

Gaete-Morales, Carlos; Gallego-Schmid, Alejandro; Stamford, Laurence;
Azapagic, Adisa

Article — Published Version

A novel framework for development and optimisation of future electricity scenarios with high penetration of renewables and storage

Applied Energy

Provided in Cooperation with:

German Institute for Economic Research (DIW Berlin)

Suggested Citation: Gaete-Morales, Carlos; Gallego-Schmid, Alejandro; Stamford, Laurence; Azapagic, Adisa (2019) : A novel framework for development and optimisation of future electricity scenarios with high penetration of renewables and storage, Applied Energy, ISSN 0306-2619, Elsevier, Amsterdam, Vol. 250, pp. 1657-1672, <https://doi.org/10.1016/j.apenergy.2019.05.006> , <http://www.sciencedirect.com/science/article/pii/S0306261919308608>

This Version is available at:

<https://hdl.handle.net/10419/201524>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>

A Novel Framework for Development and Optimisation of Future Electricity Scenarios with High Penetration of Renewables and Storage

Carlos Gaete-Morales, Alejandro Gallego-Schmid, Laurence Stamford and Adisa Azapagic

Supporting Information

Table S1. Potential renewable power and capacity factor in Chile [1–3]

Technology	Power potential (GW)	Capacity factor
Hydropower	12 – 20	0.63
Geothermal	16	
Wind	37 – 40	0.34
Biomass	14	
Concentrating solar power (CSP)	100 – 548	0.52
Solar PV	1,263 ^a	0.33
Biogas	1	0.60
Total	1,865	

^a One axis tracking.

Table S2. Capacity to be decommissioning, considering both current and planned power plants (MW) [4–6].

Year	Coal	Gas	Oil	Run-of-river	Reservoir	Biomass	Biogas	Wind	Solar PV	CSP	Geothermal
2015											
2016											
2017											
2018											
2019											
2020			45								
2021											
2022											
2023											
2024											
2025			189								
2026											
2027		370									
2028		729						18			
2029								7			
2030		501	105				2	152			
2031			36	890			2				
2032							18	20			
2033	686	252					10	97			
2034	143	390					14	272			
2035	331	175	513		106	10	0	324			
2036	63					17	5	15			
2037	561	236	107					333			
2038		393					10	171	3		
2039		14	18	18				150	213		
2040		6	199						293		
2041			61	178					324		
2042		2	275						1092		48
2043		19	138	165		13		350	842		
2044			734	32		67		130	74		
2045		633	772	12		14		150			
2046		29	168	37				400			
2047		521	6	40	0	1					
2048	525	328	80	178	377	48				110	
2049	502		2	3		2			780		
2050	454		389	140					530		

Table S3. Capacity of power plants planned or under construction up to 2027 (MW) [4, 5].

Year	Coal	Gas	Oil	Run-of-river	Reservoir	Biomass	Biogas	Wind	Solar PV	CSP	Geothermal
2015											
2016	132	29	218		100		5	15	324		
2017	472	521	49		85			333	1092		48
2018	375	328			75	16	10	171	842	110	
2019					832			150	74		
2020											
2021					170						
2022											
2023								350			
2024								130	780		
2025								150	530		
2026					20			400	410		
2027					20				625		

