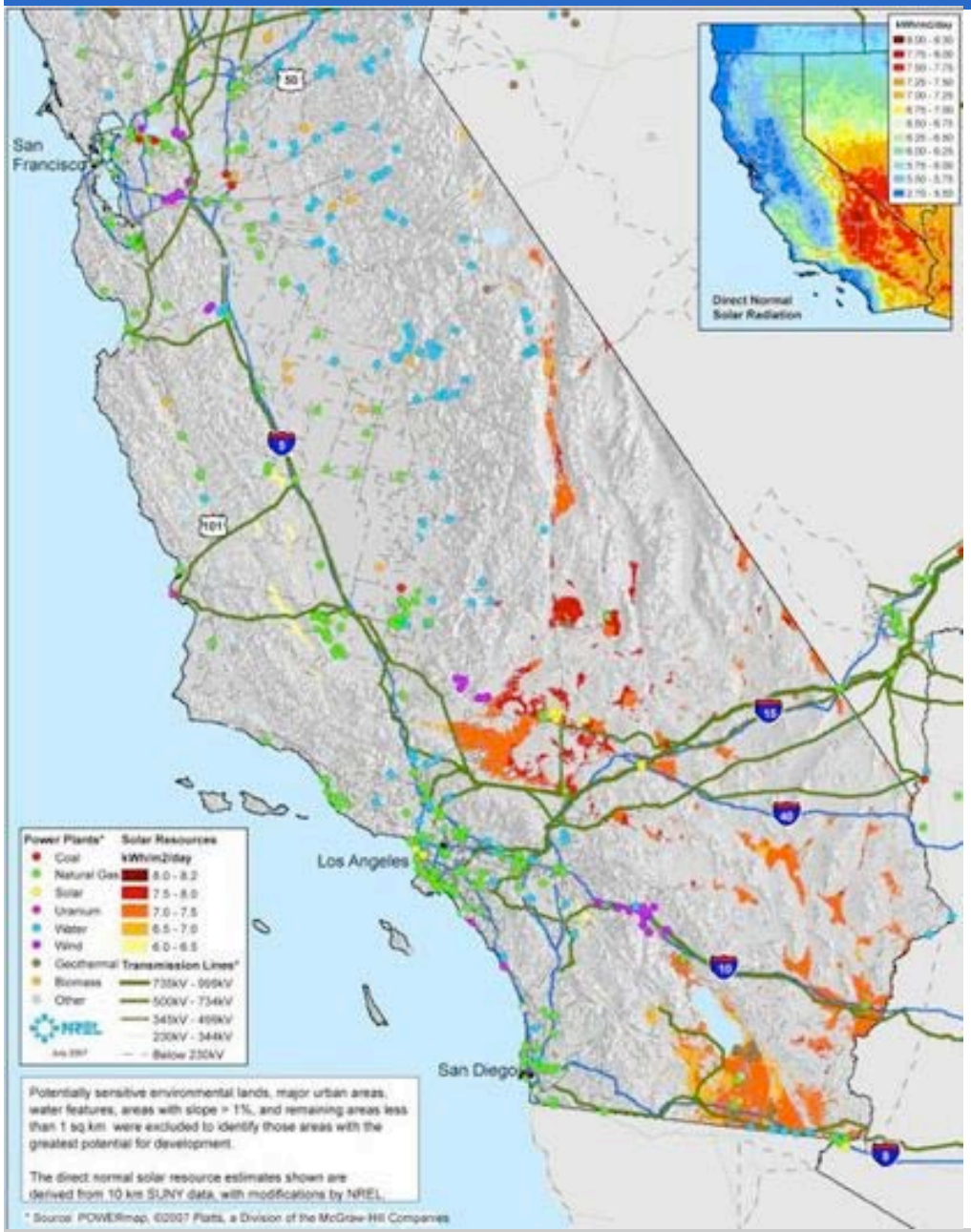
Hydroelectric Assessment Results

	Total Potential (MW) for Sites Between 10 and 30 MW
Arizona	0
Baja California	0
British Columbia	162
California	231
Nevada	0
Oregon	66
Washington	244
Total	**703**

1.1% of California Load

Hydroelectric Assumptions

Type	New	Incremental
Performance		
Net Plant Capacity (MW)	<50	1 to 600
Capacity Factor (percent)	40 to 60	40 to 60
Economics ($2008)		
Total Project Cost ($/kW)	2,500 to 4,000	600 to 3,000
Fixed O&M ($/kW-yr)	5 to 25	5 to 25
Variable O&M ($/MWh)	5 to 6	3.5 to 6
Levelized Cost of Energy ($/MWh)	57 to 136	10 to 98



Solar Thermal

- Significant High Quality Resource in CA, AZ and NV
- NREL GIS-level screen – exclude lands:
  - > 1% slope
  - In National Parks or wilderness areas
  - < 7 kWh/m^2/day
- More sophisticated screen to be developed by environmental working group
- Assumed 25 MW/km^2 (10 acres/MW

Solar Thermal Assessment Results

	Potential Capacity (MW)	
Arizona	316,628	Western Only
Baja California		
British Columbia	0	
California	443,799	
Nevada	172,181	Southwestern Only
Oregon	0	
Washington	0	
Grand Total	932,608	

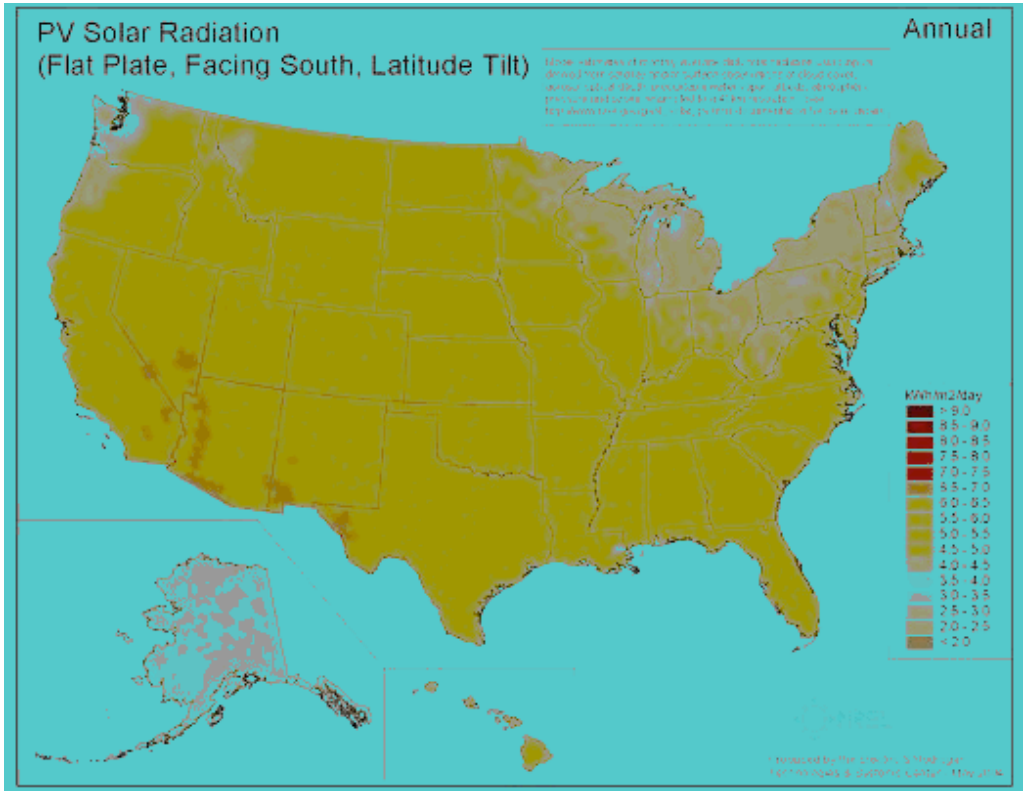
>100% of California 2020 Load

Solar Thermal Assumptions

- Assumed Dry-cooled Parabolic Trough

Performance	
Net Plant Capacity (MW)	200 MW
Integrated Storage	None
Capacity Factor (percent)	26 -29
Economics ($2008)	
Total Project Cost ($/kW)	3600 to 4200
Variable O&M ($/MWh)	N/A
Fixed O&M ($/kW)	66
Levelized Cost of Energy ($/MWh)	137 to 176

