Interregional Transmission Benefit Accrual Study

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Energy+Environmental Economics

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Outline

1. Executive Summary
2. Background and Project Motivation
3. Challenges and solutions to interregional transmission planning and benefit accrual
4. Solutions: defining and categorizing distinct interregional transmission benefits
5. Benefit accrual calculator skeleton
6. Topics for regulatory proceedings

Outline

Executive Summary (1/2)

+ Background

- Previously, E3 supported Electricity Canada in understanding the role of transmission in net-zero
- E3 found that interregional transmission is understood to have widespread social, environmental, and economic benefits; however, one of the largest barriers to transmission development is the lack of common cost allocation and benefit accrual methodologies
- Contributes to the under-valuation and under-development of transmission in interregional planning

+ Benefit categorization and allocation is complex

- Through a literature review E3 developed an understanding of the benefit accrual landscape while also highlighting past and current efforts on benefit accrual processes for transmission projects:
  - Disconnect in evaluating benefits between those involved in transmission project seen across the US; similarities can be draw between the challenges highlighted in the literature review and Canada’s challenges
- There has yet to be a consistently successful benefit allocation framework developed for more than two entities
  - FERC Order 1000 meant to encourage regional cost and benefit allocation frameworks, but has been unsuccessful
    - Agreement on a methodology is difficult between parties
  - US RTO inter-jurisdictional allocation framework currently under development does not stem from the need for interregional transmission but rather from a shared interconnection issue

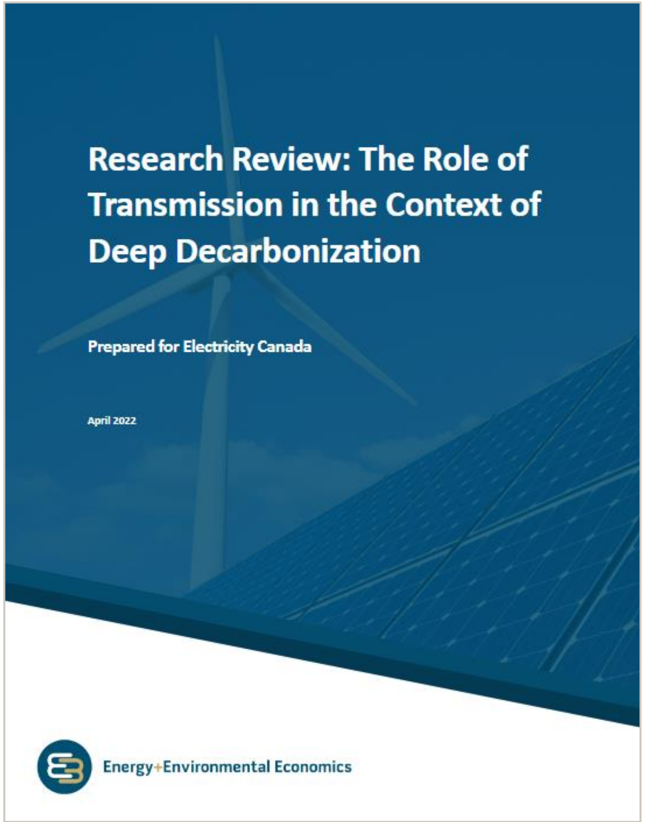
Executive Summary (2/2)

- **Benefit accrual frameworks should be established on a fundamental list of transmission benefits**
  - FERC provides a list of benefits from which to evaluate transmission projects
  - To facilitate an understanding of functional differences between benefits, the list can be categorized by:
    - Benefits that have quantification methods that are well understood and widely utilized versus those that are more uncertain
    - Benefits that accrue to individual ratepayers versus more widely to society
- **Solutions that build off a solid benefit accrual framework will be most effective with the involvement of body that can enforce the framework and enable constructive discussion**
  - Federal government can play this role within the context of Canada’s interregional transmission planning
  - Either as an entity with a stake in a transmission project or as a convening body to ensure benefit framework is being implemented fairly and appropriately
- **Benefit accrual skeleton calculator**
  - E3 has built an excel-based model that allows stakeholders to view benefit categories and calculate benefit accrual
  - The calculator can be used to facilitate discussion and negotiation during transmission planning processes
- **Topics for regulatory proceedings addressing Canadian interregional transmission planning: (1) common benefit accrual processes across Canada; (2) expanding the role of Federal government**