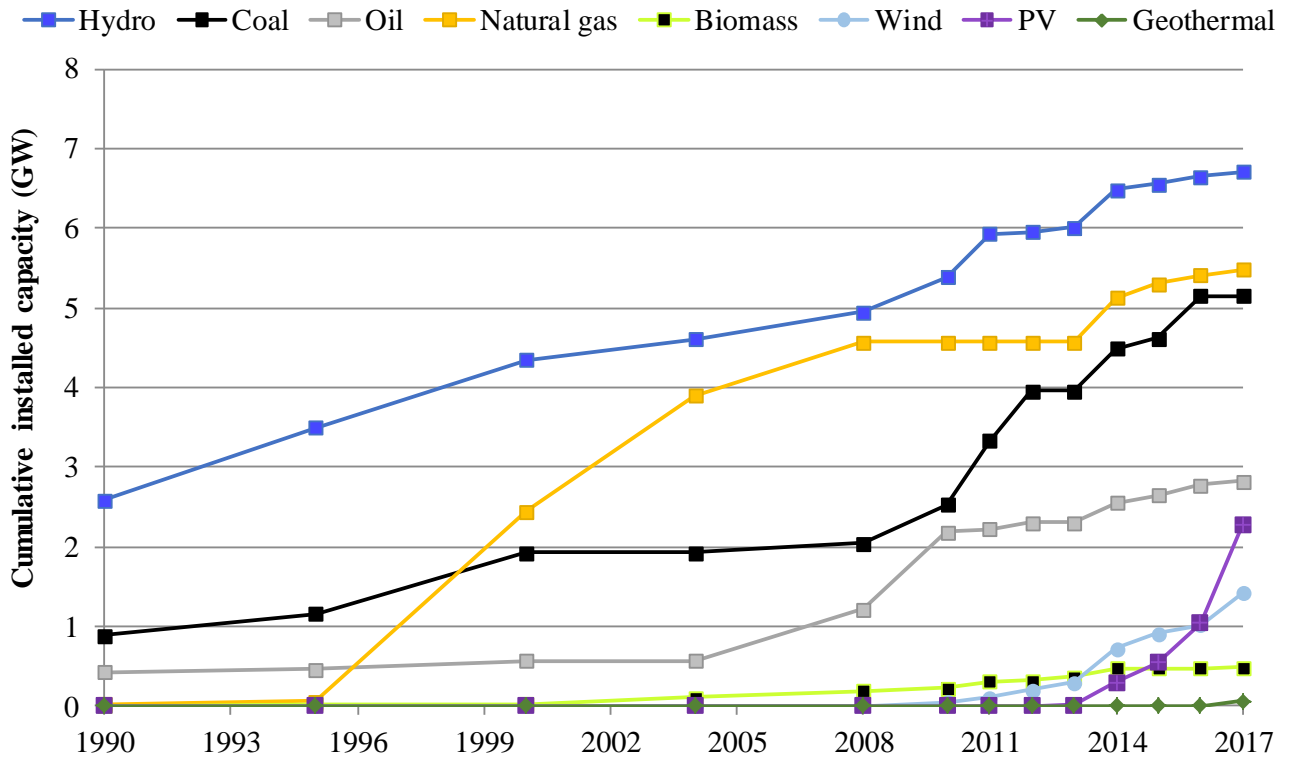


Figure S1. Cumulative installed capacity by technology in Chile over the period 1990 to 2017 [6–9].

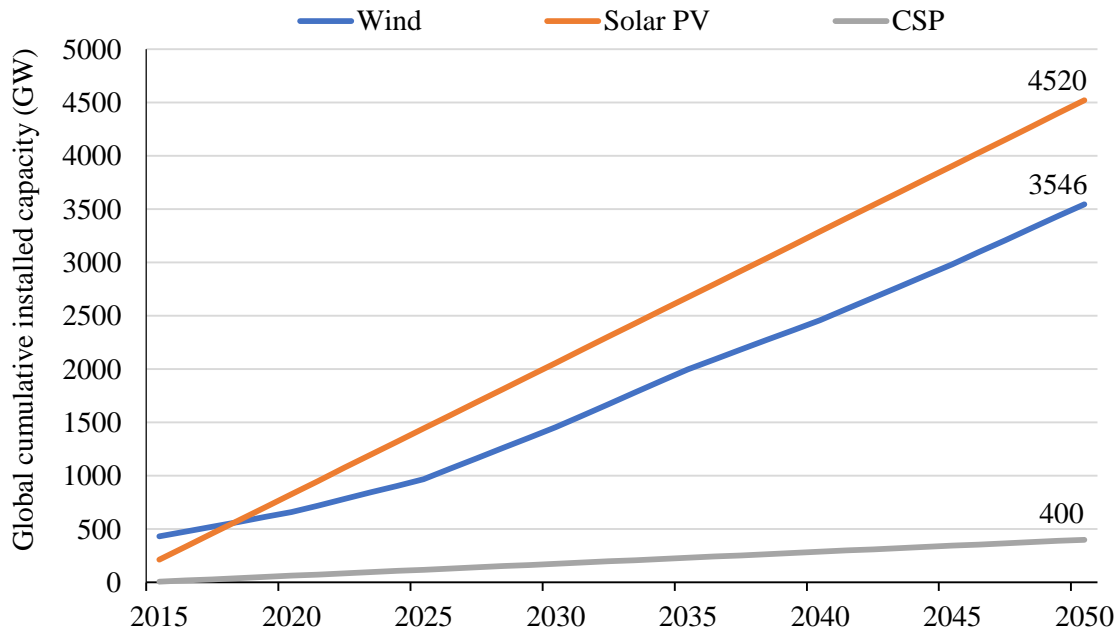


Figure S2. Global cumulative installed capacity used to estimate future capital costs based on learning curves [10–12].