Solar Photovoltaic



>100% of California 2020 Load

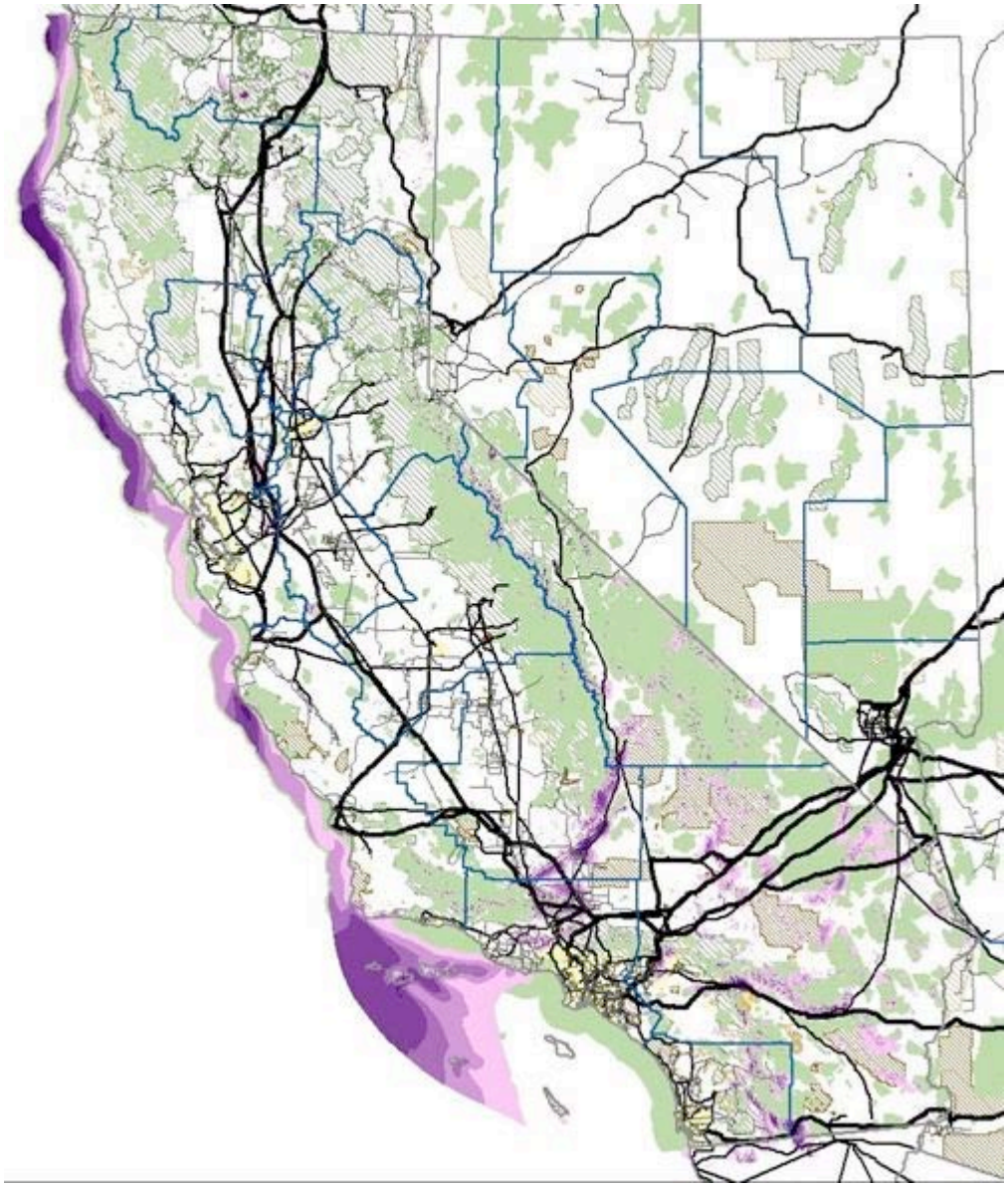
- Practically unlimited resource
- Less strict slope requirement than solar thermal
- Uses global insolation, not only direct normal
- CEC estimate of 17 TW of potential for California
- Only California carried forward, due to enormous technical potential

Solar Photovoltaic Assumptions

- Assumed Single-Axis Tracking Crystalline

Performance	
Net Plant Capacity (MW)	20 MW
Integrated Storage	None
Capacity Factor (percent)	25-30
Economics ($2008)	
Total Project Cost ($/kWe)	6500 to 7500
Variable O&M ($/MWh)	N/A
Fixed O&M ($/kW)	35
Levelized Cost of Energy ($/MWh)	201 to 276

Note: all values are on a net ac basis



Wind

- NREL GIS Analysis for most of region
  - Has numerous environmental and other exclusions
  - Class 4 and higher resources quantified for comparison
- AWS Truewind performed more detailed CA assessment for IAP

Wind Assessment Results (Class 4+)

	Potential (MW)	
Arizona	2,553	
Baja California	1,800	North Only
British Columbia	4,790	
California	21,099	
Nevada	6,178	South Only
Oregon	7,226	
Washington	9,544	
Total	53,190	

51.1% of California 2020 Load

Wind Assumptions

Type	Onshore	Offshore
Performance		
Net Plant Capacity (MW)	100	200
Capacity Factor (percent)	25 to 40	35 to 45
Economics ($2008)		
Total Project Cost ($/kW)	1,900 to 2,400	5,000 to 6,000
Fixed O&M ($/kW-yr)	50	75-100
Variable O&M ($/MWh)	Incl. in FOM	Incl. in FOM
Levelized Cost of Energy ($/MWh)	59 to 128	142 to 232

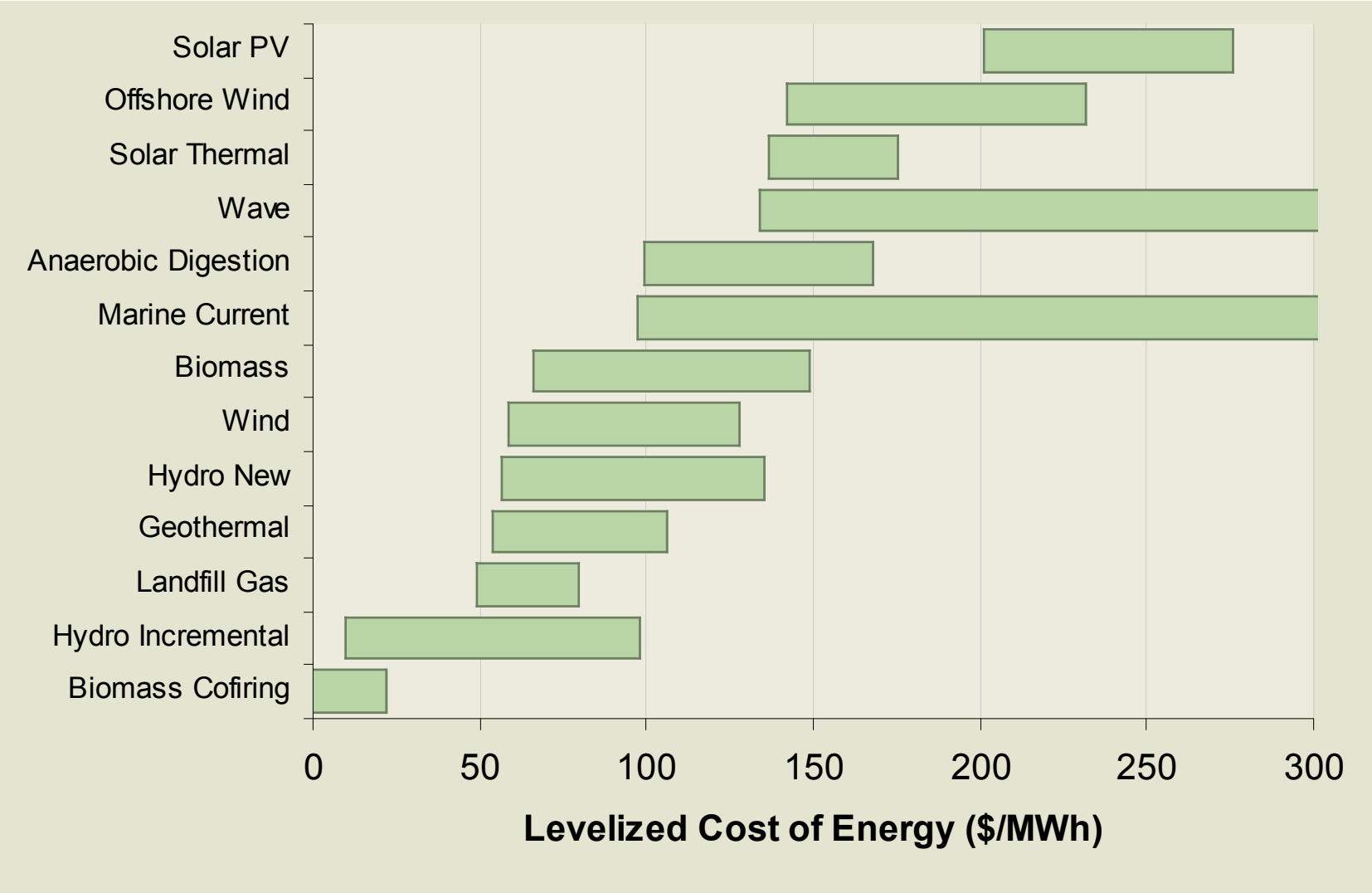
Phase 1A Deliverable: List of Screened Resources

	CA	OR	WA	NV	AZ	Baja	BC
Biomass	8.4%	0.9%	3.3%	0.1%	0.4%		5.2%
Anaer. Dig.	0.6%	0.0%	0.4%		0.0%		0.1%
Landfill Gas	0.3%	0.0%	0.0%	0.0%	0.0%		0.0%
Solar Thermal	>100%			>100%	>100%		
Solar PV	>100%						
Hydro	0.3%	0.1%	0.4%				0.2%
Wind	21.3%	7.3%	9.6%	6.2%	2.6%	1.8%	4.8%
Geothermal	5.4%	0.9%	0.1%	3.4%	0.1%	0.2%	1.4%
Wave	9.3%	4.0%	3.2%				0.9%
Marine Current	0.1%		0.0%				1.6%

List of Screened Resources

Resource Recommendations for Phase 1B.							
	CA	OR	WA	NV	AZ	Baja California, MX	British Columbia, CA
Solid Biomass	✓	✓	✓				✓
Solar Photovoltaic	✓						
Solar Thermal	✓			✓ (south)	✓ (west)		
Small Hydro	✓	✓	✓				✓
Onshore Wind	✓	✓	✓	✓ (south)		✓ (north)	✓
Geothermal	✓	✓		✓			✓

LCOE From Technology / Financial Assumptions



Future Cost and Performance

- Marine energy technologies (wave, current, off-shore wind) are still developing
- Solar technologies are still evolving
  - However, competitive today based on market
  - May examine cost reduction in alternative scenario
- Other renewable technologies relatively mature
  - Expected to exhibit same relative improvement

Key Methodological Issues

Phase 1A Draft Report – March 14

Executive Summary

Introduction

Methodology

Assumptions

Technology Characterization

Resource Screening

Phase 1B Scope of Work

Report Section 3 – Methodology

- RETI Phase 1 Methodology Overview
- Base Case Definition
- Resource Assessment and Project Identification
- Technology Characterization
- Environmental Considerations
- Transmission Methodology
- Resource Valuation
- Future Cost and Performance Projections
- Supply Curve Development
- CREZ Identification and Characterization

Generation Included in RETI Base Case

- Existing resources
- Projects under construction
- Proposed projects with all three of:
  - Power Purchase Agreement (or equivalent for utility-owned)
  - Permitting / siting approval
  - Transmission agreements

Same criteria used for California and non-California resources

Transmission Included in RETI Base Case

- Existing transmission
- Transmission projects under construction
- Transmission projects approved by the transmission control operator