Outline

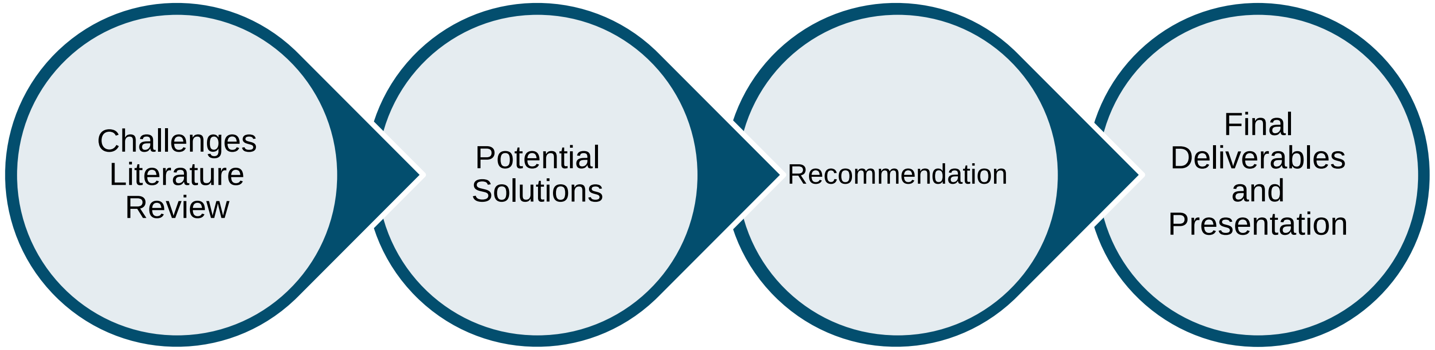
Background and Project Motivation

+ **Previously, E3 developed a report on the role of transmission in the context of Net-Zero**



+ **Recommendations that came out of that paper from previous project included:**
  - Establishing a reasonable cost allocation framework for new inter-regional transmission
  - Defining a role for the Federal Government

Current Project Tasks



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Literature Review Summary

Benefit Accrual Challenges and Solutions

- Challenges related to modeling/measuring transmission benefits
- Limitations and solutions to existing planning and benefit accrual processes
- Defining potential benefits

Regional and Interregional Examples

- Lessons learned from MISO's recent Long-Range Transmission Plan
- Solutions developed by SPP's collaborative stakeholder group
- Benefits and shortfalls of MISO & SPP's ongoing interregional planning process

Federal Backstop Authority

- History and downfall of federal backstop transmission planning authority in the US
- How federal backstop authority can be revamped with regulatory or legislative action

Literature Review Summary

Title	Organization	Description
Benefit Accrual Challenges and Solutions:		
Evaluation of Production Cost Modeling for Transmission Cost Allocation	E3 on behalf of the Northern Tier Transmission Group (NTTG)	• Uses production cost models to measure benefits of regional transmission per Order 1000 compliant cost allocation process • Details challenges to modeling accuracy and precision related to lack of access to real net revenue data, challenges in capturing impacts of bilateral contracts, and inability to capture changes in generation resources
Regulations Amending the Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations	Canada Gazette, Part I, Volume 152, Number 7	• Analysis of proposed regulatory action requiring emissions performance limits on coal-fired power generators • Provides useful quantification methods for valuing the impact of reducing greenhouse gas emissions and air pollutants
Notice of Proposed Rulemaking Addressing Transmission Planning and Cost Allocation	U.S. Federal Energy Regulatory Commission (FERC)	• FERC outlines key recommendations to overcome barriers to efficient regional and interregional transmission expansion • Solutions include involving states in cost allocation decisions, requiring 20-year planning horizons, using scenario-based planning, improving transparency in benefit accrual methodologies, better aligning transmission planning and generator interconnection processes • Details a list of transmission benefits and quantification methodologies but does not require their use
Potential Customer Benefits of Interregional Transmission	General Electric International, Inc. prepared for ACORE	• Outlines key benefits of interregional transmission under deep decarbonization scenarios and quantification methodologies • Focuses on reliability and resilience
The Value of Increased HVDC Capacity Between Eastern and Western U.S. Grids: The Interconnections Seam Study	National Renewable Energy Laboratory (NREL)	• High-resolution modeling showing the benefits of increasing capacity and quantity of HVDC interconnection between eastern and western grids in the US
MISO & SPP Examples:		
Enabling Low-Cost Clean Energy Reliable Services Through Better Transmission Benefits Analysis	American Council on Renewable Energy (ACORE)	• Compares MISO's LRTP benefit metrics to the comprehensive list identified by FERC, suggesting that MISO expands its list of quantified benefits for future tranches of LRTP
Regional Cost Allocation Review Report	Southwest Power Pool (SPP)	• Detailed list of benefit accrual categories and measurement methodologies to be considered in SPP's Integrated Transmission Plan and Highway-Byway postage-stamp cost allocation methodology
Joint Targeted Interconnection Queue Technical Report	Midwest Independent System Operator (MISO) & SPP	• Report detailing 7 projects identified to increase interregional transmission capacity • Details benefit accrual and cost allocation hurdles between regions that are otherwise leaders in regional transmission expansion
Federal Transmission Planning Backstop Authority:		
Building a New Grid Without new Legislation: A Path to Revitalizing Federal Transmission Authorities	Columbia SIPA Center on Global Energy Policy	• Reviews history of Federal transmission planning backstop authority and why it has failed to produce results • Suggests solutions for FERC to clarify their authority and utilize backstop opportunities without need for legislation
Transmission Stalled: Siting Challenges for Interregional Transmission	Niskanen Center	• Details possible legislative opportunities to bolster federal backstop authority • Solutions include establishing federal siting authority, expanding and clearly defining backstop authority, using federal rights-of-way for siting, creating Investment Tax Credit for transmission, and creating equitable eminent domain practices

Benefit Accrual Challenges

- **Undercounting of benefits results in inefficiently low levels of transmission expansion**
  - Quantified benefits vary depending on planning entity
- **Interregional planning requires reconciliation of key planning methodologies**
  - Planning regions may not reach agreement on power flow modeling techniques and dispatch methodologies
    - Ambiguity over interregional transmission transfer capacity and how to value it
    - Discrepancy in regional policy goals creates perceptions of winners and losers on policy-related benefits
  - Uncertainty over defining and measuring interregional resiliency and reliability transmission benefits
  - Discrepancies in benefit accrual methodologies lead to least-common denominator approach, undervaluing projects
- **Agencies that issue transmission project permits may delay or reject projects if they do not agree with benefit-cost analysis**
  - States and litigation functionally eliminated backstop authority in US

