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# Study Committee C2

System Operation and Control

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# Technical, Regulatory, and Economic Development for Distributed Flexible AC Transmission Systems – DFACTS


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**Colombia**


## Context

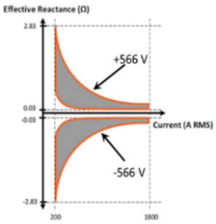
- **Power Systems challenged** due to non-conventional renewable distributed generation:
    - Intermittence
    - Planning uncertainty
    - Deregulation of the Energy markets
    - Operation closer to safety limits
- Increased **congestion** in Tx and Dx grids risking **reliability** and **increasing electricity prices**
- **Traditional Tx projects are slow and** with more and new challenges (legal litigation, environmental permits, impact on communities)
- Need for **flexible**, **intelligent** and **economic solutions** for better navigating the planning uncertainty.

## Operation

- Convert **existing transmission lines** into **Smart Assets** capable of monitoring and actively controlling power flows (Dispatchable lines)
- **Modularity** of the design allows for **relocating** if grid needs change
- Flexible and **least-regret investment**, that helps:
    - Accelerate RES interconnection
    - Increase inter-regional transfers
    - Manage planning uncertainty
    - Reduce Energy costs
    - **Avoid or defer complex infrastructure projects**
    - Extend outage windows

## DFACTS solutions (M-SSSC)

- **M**odular **S**tatic **S**ynchronous **S**eries **C**ompensator as power flow control technology. Also referred to as **DFACTS**, due to its **modularity** and **distributed** operating concept.
- Devices are based on **VSC converters** (IGBT full-bridge topology)
- Technology actively **varies the reactance of transmission lines** in capacitive and inductive rages to push or pull power to **optimize grid utilization**.
- Quickly and economically use the existing grid capacity




(1) Reactance Variation DFACTS Solution

(2) DFACTS installation in Medellín, Colombia

## Cost/Benefit Analysis

- Tool to evaluate and **compare different technical alternatives** to solve congestion issues
- **Costs** (**ToTex**) of following alternatives are assessed
    - HTLS reconducting projects
    - Traditional reconductoring
    - Building new transmission lines
    - Expansion and reconfiguration of substations
    - Phase Shifting Transformers
    - Conventional FACTS
    - **Distributed FACTS (DFACTS)**
- **Benefits** include, but are not limited to:
    - Decreased in unserved demand
    - Reduction in curtailment
    - Reduction in losses
    - Energy not supplied
    - Re-dispatch costs
    - Project Lead Times

# Technical, Regulatory, and Economic Development for Distributed Flexible AC Transmission Systems – DFACTS

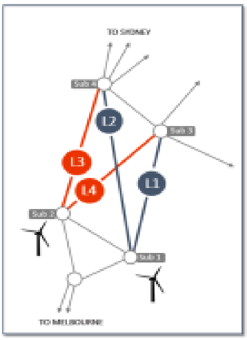
## Extended DFACTS benefits

Monetizable and non-monetizable

- Reduced footprint & simple maintenance
- Installation and operational flexibility
- Standard and modular design (faster lead times)
- Redeployable and scalable to adapt to evolving grid needs
- Distributed reliability

## Example 1: Ancillary Services

- Peak wind generation at different times
- **Limited transport capacity** and **social difficulties for traditional expansion projects**
- **DFACTS provide dynamic real-time congestion management**
- **Dispatch automatism** based on measured wind speed
- Solution **minimizes curtailment** and **utilize the existing Tx assets**




(3) DFACTS solution in Australia

- CBA for similar use cases can be based on investment remuneration via tariff.
- DFACTS proposed as **complementary non-market equipment** to mitigate curtailment, e.g.:

| | Remuneration | Payment generator |
|---|---|---|
| **F/Regulation** | "Causer pays" method | Pooling factor and residual by market customers |
| **Contingency** | Recovered as a function of energy demand/generation | Generators pay upstream service, consumers pay downstream service |
| **Reactive Power** | Based on consumption, in benefited regions | Market customers only |
| **Load sharing** | Based on consumption, in benefited regions | Market customers only |
| **System restart** | Based on energy demand/generation, in benefited regions | Payment is generated by consumers and generators |

## Example 2: Cost Relation

- **Speed of Installation from decision making** point greatly impact CBA results.
- **Political opposition, permits and approvals are delaying Tx projects** and leading to reliability risks
- DFACTS "**bridge solutions**" as a cost-effective manner to solve short-term problems. **Complementary and synergistic with longer-term bets**
- If grid needs evolve with time, **modularity allows** for **escalation** of the initial deployment, or easy **relocation**

| Year | Values in p.u. | | | |
|---|---|---|---|---|
| | DFACTS | | Alternative | |
| | Costs | Benefits | Costs | Benefits |
| 2020 | 0 | 0 | - 0.25 | 0 |
| 2021 | -1 | 0 | - 0.25 | 0 |
| 2022 | - 0.02 | 0.1 | - 0.25 | 0 |
| 2023 | - 0.02 | 0.1 | - 0.25 | 0 |
| 2024 | - 0.02 | 0.1 | - 0.02 | 0.1 |
| 2025 | - 0.02 | 0.1 | - 0.02 | 0.1 |
| 2026 | - 0.02 | 0.1 | - 0.02 | 0.1 |
| 2027 | - 0.02 | 0.1 | - 0.02 | 0.1 |
| 2028 | - 0.02 | 0.1 | - 0.02 | 0.1 |
| …. | - 0.02 | 0.1 | - 0.02 | 0.1 |
| 2060 | - 0.02 | 0.1 | - 0.02 | 0.1 |
| Total | -1.338 | 1.88 | -1.284 | 1.70 |
| B+C | 0.54 | | 0.42 | |
| **C/B** | **1.41** | | **1.33** | |

## Example 3: CBA Assessment

- **DFACTS project by Colombian utility EPM**. Four technology alternatives were evaluated
- **Traditional CBA** included loss improvement, unattended demand, generation curtailment, administration operation and maintenance.

**Holistic CBA and risk assessment:**

- **Installation in less than one year** from PO
- Modular and redeployable **"least regrets" alternative**
- Use of **existing substation area** (no new environmental, right-of-ways, archeological permits)
- No pavement breaking permits, road closures and municipality planning review. **No permits** to intervene national roads
- **Highly disruptive projects avoided in urban areas**
- **Less impact on communities and environment**

## Regulation Challenges and opportunities

- **Need for new holistic CBA risk** analysis to include non-monetizable benefits and impactful costs savings. **Permits and lead times becoming of highest relevance for convetional Tx projects**
- Project by EPM (Example 3) **motivated new regulation minset** in Colombia, and new projects approved by the national planning agency
- Globally: new regulatory incentives needed to adopt these technologies and accelerate the energy transition (**Optimize the existing grid first**)

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