Same criteria used for California and non-California transmission projects

Resource Valuation Methodology

- Valuation is a way to measure disparate resources consistently. Valuation is designed to identify:
  - Lowest cost renewable resources

    and

  - Highest value renewable resources
- Values will be used to:
  - Develop resource supply curves
  - One of criteria used to develop and rank CREZ's

RETI valuation methodology to be consistent with process utilities use to procure renewable resources

Resource Valuation Methodology

Ranking Cost = Costs - Value

Costs	Value
Generation Cost + Transmission Cost + Integration Cost	Energy Value + Capacity Value

Generation Cost

- Levelized Cost of Energy (LCOE) - $/MWh
  - Calculated using a pro forma cash flow model for each project
  - Model is consistent with that used by the CPUC for MPR, CEC for Cost of Generation

Technology – Specific Assumptions	
Capital Cost	**Incentives**
Fixed O&M	**Net Plant Output**
Variable O&M	**Capacity Factor**
Fuel Costs	**Economic Life**
Heat Rate	

General	**Discount Rate** **Inflation**

Transmission Cost

- Levelized Cost of Transmission (LCOT) - $/MWh
  - Calculated with economic model consistent with that used by California IOUs

Fixed Costs

- **Resource interconnection costs**
- **Network upgrade costs**
- **Trunk line costs**

Variable Costs

- **Transmission access / wheeling charges**
  - **Assume CAISO charges for all projects**
  - **Pancake wheeling rates for out-of-state resources**
- **FTR/CRRs – no cost / value assumption**

Integration Cost

- Integration cost will be neglected in the base case
  - CEC has not adopted integration values
  - CAISO identifies integration requirements but not cost

May be revisited in RETI Phase 2

Energy Value

Energy value = (resource generation) x (zonal, T.O.D. market price), where:

- Market Price – hourly forecast (2010-2020) using commercially available production cost model
- Zonal prices – energy priced in zone where resource is located (15 zones):
  - 8 in California, 7 outside California
- TOD factors – based on WECC trade periods
  - Super-peak
  - On-peak
  - Off-peak

Price Zones

N. California (NP15)	Imperial I.D.	N. Nevada
C. California (ZP26)	Imperial V. - NG	S.Nevada
SCE	CA/OR Border (COB)	Palo Verde
LADWP	Pacific Northwest	Arizona
SDG&E	British Columbia	N. Baha (Mex.)

Capacity Value

Capacity value = (Resource availability) x (Annual value of capacity),

where:

- Resource Availability – projected average resource capacity factor during 12:00 - 6:00 p.m. period (*summer* months)
  - Consistent with current Resource Adequacy practice
- Annual Value of Capacity – fixed carrying costs of the gas turbine (Capital Costs, Fixed O&M, fixed charges)
  - $204/kW-yr per CEC Cost of Generation

Example Ranking Cost Calculation

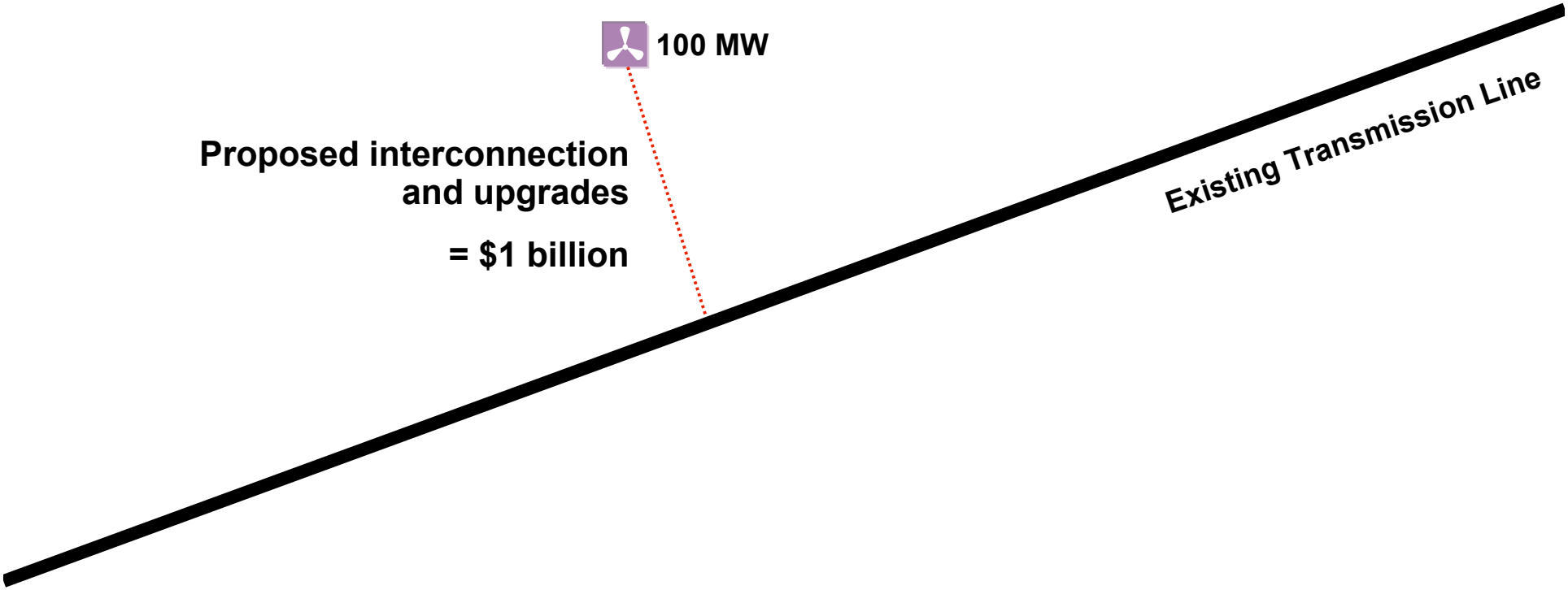
Generation Cost =	+ $70 / MWh
Transmission Cost =	+ $10 / MWh
Energy Value=	- $60 / MWh
Capacity Value =	- $5 / MWh
Rank Cost =	**+ $15/MWh**

CONCEPTUAL – FOR EXAMPLE ONLY

What is a Competitive Renewable Energy Zone?

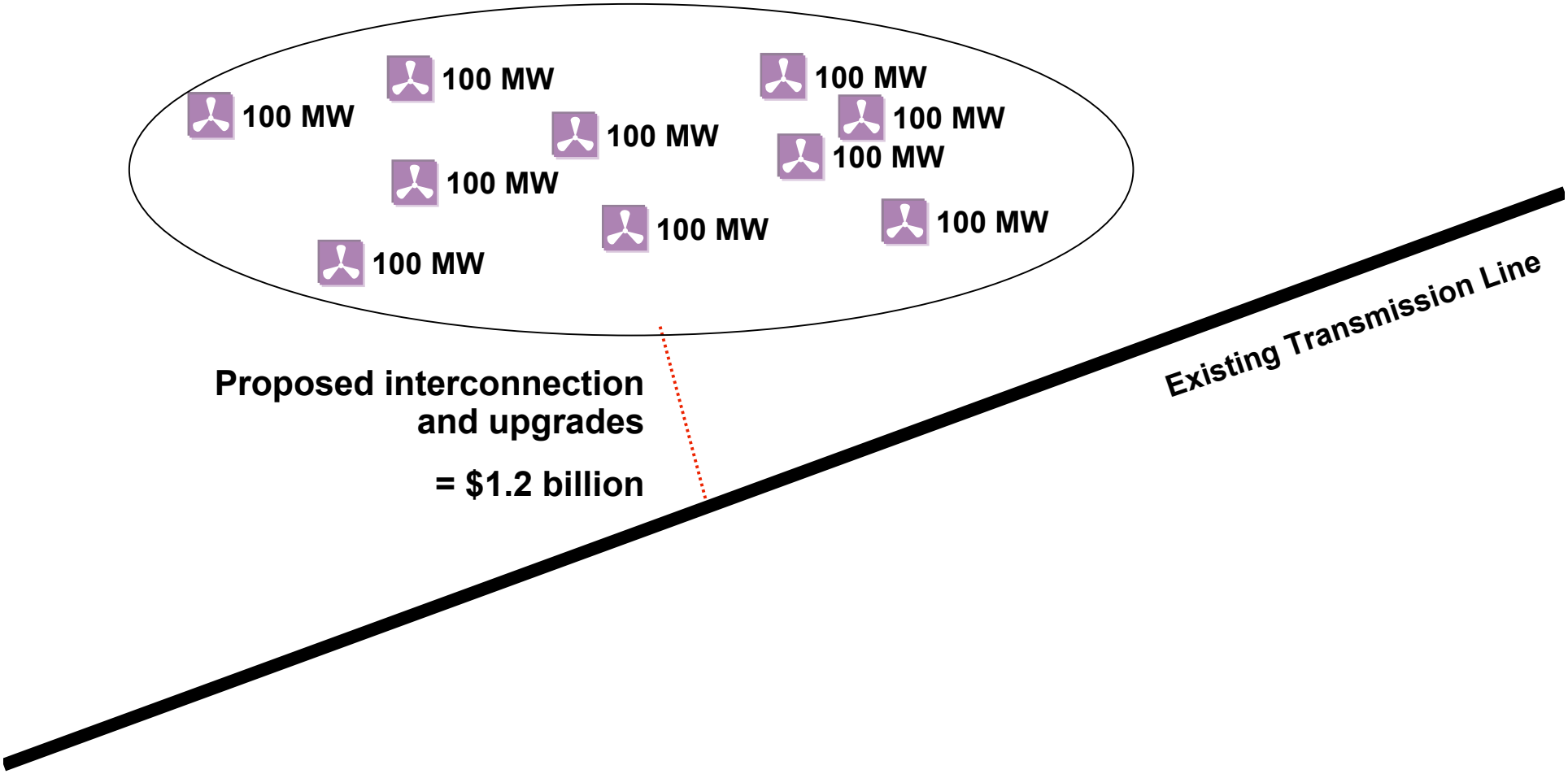
- A group of projects that when combined has improved economics (ie, Economies-of-scale)
- *Also -*
  - Common transmission interconnection
  - Similar development timeframe