Benefits Assessments Across US RTOs

	SPP	MISO	CAISO	NYISO
	2016 Regional Cost Allocation Review, 2013 Metrics Task Force	*2011 Multi Value Projects Analysis*	*2007 Team Analysis of Devers–Palo Verde No. 2 Transmission Line Project*	*2015 Study of Proposed AC Transmission Upgrades*
QUANTIFIED	1. production cost savings value of reduced emissions reduced AS costs 2. avoided transmission project costs 3. reduced transmission losses capacity benefit energy cost benefit 4. lower transmission outage costs 5. value of reliability projects 6. value of meeting policy goals 7. increased wheeling revenues	1. production cost savings 2. reduced operating reserves 3. reduced planning reserves 4. reduced transmission losses 5. reduced renewable generation investment costs 6. reduced future transmission investment costs	1. production cost savings and reduced energy prices from both a societal and customer perspective 2. mitigation of market power 3. insurance value for highimpact low-probability events 4. capacity benefits due to reduced generation investment costs 5. operational benefits (RMR) 6. reduced transmission losses* 7. emissions benefit	1. production cost savings (includes savings not captured by normalized simulations) 2. capacity resource cost savings 3. reduced refurbishment costs for aging transmission 4. reduced costs of achieving renewable & climate goals
NOT QUANTIFIED	8. reduced cost of extreme events 9. reduced reserve margin 10. reduced loss of load probability 11. increased competition/liquidity 12. improved congestion hedging 13. mitigation of uncertainty 14. reduced plant cycling costs 15. societal economic benefits	7. enhanced generation policy flexibility 8. increased system robustness 9. decreased nat. gas price risk 10. decreased CO_2 emissions 11. decreased wind volatility 12. increased local investment and job creation	8. facilitation of the retirement of aging power plants 9. encouraging fuel diversity 10. improved reserve sharing 11. increased voltage support	5. protection against extreme market conditions 6. increased competition and liquidity 7. storm hardening and resiliency 8. expandability benefits

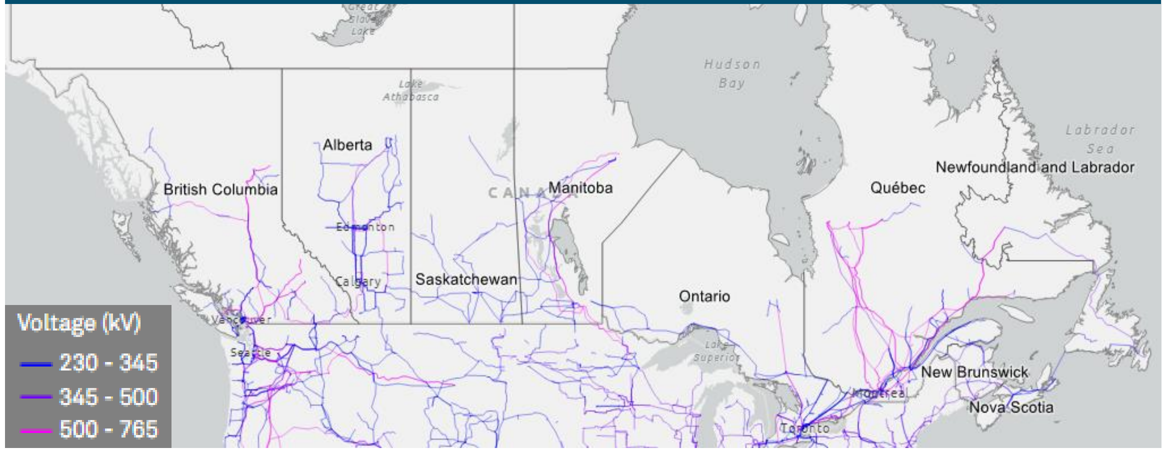
* Source ACORE: Enabling Low-Cost Clean Energy and Reliable Service Through Better Transmission Benefits Analysis

Benefit Accrual Challenges: Canadian Context

Benefit Categorization

- No federal or national benefit categorization framework
- Provinces may have their own benefit categories that they use in determining a viable transmission project

Canadian Transmission Network



Allocation

- **Methodology**
  - Canadian interregional planning usually involves bilateral negotiation between entities and can include help from the federal government (Birtle Tantallon Transmission Line)
  - Recent efforts on multi-provincial Atlantic Loop transmission project
- **Authority**
  - Crown corporations dictate intra-regional transmission planning and distribution planning
  - Federal government has some authority over designated interregional or international projects; but otherwise not very active in the inter-regional transmission planning process
  - No entity to help facilitate or support benefit allocation discussions between Provinces