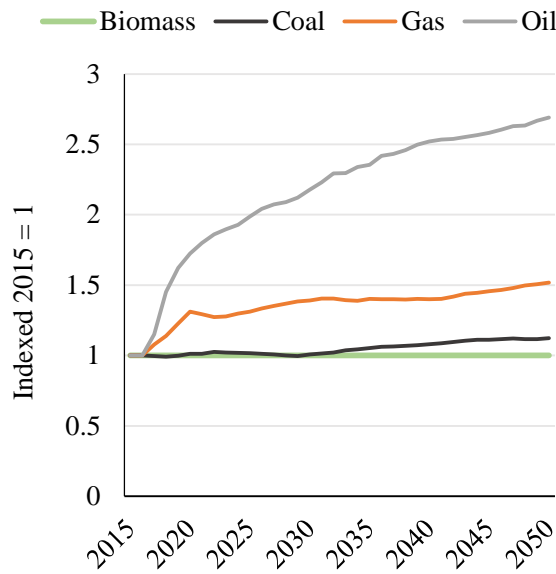


Figure S3. Variation of fuel costs from 2015 to 2050 [5, 13, 14].

(Costs in 2015: 83.8 US\$/t coal, 7.4 US\$/Nm³ gas, 43.4 US\$/bbl diesel and 58.9 US\$/t biomass (40% humidity))

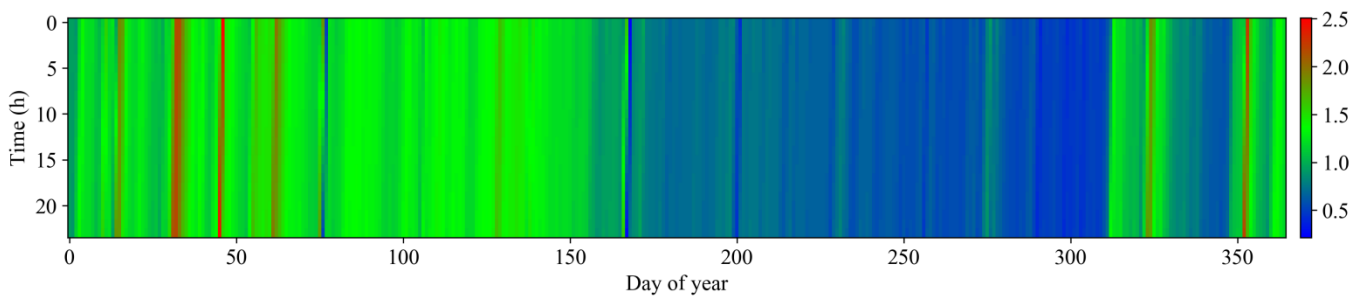


Figure S4. Variation of capacity factor (CF) for hydropower dam through hours in a day and days in a year. (Indexed CF: 43% = 1. Adapted from [5])

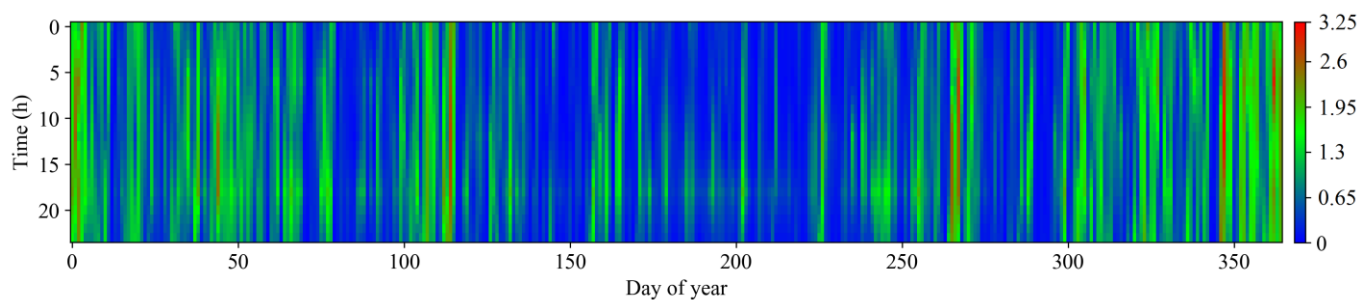


Figure S5. Capacity factor (CF) variation for wind power through hours in a day and days in a year.
(Indexed CF: 32% = 1. Adapted from [15].)