Simple CREZ Example



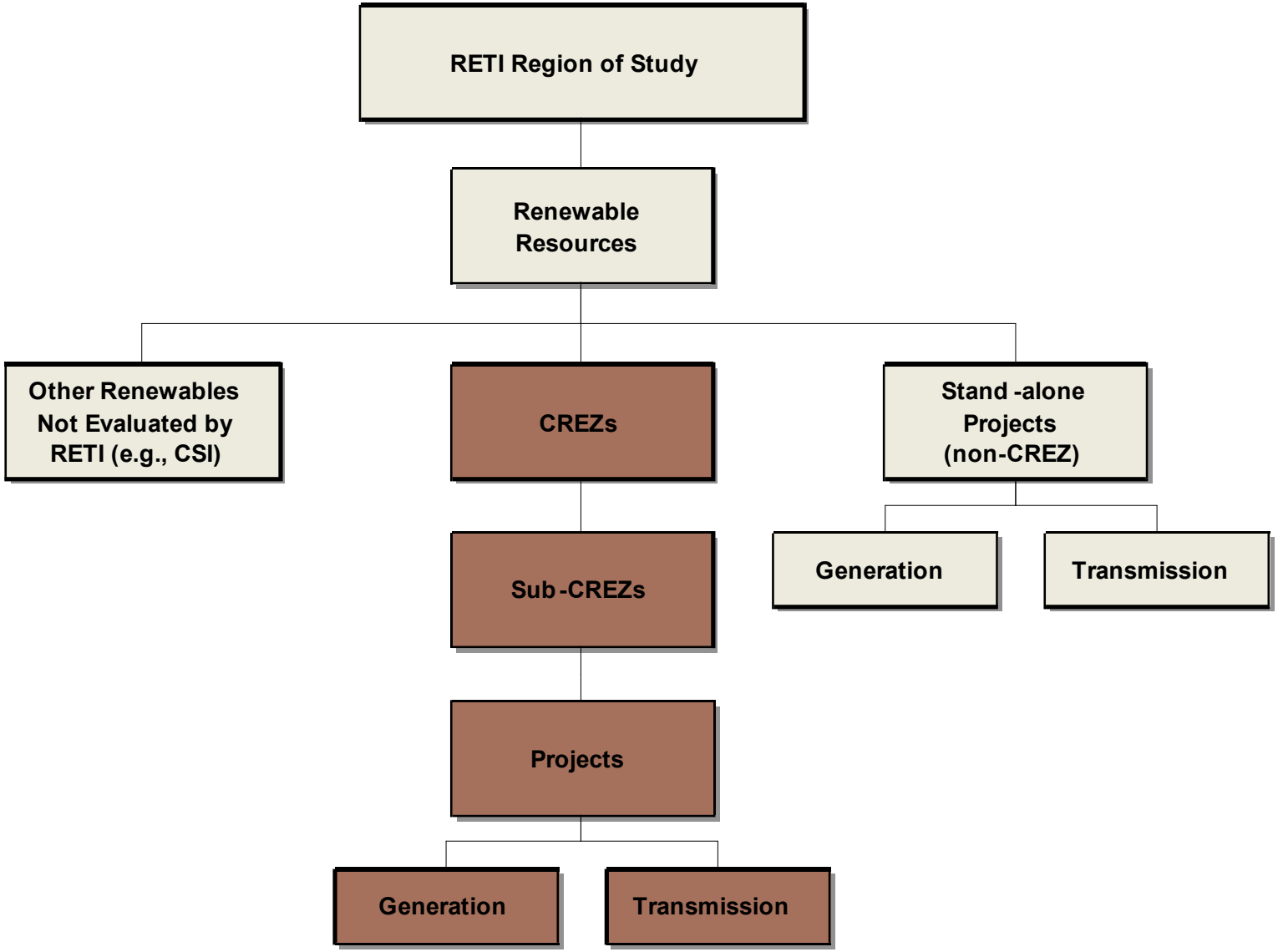
CONCEPTUAL – FOR EXAMPLE ONLY

Simple CREZ Example

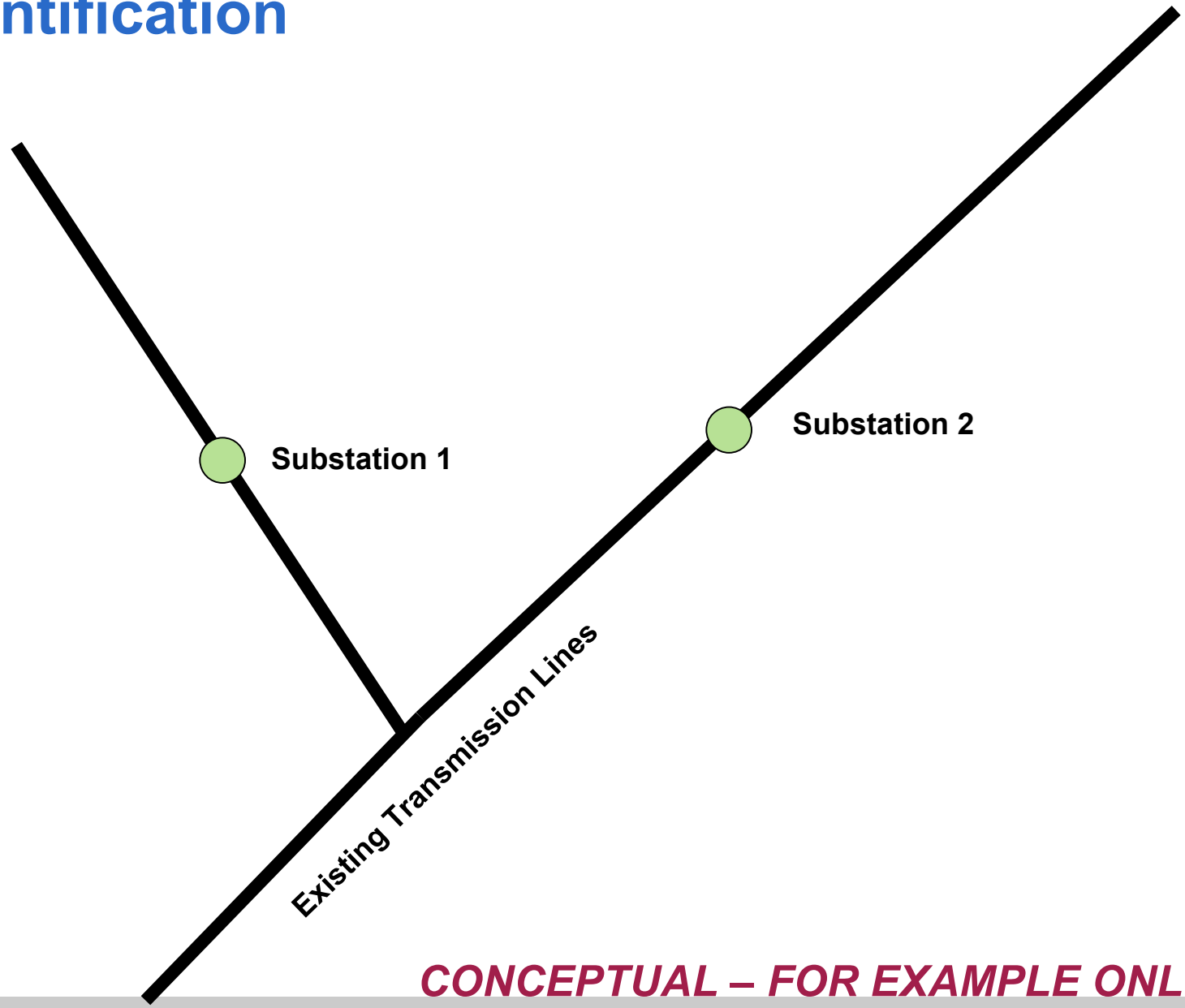


CONCEPTUAL – FOR EXAMPLE ONLY

RETI Structure and CREZs

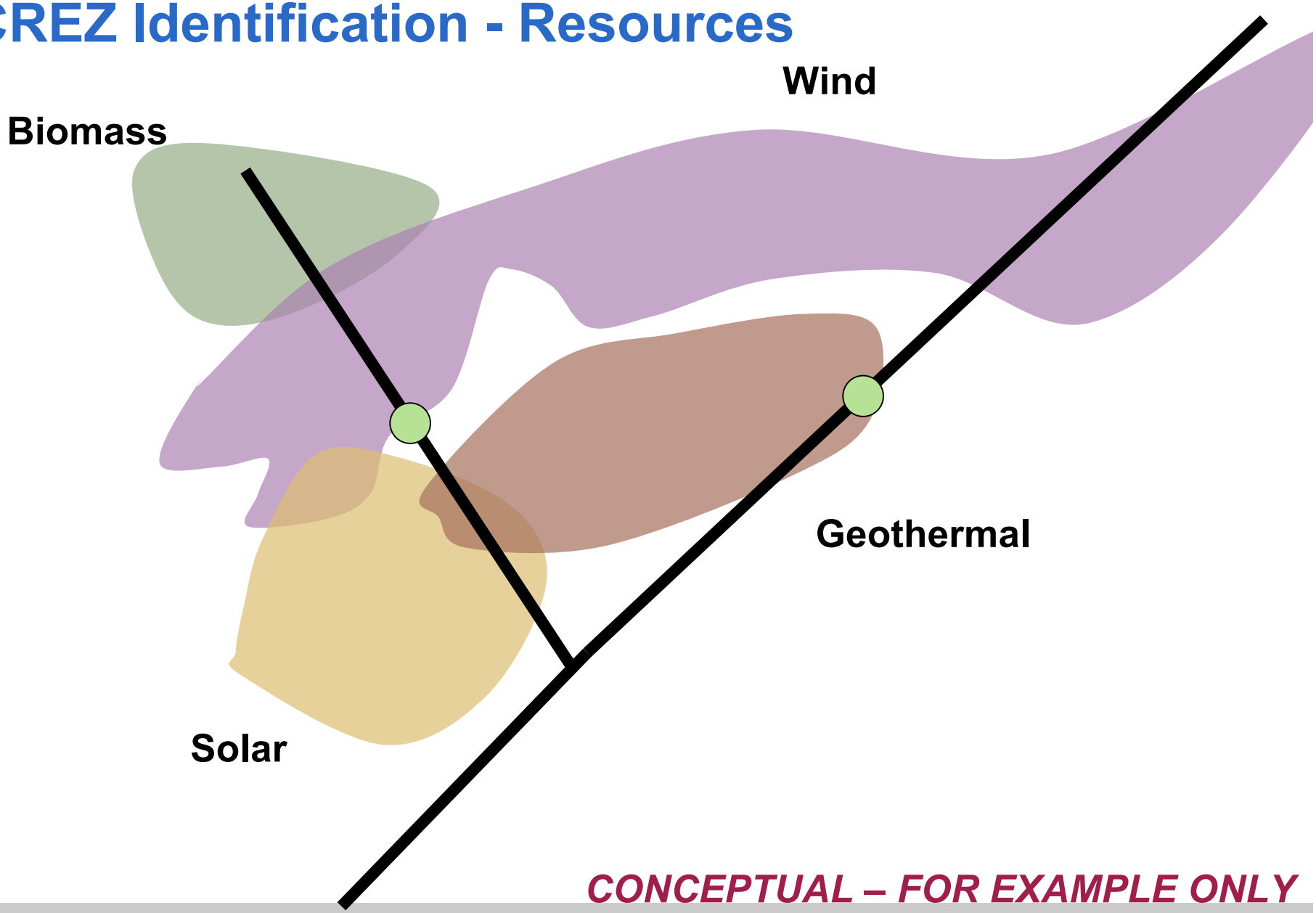


CREZ Identification



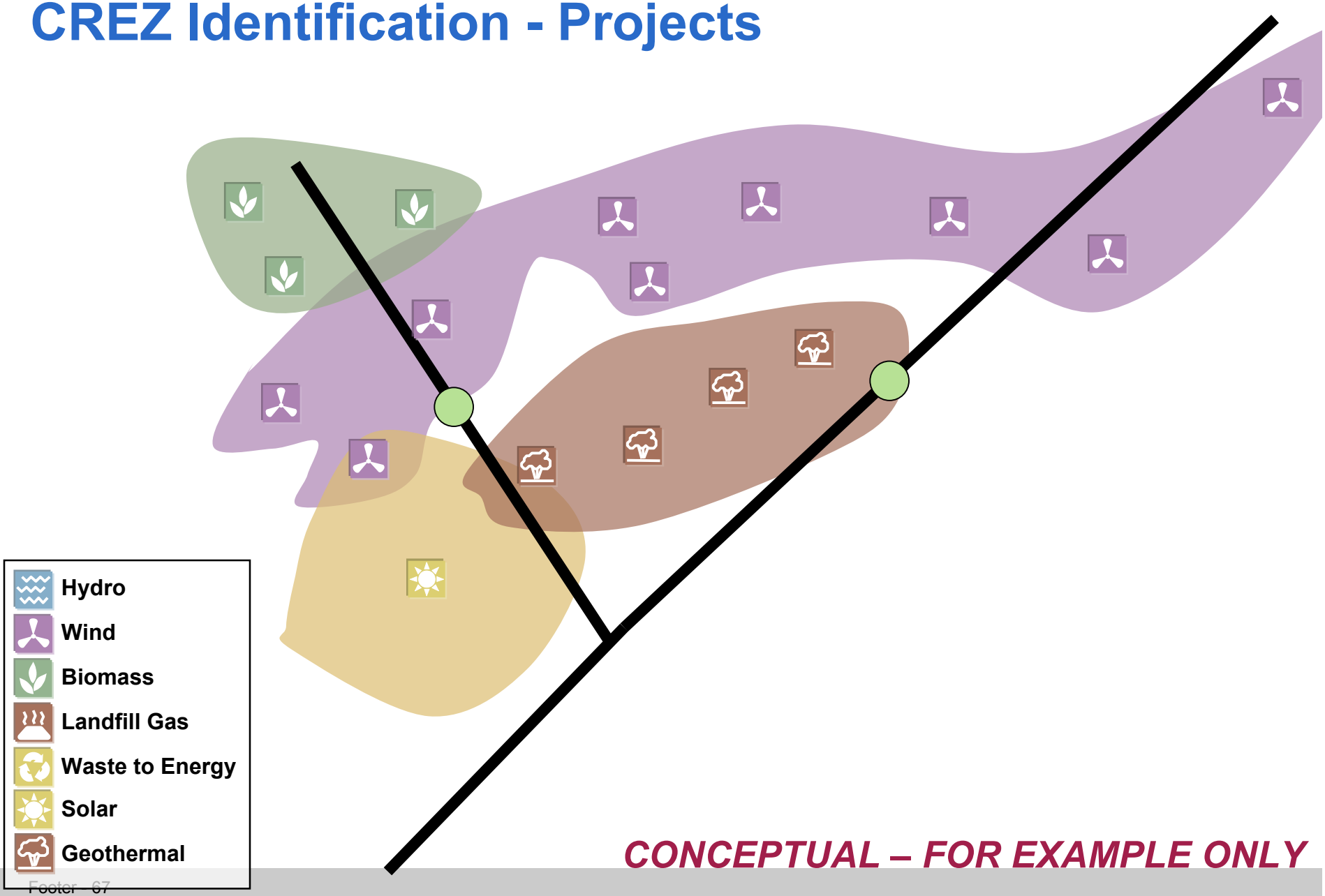