Benefit Accrual Solutions

- **There has yet to be an effective interregional benefit allocation methodology encompassing more than two planning entities or RTOs**
  - Jurisdictional allocation methodology is currently under development between two US RTO’s (SPP-MISO), not holistic but stems from shared interconnection queue issues at their seam.
  - Current methodologies for multi-entity benefit allocation are flawed
    - FERC Order 1000 regional planning groups have frameworks but only look at a small subset of benefits. This process is not often used and is frequently bypassed.
    - NTTG found it difficult to reasonably allocate benefits using production cost modeling
- **FERC has identified a list of benefits for entities to use when evaluating transmission projects**
  - To allocate these effectively, group into buckets based on clarity of benefit allocation:
    - Directly Attributable: Fairly clear allocation of benefits
    - Shared: More nuanced allocation of benefits

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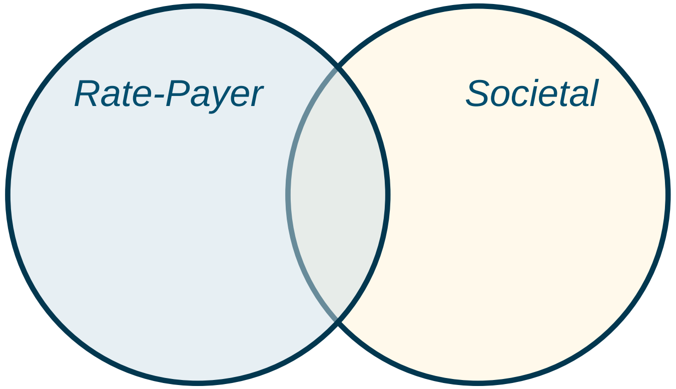
Interregional Transmission Benefit Accrual Categorization

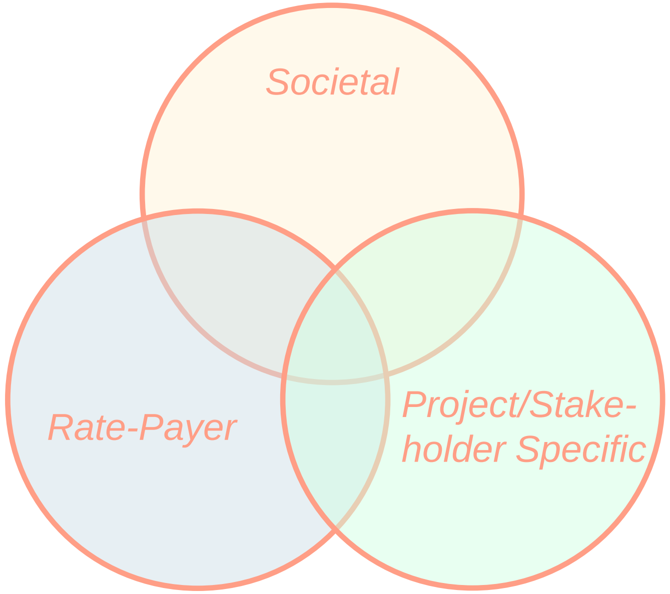
- Many benefits can be directly attributed and can be reasonably allocated among entities if all parties agree on a production cost model and capacity expansion methodology
- However, some benefits are not as easily allocated among members and may provide significant benefits to consumers
- Both types of benefits can either be directly passed to rate-payers, provide benefits on a larger scale, or may depend on the interests of stakeholders and needs particular to regulatory environments

Directly Attributable Benefits:

Directly attributable benefits can be allocated from quantitative techniques



Shared Benefits: Shared benefits are more nuanced and more difficult to allocate among participants



Benefit Accrual Allocation Categories

Benefit Metric	Quantification Method	Allocation Category	Benefit Category
Production cost savings	Production Cost Modeling	Directly Attributable	Rate-Payer
Either reduced loss of load probability -OR- Reduced planning reserve margin	Reliability Modeling	Shared	Rate-Payer
Avoided or deferred reliability transmission expenses and infrastructure replacement	Other Methods	Shared	Rate-Payer
Reduced transmission energy losses	Production Cost Modeling	Directly Attributable	Rate-Payer
Reduced congestion due to transmission outages	Production Cost Modeling	Directly Attributable	Rate-Payer
Mitigation of extreme events and system contingencies	Reliability Modeling/ Other Methods	Shared	Societal
Load and weather diversity	Production Cost Modeling	Directly Attributable	Rate-Payer
Capacity cost benefits from reduced peak energy losses	Production Cost Modeling	Directly Attributable	Rate-Payer
Deferred generation capacity investments	Capacity Expansion Modeling	Directly Attributable	Rate-Payer
Access to lower-cost generation	Production Cost Modeling	Directly Attributable	Rate-Payer
Increased competition	Production Cost Modeling	Directly Attributable	Rate-Payer
Increased market liquidity	Production Cost Modeling	Directly Attributable	Rate-Payer
Decarbonization/Meeting public policy goals	Production Cost Modeling	Directly Attributable	Societal
Air quality improvements	Other Methods	Directly Attributable	Societal
Job creation and local investment	Other Methods	Shared	Project- or Stakeholder-Specific
Integration of remote territories to power grid and associated infrastructure	Other Methods	Shared	Project- or Stakeholder-Specific
Partnership with First Nations	Other Methods	Shared	Project- or Stakeholder-Specific
Reduced environmental compliance costs	Other Methods	Directly Attributable	Rate-Payer
Environmental protection	Other Methods	Shared	Project- or Stakeholder-Specific

Other non-FERC benefits (bracket spanning rows from "Decarbonization/Meeting public policy goals" to "Environmental protection")

