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# Central America as a Blueprint for Regional Power Integration

**BLUF:** *Central America's grid system can serve as a blueprint for multi-national, multi-market, multi-resource interconnected grid systems in other emerging and developing regions. It reveals three necessary conditions for regional integration: financial support from inception to deployment, electricity trading structures with national autonomy, and independent regulatory and operational institutions.*

**Why it matters:** *Regional interconnections come with high financial and political costs. In regions where countries have varying governance systems, growth rates, power markets, generation capacity, and grid infrastructure, investment in regional integration can be hard to justify. However, Central America offers a compelling, successful proof of concept. Its grid integration, enabled by international financing institutions, demonstrates that regional connectivity can be achieved without governance harmonization by leveraging supranational infrastructure and institutions. The case highlights how shared physical infrastructure can unlock energy resources across borders and underscores the proactive role of international institutions.*

Multinational grid integration projects take time to design and implement. While the European Union's regional grid system might be best known to global audiences, it has lagged behind the region's economic integration. Central America provides a more immediate and replicable example for other developing economies. The region's interconnection system demonstrates that ambitious integration initiatives can succeed with external financial backing, market structures that balance autonomy with interdependence, and purpose-built institutions.

## Unifying Central America's diverse energy landscape

Central America is a highly unequal and diverse energy region, with GDP per capita ranging between \$2,500 and \$19,000 (current 2024). Power generation is varied, with more than 50% coming from hydropower, 23% from thermal power, and meaningful shares of wind, solar, and geothermal. About one-third of power generation across these countries is state-owned, while the rest is privately owned. Electricity market sizes also vary between 5 and 12 terawatt-hours (TWh). The region includes liberalized wholesale markets in El Salvador, Guatemala, Nicaragua, and Panama, alongside single-buyer markets in Costa Rica and Honduras. Underpinning this heterogeneous system is the SIEPAC (Sistema de Interconexión Eléctrica de los Países de América Central, or Central American Electrical Interconnection System), which links the electrical grids of six Central American countries — Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama — through a main power transmission network and an additional single bilateral link.

## Benefits of Central America's regional grid

SIEPAC's 1800km transmission line, equivalent to the distance between Madrid and Berlin, has been operational since 2014, delivering the following valuable benefits to the region:

- **Regional energy diversity:** Initially, hydropower facilities near borders drove bilateral interconnections, but as climate change affects hydropower reliability, the need for diverse energy sources like wind and solar has become the main driver. Between 2014 and 2022, generation from non-hydro renewables increased by 94%.
- **Enhanced electricity trade:** SIEPAC enabled 3,079 GWh of electricity trade in 2022, about 5% of the region's total energy generation. Guatemala and Costa Rica are large exporters; Nicaragua and Honduras are importers, while El Salvador and Panama are active in exports and imports. Forecasts suggest electricity trade could exceed 4,900 GWh by 2025, indicating the potential for growth within the current system.
- **Grid decarbonization:** The region's lack of fossil fuel resources (unlike the oil-endowed Colombia and Mexico) and the diverse renewable sources integrated through SIEPAC have helped the region decarbonize. Between 2014 and 2022, thermal generation from fossil fuels decreased by 21%, declining its overall share from 37% to 23%.

## DIY: How to build a regional interconnection system

The Central American region reflects the energy resource, power market, economic and governance heterogeneity seen in other developing regions. However, its grid integration demonstrates that regional connectivity — with energy diversity, abundance, and decarbonization benefits — can be achieved without forcing countries into economic, power market, and governance harmonization. Three key building blocks have made this possible:

1. **Regional connectivity requires external financial support from inception to deployment.** Early financing from the UN's Economic Commission for Latin America and the Caribbean (ECLAC) and the Inter-American Development Bank (IDB) was critical for conducting key technical studies. The most catalytic phase began in 1987 with work supported by the government of Spain and the country's then-public utility, Empresa Nacional de Electricidad S.A. Later, additional financing from IDB, US, Denmark, and Norway propelled the interconnection project's development.
2. **Grid integration in a heterogeneous region requires an electricity trading system that supports national sovereignty.** Unlike the EU, Central America does not have a single market or the intention to integrate governance institutions. Instead, a supranational market, the Central American Electricity Market (MER), facilitates the electricity trade among countries interconnected by SIEPAC. The structure allows national governments to manage local energy systems with independence and flexibility while leveraging MER and SIEPAC for regional cooperation and to access more power sources.
3. **Successful functioning of a regional grid requires autonomous, purpose-built institutions.** The decade-long operation of the SIEPAC demonstrates the effectiveness of its four autonomous institutions in steering, regulating, and operating both the market and grid. The Directive Council oversees these institutions and ensures treaty compliance, while MER is regulated by the self-funded Regional Electricity Interconnection Commission (CRIE). The Regional Operating Entity implements CRIE's regulations and manages MER's dispatch and transaction system. Finally, the Grid Owning Company (EPR) is a private company, established under Panama law, co-owned and operated by transmission companies of all six countries, and three companies, all holding equal shares.

## Conclusion

The Central American electricity grid integration experience proves that ambitious integration projects can succeed, even in a region marked by economic, market, resource, and governance diversity. The case reveals three necessary conditions for regional integration:

external financial support from inception to deployment, intra-regional electricity trading market structure with national autonomy, and independent regulatory and operational institutions. The benefits are evident in Central America's steady growth of energy trade and increasing access to renewable energy resources, offering a model that can be replicated in other developing regions worldwide.