CONCEPTUAL – FOR EXAMPLE ONLY

CREZ Identification - Resources



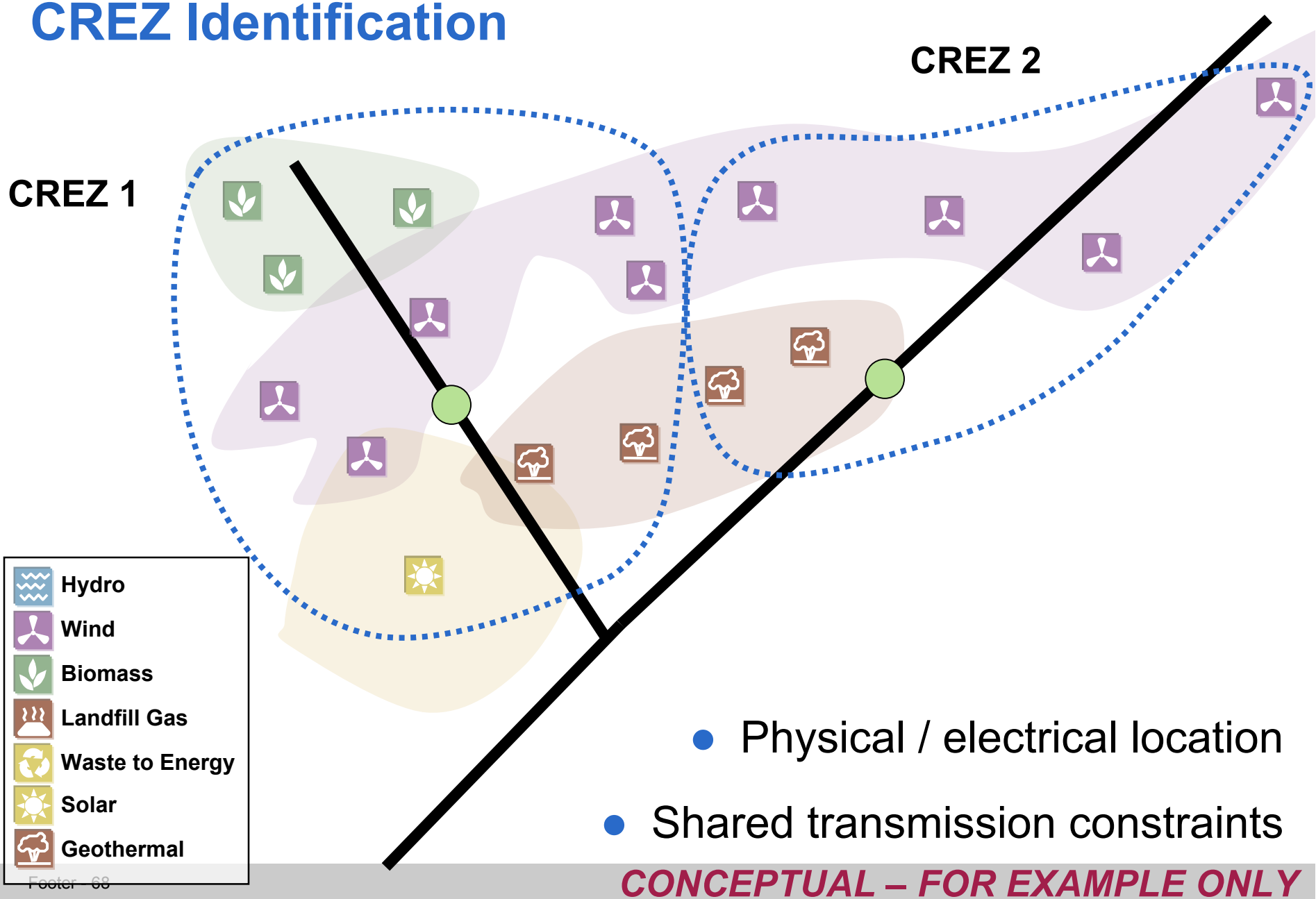
CONCEPTUAL – FOR EXAMPLE ONLY

CREZ Identification - Projects



CONCEPTUAL – FOR EXAMPLE ONLY

CREZ Identification

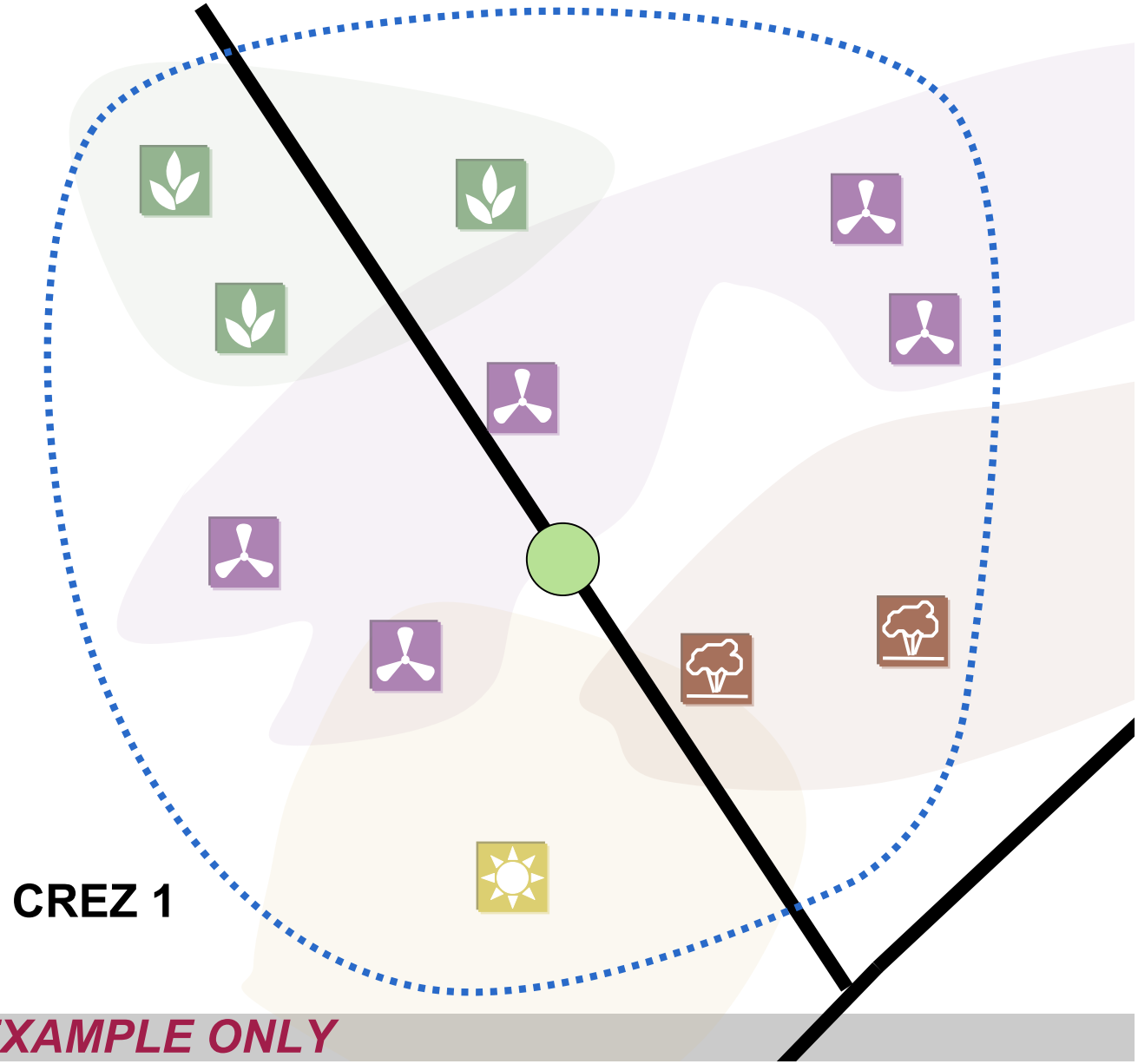


- Physical / electrical location