* Source FERC NOPR: Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection

Benefit Accrual Methodology Solutions

Directly Attributable benefits

- **Will be allocated to individual utilities based on quantitative methods**
- **Quantitative methods have been approved by parties involved, with oversight from the Federal government**

Total Benefits by Type	Entity 1	Entity 2	Entity 3
$$$$$	$$	$$	$
$$$	$$	$	-
$$$$	$	$	$$

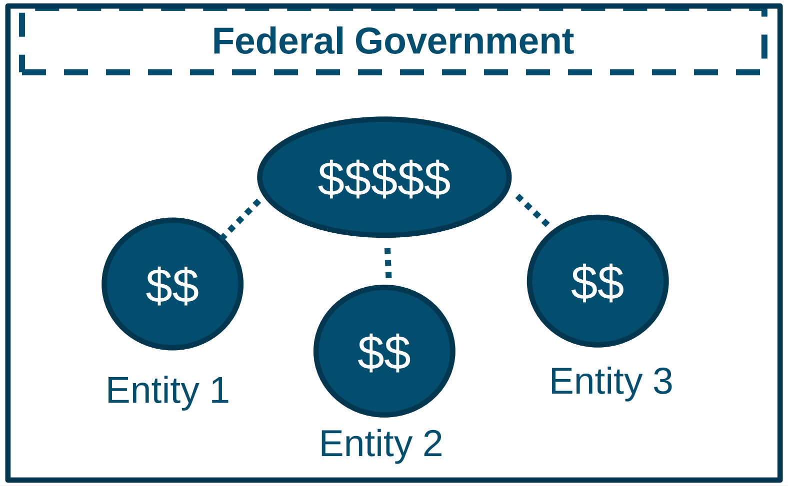
Shared benefits

- **Benefits that are not as distinguishable as the benefits reflected via modeling methods will need to be allocated fairly. Allocation can range between the two ends of the spectrum:**
  - *Provincially allocated*: Postage Stamp Rate with potential adjustments to account for risk carrying;
  - *Allocated Nationally via the Federal Government:* Federal government assumes these benefits to be a national issue and funds the project proportionally based on these benefits

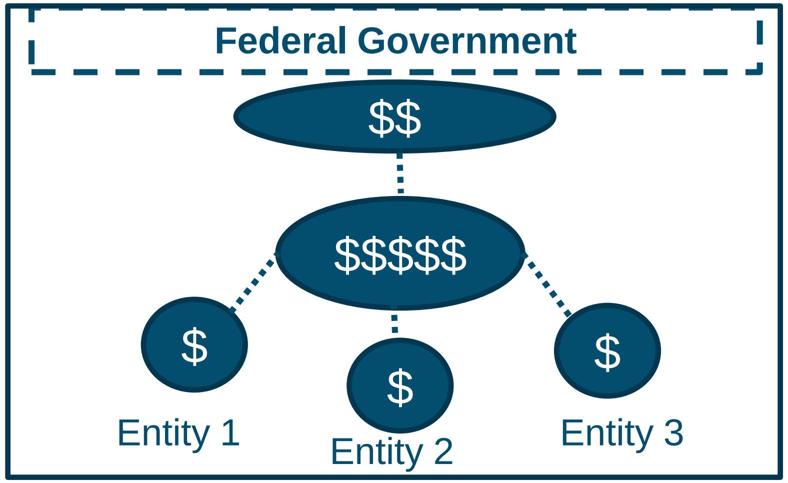
Shared Benefits & Federal Interaction Solutions

- **The most difficult aspect of benefit accrual is allocation of these shared benefits which may need to be negotiated among energy providers, First Nations, and other participants**
- **Early engagement of Federal government and all parties may streamline interregional planning processes to reach Canada's 2030 and 2050 targets**
- **Federal government or an inter-regional authority would play a part in allocating shared benefits:**

Provincially Allocated: Federal governing body would work with provinces to establish a reasonable benefit allocation rate. Similar frameworks related to cost are already used in RTOs in the U.S. today, but may be more challenging to integrate across multiple Provinces and RTOs.



Nationally Allocated via Federal Government: The Federal government acts as a stopgap or becomes a participant in the inter-regional transmission project by providing capital proportional to the share of shared benefits to total benefits. US Department of Energy's (DOE) Build a Better Grid Initiative has proposed a Transmission Facilitation Program that looks to fund new high voltage transmission through: (1) DOE loans, (2) DOE participation in public-private partnership, (3) capacity contracts that would make DOE the "anchor tenant" of a line.



Outline

Benefit Accrual Skeleton Calculator Overview

Review Benefit Categories

"Benefit Descriptions" Tab

Found in the appendix, this tab houses a list of benefits with associated quantification and allocation categories, description, and quantification methods

Create Allocation Methodologies

"Allocation Methodologies" Tab

This tab enables the user to create allocation methodologies (e.g. postage stamp, adjusted production cost) including percentage of benefits accrued to each entity

Include or Exclude Benefit Categories

"Benefit Accrual" Tab

Use the dropdown menu in the "Include Benefit Metric?" column to include or exclude individual benefits from accrual calculation – benefits are organized by quantification and accrual subcategories

Match Benefit Categories and Allocation Methods

"Benefit Accrual" Tab

Use the dropdown menus in the "Allocation Method" and "Allocation of Shared Benefits" columns to assign a method to each category to populate the allocation calculations by entity

Calculate Total Share of Benefits

"Benefit Accrual" Tab

The Total Benefits table auto-populates from the Directly Attributable and Shared Benefits tables and shows the breakdown of total benefits accrued to each entity

Benefit Quantification

Benefits should be pre-quantified and added as inputs under "Total Benefit" in the "Benefit Accrual" tab. In the future, Electricity Canada could explore adding the functionality to calculate individual benefit categories within this calculator tool. The "Benefit Calculations" section shows what this could look like at a high level.