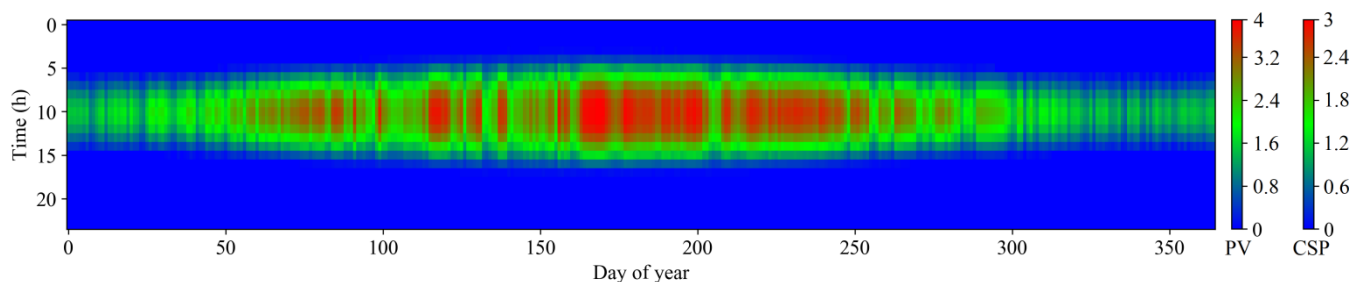


Figure S6. Capacity factor (CF) for solar power through hours in a day and days in a year.
(Indexed CFs: for solar PV: 25% = 1 and for CSP: 35% = 1. Adapted from [16].)

References

1. PRIEN-UTFSM. (2008). *Aporte potencial de energías renovables no convencionales y eficiencia energética a la matriz eléctrica 2008 - 2025*.
2. Santana, C., Falvey, M., Ibarra, M., & García, M. (2014). *Energías renovables en Chile. El potencial eólico, solar e hidroeléctrico de Arica a Chiloé*. Ministerio de Energía del Gobierno de Chile and GIZ. Santiago, Chile.
3. Chamy, R., & Vivanco, E. (2008). *Potencial de Biogás. Identificación y clasificación de los distintos tipos de biomasa disponible en Chile para la generación de biogás de los distintos tipos de biomasa disponible en Chile*. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH.
4. Comisión Nacional de Energía. (2015). *Fijación de precio de nudo de corto plazo - Sistema interconectado del Norte Grande - Informe técnico definitivo*.
5. Comisión Nacional de Energía. (2015). *Fijación de precio de nudo de corto plazo - Sistema interconectado central - Informe técnico definitivo*.
6. Centro de Despacho Económico de Carga. (2016). Updated database. *Sistema Eléctrico Nacional*. Retrieved May 5, 2016, from <https://www.coordinador.cl/informes-y-documentos/>.
7. Generadoras de Chile AG. (2018). Annual reports. Retrieved March 5, 2018, from www.generadoras.cl.
8. Comisión Nacional de Energía de Chile. (2015). Database of electricity generation in Chile. Retrieved May 5, 2015, from <https://www.cne.cl/estadisticas/electricidad/>.
9. Ministerio de Energía. (2015). *Energía Abierta*. Retrieved May 1, 2015, from <http://energiaabierta.cl/>.
10. International Energy Agency. (2013). Technology roadmap - Wind energy. *Technology Roadmap*, 58. doi:10.1007/SpringerReference_7300.
11. International Energy Agency. (2014). Technology roadmap - Solar Photovoltaic Energy. *Technology Roadmap*, 60. doi:10.1007/SpringerReference_7300.
12. International Energy Agency. (2010). Technology Roadmap - Concentrating Solar Power. *International Energy Agency*, 52. doi:10.1787/9789264088139-en.
13. U.S. Energy Information Administration. (2017). *International Energy Outlook 2017*.
14. Berg, A., Bidart, C., Espinoza, D., Flores, M., Moraga, A., Müller, N., & Segura, C. (2013). *Recomendaciones para la elaboración de una Estrategia Nacional de Bioenergía*. Ministerio de Energía.
15. Ministerio de Energía del Gobierno de Chile. (2017). Explorador Eólico. Retrieved November 5, 2017, from <http://walker.dgf.uchile.cl/Explorador/Eolico2/>.
16. Ministerio de Energía del Gobierno de Chile. (2017). Explorador Solar. Retrieved November 5, 2017, from <http://www.minenergia.cl/exploradorsolar/>.