- Shared transmission constraints

CONCEPTUAL – FOR EXAMPLE ONLY

Sub-CREZ Delineation

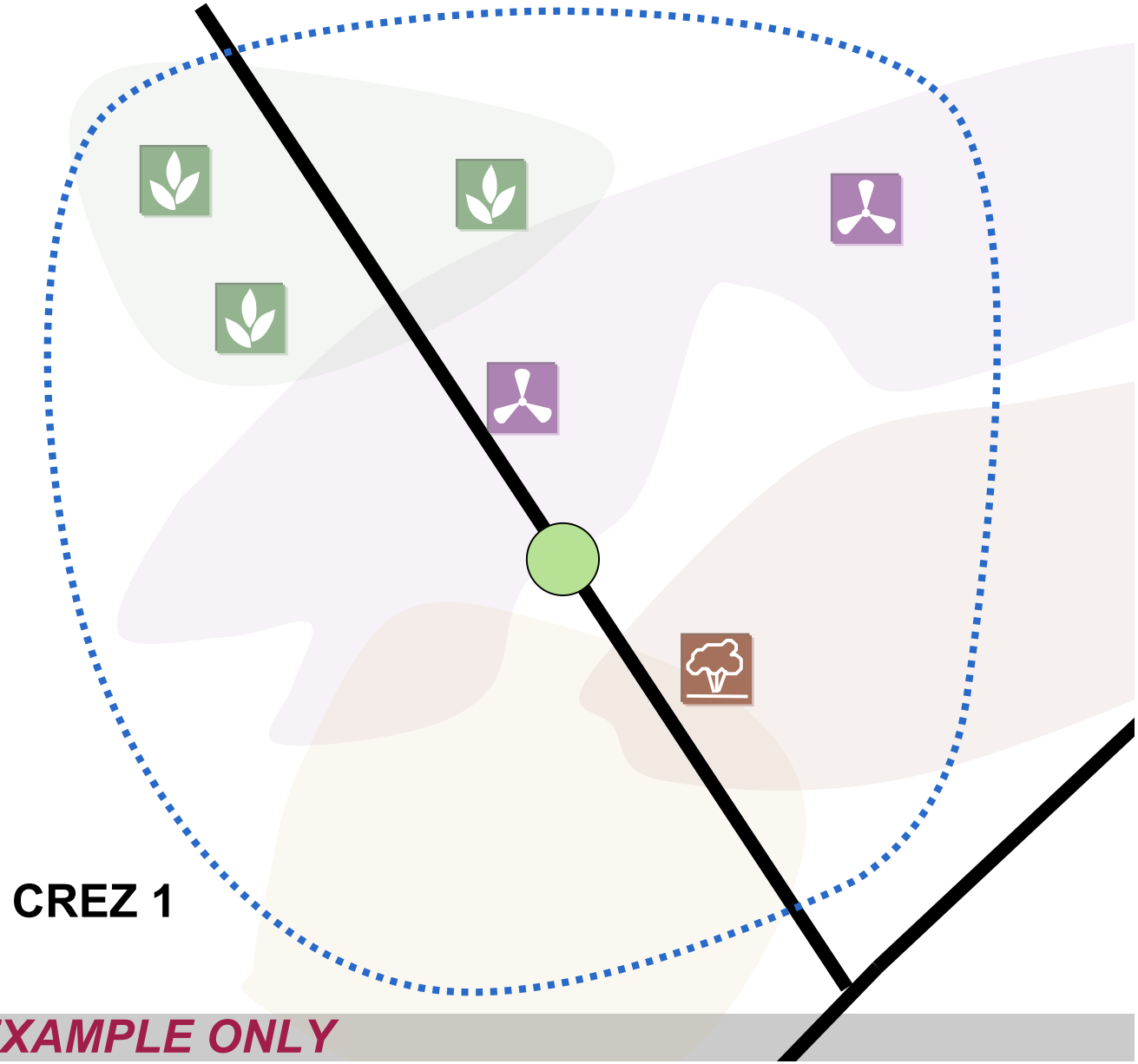
- Timeframe
- Economics



CONCEPTUAL – FOR EXAMPLE ONLY

Sub-CREZ Delineation

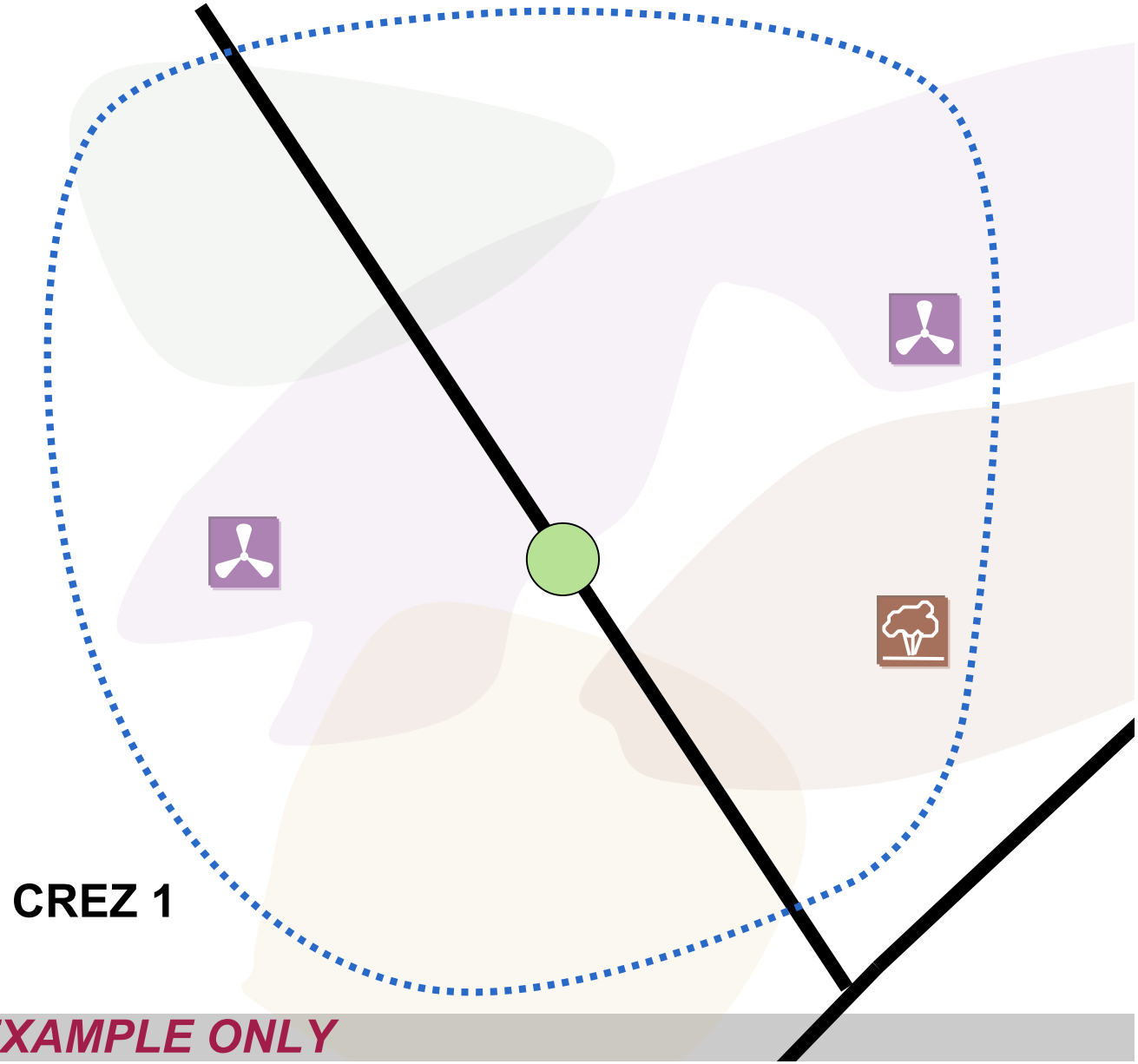
- Timeframe = **NEAR-TERM** (prior to 2013)