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Topics for Regulatory Proceedings

- **Proposed topics for regulatory proceedings to overcome interregional transmission challenges:**
  - *Setting an interregional planning framework including:*
    - An agreed-upon list of benefit metrics and quantification methodologies
    - Create a baseline benefit accrual calculator used in multi-stakeholder planning and negotiation
    - Modeling techniques and procedures on a nation-wide scale
    - Regional planning group with governing body that can carry out procedures
  - *Expanding the role of the federal government in interregional transmission planning including:*
    - Acting as governing body of Canadian regional planning groups to move transmission planning processes forward
    - Cost allocation to federal government in proportion to share of benefits that accrue to society and achieve federal public policy goals
    - Federal backstop planning authority (informed by lessons learned from US implementation challenges)

Appendix

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Benefit Categorization and Descriptions (1/2)

Benefit Metric	Quantification Category	Allocation Category	Description
Production cost savings	Direct	Ratepayer	Reduction in production costs, including savings in fuel and other variable operating costs of power generation, that are realized when transmission facilities allow for the increased dispatch of suppliers that have lower incremental costs of production, displacing higher-cost supplies; also reduction in market prices as lower-cost suppliers set market clearing prices; when adjusted to account for purchases and sales outside the region, called adjusted production cost savings.
Either reduced loss of load probability -OR- Reduced planning reserve margin	Shared	Ratepayer	Reduced frequency of loss of load events by providing additional pathways for connecting generation resources with load (if planning reserve margin is constant), resulting in benefit of reduced expected unserved energy by customer value of lost load. -OR- While holding loss of load probabilities constant, system operators can reduce their resource adequacy requirements (i.e., planning reserve margins), resulting in a benefit of reduced capital cost of generation needed to meet resource adequacy requirements.
Avoided or deferred reliability transmission projects and infrastructure replacement	Shared	Ratepayer	Reduced costs of avoided or delayed transmission investment otherwise required to address reliability needs or replace transmission facilities.
Reduced transmission energy losses	Direct	Ratepayer	Reduced energy losses incurred in transmittal of power from generation to loads, thereby reducing total energy necessary to meet demand.
Reduced congestion due to transmission outages	Direct	Ratepayer	Reduced production costs during transmission outages that significantly increase transmission congestion.
Mitigation of extreme events and system contingencies	Shared	Societal	Reduced production costs during extreme events, such as unusual weather conditions, fuel shortages, and multiple or sustained generation and transmission outages, through more robust transmission system reducing high-cost generation and emergency procurements necessary to support the system.
Load and weather diversity	Direct	Ratepayer	Reduced production costs during higher than normal load conditions or significant shifts in regional weather patterns.
Capacity cost benefits from reduced peak energy losses	Direct	Ratepayer	Reduced energy losses during peak load reduces generation capacity investment needed to meet the peak load and transmission losses.
Deferred generation capacity investments	Direct	Ratepayer	Reduced costs of needed generation capacity investments through expanded import capability into resource-constrained areas.
Access to lower-cost generation	Direct	Ratepayer	Reduced total cost of generation due to ability to locate units in a more economically efficient location (e.g.,low permitting costs, low-cost sites on which plants can be built, access to existing infrastructure, low labor costs, low fuel costs, access to valuable natural resources, locations with high-quality renewable energy resources).

Benefit Categorization and Descriptions (2/2)

Benefit Metric	Quantification Category	Allocation Category	Description
Increased competition	Direct	Ratepayer	Reduced bid prices in wholesale electricity markets due to increased competition among generators and reduced overall market concentration/market power.
Increased market liquidity	Direct	Ratepayer	Reduced transaction costs (e.g.,bid-ask spreads) of bilateral transactions, increased price transparency, increased efficiency of risk management, improved contracting, and better clarity for long-term transmission planning and investment decisions through increased number of buyers and sellers able to transact with each other as a result of transmission expansion.
Decarbonization	Direct	Societal	Avoided climate damages from reductions in greenhouse gas emissions enabled by the integration of low- or zero-emissions resources that displace the use of or cause the retirement of higher-emissions resources as a result of transmission expansion.
Air quality improvements	Direct	Societal	Avoided public health, welfare, and agricultural damages from reductions in air pollutants enabled by the integration of low- or zero-polluting resources that displace the use of or cause the retirement of higher-polluting resources as a result of transmission expansion.
Partnership with First Nations	Shared	Societal	Addressing historical injustices and advancing the principles of Reconciliation to ensure First Nations are equitable recipients of transmission-related benefits.
Job creation and local Investment	Shared	Societal	New employment and economic development opportunities created by transmission development strategically targeted to local workers. Examples include using prevailing wage and local labor unions and transmission ownership groups investing in job training, apprenticeship programs, and other local economic development efforts.
Integration of remote territories to power grid and associated infrastructure	Shared	Ratepayer/Societal	Connecting remote communities to the central transmission system enables reliable access to low cost energy, improving welfare, attracting local commercial and industrial investment, and providing other nation building objectives. The development of new transmission often comes with other kinds of infrastructure like improved roads, telecommunication infrastructure, and other services that have similar beneficial economic characteristics.
Reduced environmental compliance costs	Direct	Ratepayer	Transmission projects that lead to a reduction in land impacts may also reduce the amount of costs incurred by generation owners by meeting environmental protection and remediation regulatory standards.
Environmental protection	Shared	Societal	Transmission projects may generate benefits by reducing resource extraction and waste product from fuel combustion that constribute to environmental degradation in ways not captured in other benefit categories. Additionally, transmission may be designed to avoid environmental damages including impacting sensitive habitat and degrading recreational areas. Rerouting an otherwise optimal transmission line has implied costs and the avoided impacts could be measured accordingly.
Other public policy benefits	Shared	Societal	Addressing other local and federal public policy objectives including but not limited to providing economic benefits to historically disadvantaged communities, relieving energy burden, supporting manufacturing of advanced energy technology, and improving energy security.