## Endnotes

1. Ente Operador Regional (EOR). 2024. Planeamiento Operativo de América Central 2024-2025.  
[https://www.enteoperador.org/archivos/download/Informe\\_Planeamiento\\_Operativo\\_2024-2025-Actualizacion\\_jul-2024.pdf](https://www.enteoperador.org/archivos/download/Informe_Planeamiento_Operativo_2024-2025-Actualizacion_jul-2024.pdf).
2. Echeverría, C., Jesurun-Clements, N., Mercado, J. and Trujillo, C. 2017. Integración eléctrica centroamericana: Génesis, beneficios y prospectiva del Proyecto SIEPAC: Sistema de Interconexión Eléctrica en los Países de América Central. Interamerican Development Bank (IADB) <http://dx.doi.org/10.18235/0012708>.
3. Torijano E. (CEPAL). 2023. Estadísticas del subsector eléctrico de los países del Sistema de la Integración Centroamericana (SICA), 2022 (LC/MEX/TS.2023/42). Mexico City: CEPAL.  
<https://repositorio.cepal.org/server/api/core/bitstreams/a45c3739-bc9c-4334-a514-dc6e62a21a60/content>.

## Appendix

**TABLE 1:** General statistics for the region in 2022

Country	National electricity consumption	Electricity consumption per capita	GDP per capita	Electrification rate	Population
	<i>TWh</i>	<i>kWh/pop</i>	<i>(current US\$)</i>	<i>%</i>	<i>Mill.</i>
Panama	11.8	2,679.09	18,661	95	4.41
Costa Rica	11.9	2,290.95	16,595	100	5.18
El Salvador	7.5	1,186.95	5,344	97.9	6.34
Honduras	10.0	954.58	3,247	94.9	10.43
Nicaragua	4.9	701.75	2,530	86.5	6.95
Guatemala	12.3	708.84	5,797	99.1	17.36

Source: World Bank, CEPAL.

**TABLE 2:** Generation by energy source in gigawatt-hour (GWh)

Country	Total	Non-conventional					Conventional	
		Geothermal	Wind	Biomass	Solar	Biogas	Hydro	Thermal
Costa Rica	12,592	1,619	1,369	56	8	-	9,449	92
El Salvador	7,154	1,468	135	552	1,122	1,122	2,234	1,620
Guatemala	12,025	282	314	1,627	220	19	6,942	2,621
Honduras	9,769	278	685	445	940	-	3,835	3,587
Nicaragua	3,814	615	552	579	22	-	637	1,409
Panama	13,890	-	579	-	679	17	8,152	4,462
SIEPAC	59,244	4,261	3,633	3,258	2,992	59	31,249	13,792
SIEPAC	%	7.2%	6.1%	5.5%	5.0%	0.1%	52.7%	23.3%

Source: CEPAL 2023.

FIGURE 1: Historical timeline of the Central American Electrical Interconnection system.

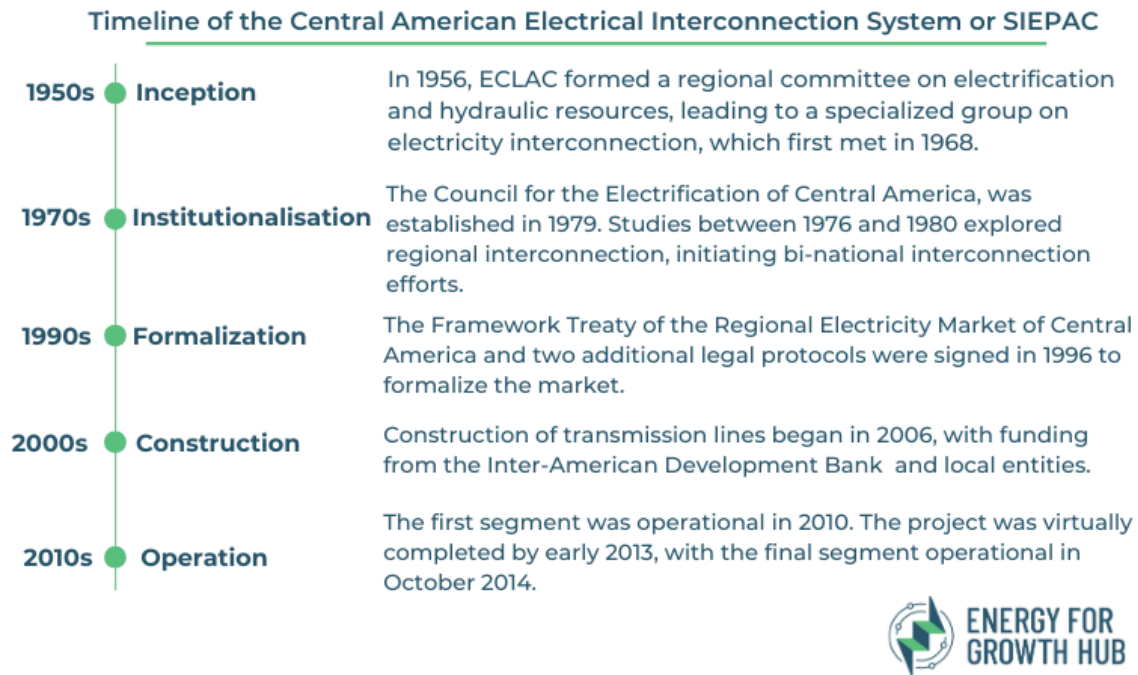


FIGURE 2: [Interactive map](#) from the IEA Energy system for Latin America and the Caribbean.