CONCEPTUAL – FOR EXAMPLE ONLY

Sub-CREZ Delineation

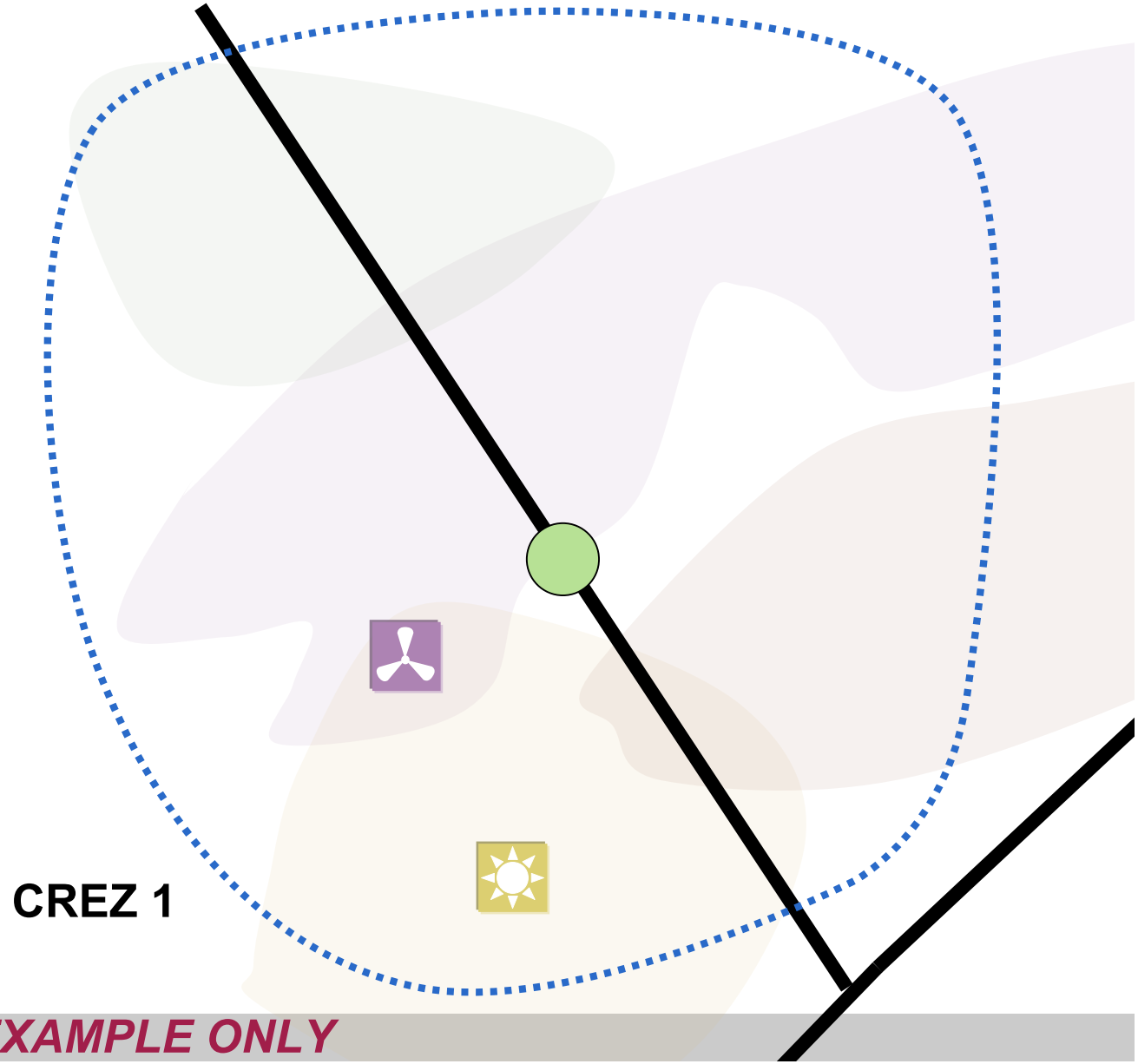
- Timeframe = **MID-TERM** (2013-2016)



CONCEPTUAL – FOR EXAMPLE ONLY

Sub-CREZ Delineation

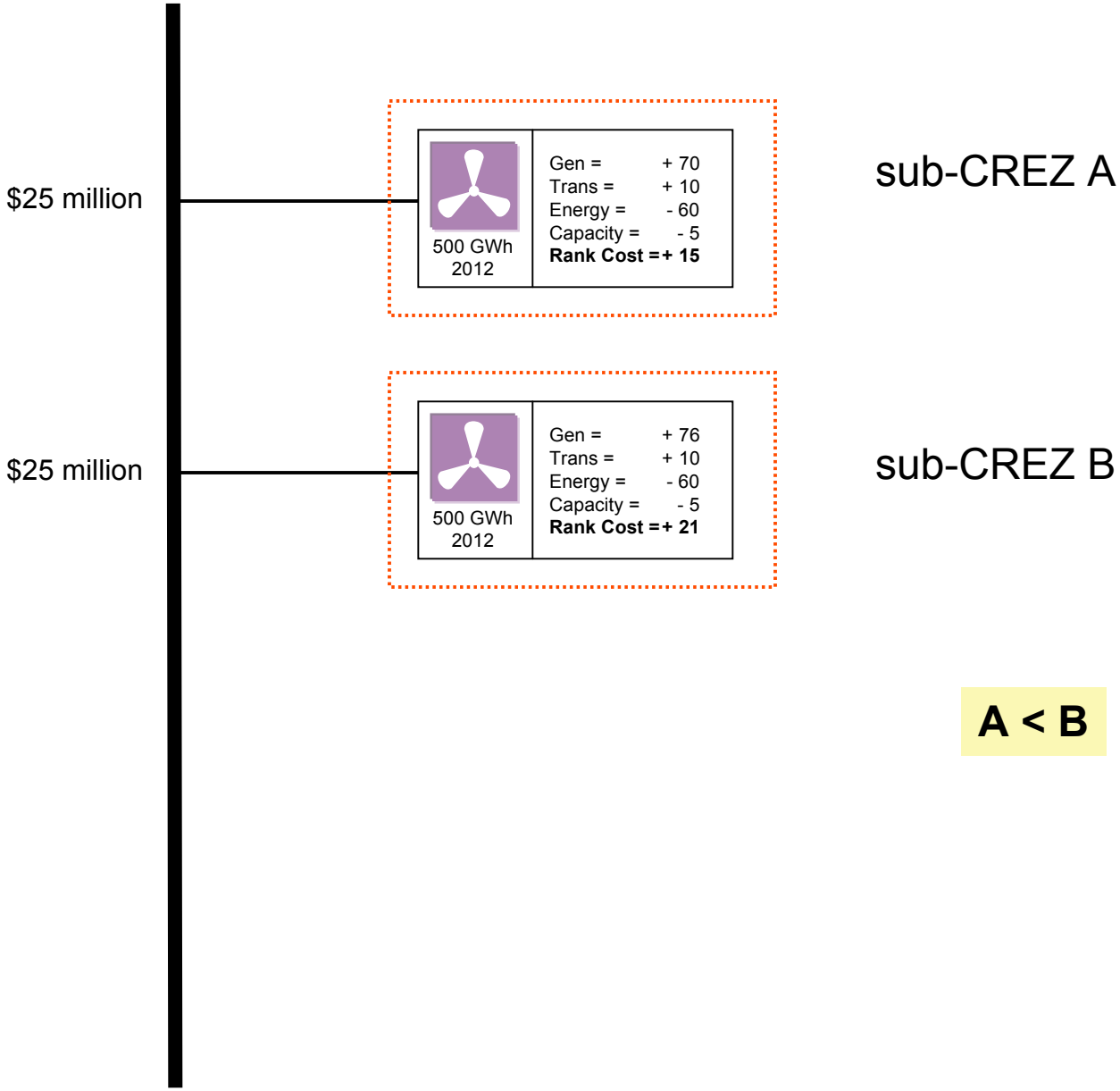
- Timeframe = **LONG-TERM** (2017-2020)