Benefit Quantification Methods (1/3)

Benefit Metric	Quantification Method
Production cost savings	Security-constrained production cost models simulate the hourly operations of the electric system and the wholesale electricity market by emulating how system operators would commit and dispatch generation resources to serve load at least cost, subject to transmission and operating constraints. The traditional method for estimating the changes in adjusted production costs associated with proposed transmission facilities (or portfolio of facilities) is to compare the adjusted production costs with and without those facilities. MISO uses production cost savings (adjusted for import costs and export revenues) to allocate the costs of its Market Efficiency Projects to cost allocation zones based on each zone's share of the total adjusted production cost savings. NYISO and PJM, in contrast, use reductions to load energy payments (adjusted to reflect the reduced value of transmission congestion contracts) to allocate the costs of economic transmission facilities. WestConnect considers the transactions between loads and lower-cost generation that a proposed regional transmission facilities could support and, accounting for the costs associated with transmission service, identifies the transactions that are likely to occur. WestConnect then estimates any resulting cost savings (in the form of reductions in production costs and reserve sharing requirements) and allocates the costs of the regional transmission facilities on that basis.
Either reduced loss of load probability -OR- Reduced planning reserve margin	Quantify the incremental increase in system reliability by determining the reduction in expected unserved energy between the base case and the change case, obtaining the value of lost load, and multiplying these two values to obtain the monetary benefit of enhanced reliability associated with a transmission expansion. -OR- Calculate a reduction in planning reserves associated with transmission expansion that reduces the need for future generation buildout to meet reserve requirements by using loss of load expectation reliability simulations. Estimated the percentage by which that expansion projects reduce the required planning reserve margin and translate into a projected savings.
Avoided or deferred reliability transmission projects and infrastructure replacement	Public utility transmission providers in each transmission planning region could first identify transmission facilities that could defer or replace an identified reliability transmission solution. Avoided cost benefits could be calculated by comparing the cost of transmission facilities required to address the reliability need without the proposed regional transmission facility to the cost of transmission facilities needed to address the reliability need assuming the regional transmission solution were in place. Similarly, this benefit could also include the separate benefits stream caused by a deferral of replacement of other transmission facilities through identification and selection for purposes of cost allocation in the regional transmission plan of a transmission facility or facilities. This could be measured through calculation of the present value savings for the period of deferral of additional replacement transmission facilities multiplied by their estimated capital cost.
Reduced transmission energy losses	To measure reduced transmission energy losses, public utility transmission providers could: (1) simulate losses in production cost models; (2) estimate changes in losses with power flow models for a range of hours; or (3) estimate how the cost of supplying losses will likely change with marginal loss charges.
Reduced congestion due to transmission outages	Production cost simulations tend to consider both planned and unplanned generation outages, but not transmission outages. Public utility transmission providers could measure this benefit by either building a data set of a normalized transmission outage schedule (not including extreme events) that can be introduced into simulations or by inducing system constraints more frequently. In its RCAR process, SPP measured the benefits of reducing congestion resulting from transmission outages. SPP modeled outage events and new constraints based on these outages in PROMOD for a 2025 case year, and then conducted PROMOD simulations to calculate adjusted production cost savings for a base case and the change case including the transmission line. In another example, SPP calculated the financial value of reducing congestion caused by outages based on a rerun of its entire day-ahead and real-time market
Mitigation of extreme events and system contingencies	Calculate the probability-weighted production cost savings through production cost simulation for a set of extreme historical market conditions. One example is CAISO's analysis of Devers-Palo Verde Line No. 2 (PVD2), where CAISO modeled several contingencies to determine the value of the line during high-impact, low-probability events. Another example is ATC's production cost simulation analysis of insurance benefits for the ATC Paddock-Rockdale transmission line.