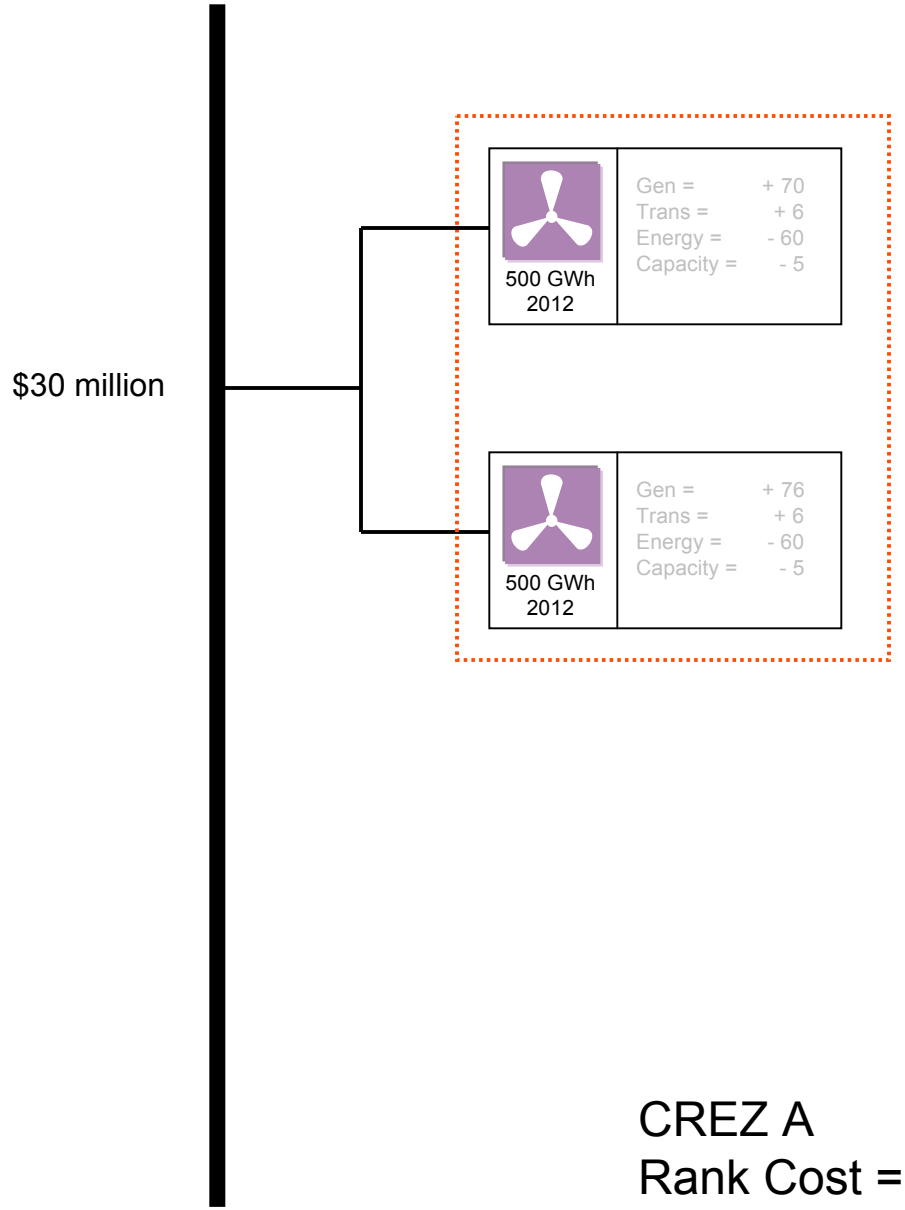
CONCEPTUAL – FOR EXAMPLE ONLY

Principle of Additive Economics in Identifying Sub-CREZs

- If two or more projects have improved economics when they are pooled together, then the projects will be grouped as sub-CREZ
- If adding a project does not improve the economics of the collective sub-CREZ, then a new sub-CREZ will be formed for that project



CONCEPTUAL – FOR EXAMPLE ONLY



Sub-CREZ C

Gen =	+ 73
Trans =	+ 6
Energy =	- 60
Capacity =	- 5
Rank Cost =	**+ 14**

C < A < B

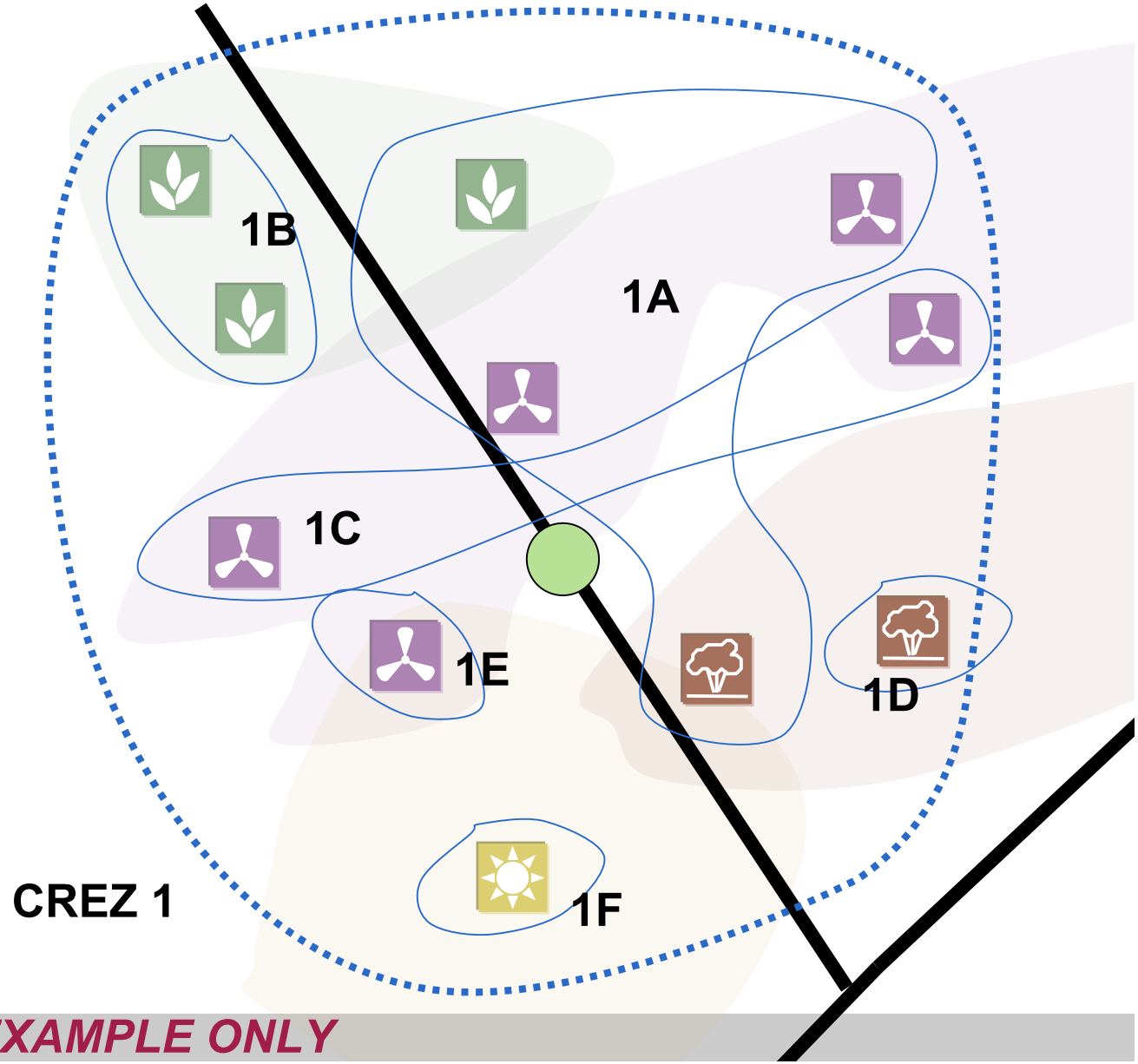
CREZ A
Rank Cost = 15

CREZ B
Rank Cost = 21

CONCEPTUAL – FOR EXAMPLE ONLY

Sub-CREZ Delineation

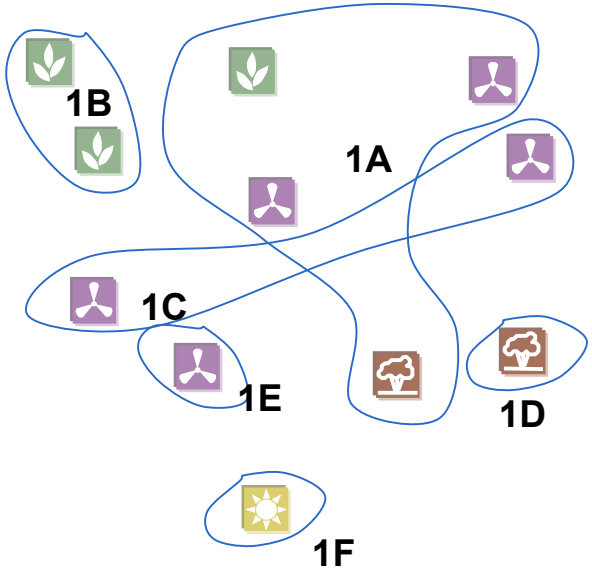
- Timeframe + Economics



CONCEPTUAL – FOR EXAMPLE ONLY

CREZ Characterization and Ranking

- Sub-CREZ characteristics will be developed based on constituent projects



	Timeframe Available	Annual Generation (GWh)				Resource Valuation (2008$/MWh)				Ranking Cost
		Wind	Geo	Solar	Bio	Gen	Trans.	Energy	Capacity	
CREZ 1A	Near	600	300		350	80	7	73	9	5
CREZ 1B	Near				600	97	10	75	13	20
CREZ 1C	Mid	500				80	15	70	6	19
CREZ 1D	Mid		250			95	15	75	13	23
CREZ 1E	Long	400				84	15	70	6	23
CREZ 1F	Long			700		140	20	100	22	38

CREZ Characterization and Ranking

- All potential sub-CREZs in a given time period will be compared
- The needed RPS demand for that period will be identified
- The lowest cost sub-CREZs will be built until demand is met

Phase 1B Scope of Work and Schedule

Phase 1B

- Schedule: April – August 2008
- Proposed Scope of Work - Draft Phase 1A Report, Appendix A
- Please provide any comments on Phase 1B Scope in comments to the Draft Phase 1A Report

Phase 1B Scope of Work

- Project identification and characterization
- Assessment of project and transmission costs
- Development of supply curves
- Integration modeling
- CREZ identification and characterization

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BLACK & VEATCH

Thank You!

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