Benefit Quantification Methods (2/3)

Benefit Metric	Quantification Method
Load and weather diversity	Production cost model inputs under high and low load conditions can be used to develop regional variations of relative benefits under these conditions. Production cost benefits can then be modeled based upon a probability weighted average anticipating varying load conditions, with the increment over a base case representing additional production cost savings.
Capacity cost benefits from reduced peak energy losses	Calculate the present value of capital cost savings associated with the reduction in installed generation requirements. To arrive at the value of capital cost savings associated with these savings, the estimated Net CONE would be multiplied by the reduction in installed generation capacity requirements. The resulting value would represent the avoided cost of procuring more generation to cover transmission system losses during peak-load conditions that would be passed on to consumers via lowered generation capacity costs.
Deferred generation capacity investments	Calculate the present value of generation capacity cost savings resulting from deferred generation investments, based on Net CONE. Specifically, the total value of deferred generation investments could be determined by multiplying the change in the public utility transmission provider's installed capacity requirement by Net CONE.
Access to lower-cost generation	Calculate the reduction in total generation investment costs by comparing the status quo (i.e., higher-cost local generation) to a future (i.e., lower-cost distant generation) where the proposed new regional transmission facilities allow for the import of those lower-cost generation. By allowing for the import of lower-cost generation, consumers would benefit via reduced total cost of generation.
Increased competition	The "Modified MISO IMM Method" draws from two key assumptions to determine price mark-ups. First, the Modified MISO IMM Method requires an estimate of the pivotal supplier's price-cost markup for the area served by the transmission facility for all times when the supplier is pivotal. Second, this method assumes that the price-cost markup increases linearly as the Residual Supplier Index falls below 1.2, such that there is no price-cost markup where the Residual Supplier Index for an hour is above 1.2 (i.e., no improved competition benefit) and the price markup is half the estimated price-cost markup from the first assumption where the Residual Supplier Index for an hour is less than 1.0. Finally, this method assumes that the pivotal supplier is the marginal resource that sets the energy price when the Residual Supplier Index is below 1.2. The difference in price-cost markup for hours when the Residual Supplier Index is below 1.2 provides the benefits from increased competition. -OR- The "Modified CAISO Method" estimates the energy price impacts of a new transmission facility by using regression analysis to find the relationship between historical market structure and price-bid markups. CAISO first developed this regression equation and its coefficients in its 2004 report evaluating the economic viability of certain transmission upgrades, including the PVD2 and Path 26 Upgrade projects. CAISO's study also used two binary indicator variables: one for the summer period in CAISO and another for peak hours. We note that public utility transmission providers using the Modified CAISO approach may find that coefficients developed using data specific to the transmission planning region where the public utility transmission provider is located are more appropriate and may also wish to include more independent variables specific to their respective transmission planning regions. -OR- The "Bidding Behavior Method" relies on a simulation model that optimizes bidding behavior from a supplier perspective given each supplier's supply portfolio and load obligations. This model could be based on the theoretical incentive that suppliers have to increase price-cost markups in proportion to the absolute value of the slope of residual demand (i.e., total demand less the supply of all other resources serving the same load). Public utility transmission providers in a transmission planning region would develop a study estimating market prices for a future period matching the planning horizon as load, generation supply, transmission constraints, and import capability changed. Public utility transmission providers in a transmission planning region would also assume that a percentage of load was exposed to congestion.
Increased market liquidity	Public utility transmission providers could quantify increased market liquidity benefits to transmission customers by estimating (1) how additional transmission facilities may increase liquidity and (2) how increased liquidity may reduce bid-asks spreads or energy prices.

Benefit Quantification Methods (3/3)

Benefit Metric	Quantification Method
Decarbonization	Production cost model will yield a reduction in generation from greenhous gas emitting resources. Calculate tonnes of emissions abated from CO2, CH4, and N20 by multipling avoided generation by power plant-specific rates of emission. Multiply emissions abated by the social cost of each category of greenhouse gas.
Air quality improvements	Production cost model will yield a reduction in generation from resources that contribute to air quality contamination. Calculate tonnes of emissions abated from NOx, Sox, PM2.5, and mercury by multiplying avoided generation by power plant-specific rates of emission. Input health and environmental benefits resulting from air pollutant emissions reduction by using the emissions abated as inputs to run the A Unified Regional Air-quality Modelling System (AURAMS) atmospheric model created by the ECCC's Meteorological Service of Canada to determine the change in ambient air quality. Then use the Air Quality Benefits Assessment Tool (AQBAT) to determine how improvements in ambient air quality would affect the health of Canadians. Benefit areas include but are not limited to reduction in respiratory illness and other public health hazards, visibility (change in welfare for households), avoided soiling costs for households, and change in crop production revenues.
Collaboration with First Nations	Methodology may vary depending on project
Job creation and local investment	Methodology may vary depending on project
Integration of remote territories to power grid & associated infrastructure	Methodology may vary depending on project
Reduced environmental compliance costs	Costs depend on generation resource, fuel type, and regulatory standards. Generally, this benefit can be calculated by comparing compliance costs in a business as usual future scenario and a scenario including the new transmission project.
Environmental protection	Methodology may vary depending on project
Other public policy benefits	Methodology may vary depending on project

Calculator User Guide

User Guide:

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Input
Dropdown Input
Calculation
Output
Table Value

- **Reference the user guide on the left to follow the functionality of different fields within the calculator**
- **Unless making fundamental changes to the structure of the model only change inputs and dropdown inputs**
- **Inputs and dropdown inputs include:**
  - The total dollar amount of benefits for each benefit category
  - Assigning allocation methods to benefit categories
  - Deciding percent share of benefits accrued per entity in each allocation methodology
- **Fundamental changes that could be made outside of inputs listed above include:**
  - Adding, deleting, redefining, or recategorizing benefit categories
  - Adding or deleting allocation methodologies
  - Adding entities