Table II. Electrical demand increase

25% LEV		
2030 annual electricity demand increase (MWh)	2030 daily electricity demand increase (MWh)	2030 percentage increase (%)
14.734.000	40.367	5

Temporal valleys use

Firstly, daily electrical demand curve is deduced using a lineal estimation based on [20] historical data trend, following methodology. This curve represents the forecasted daily consumption in Spain by 2030 if LEV were not brought in the society.

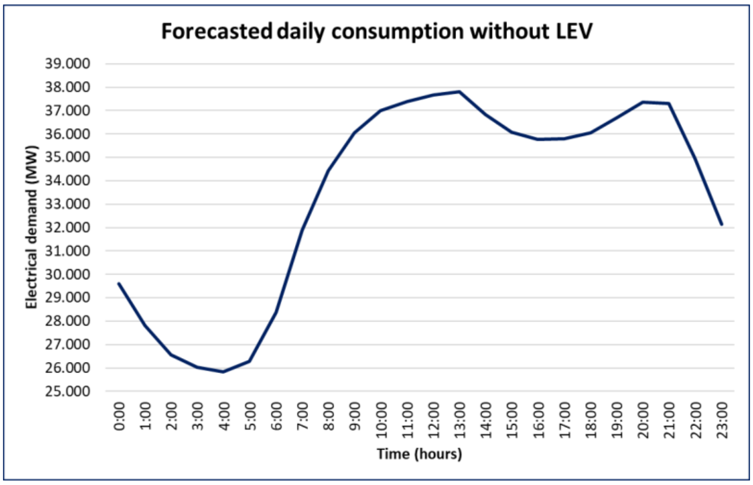

Image 2. Forecasted daily consumption without LEV introduction in Spain by 2030

Like Image 2 shows, most remarkable temporal valleys are mainly given during night and also during early afternoon. Considering additional total daily energy rise caused by LEV introduction, present study proposes distributing it among these temporal valleys, in a balance way. Hence, an almost flat daily consumption curve is achieved (Image 3).

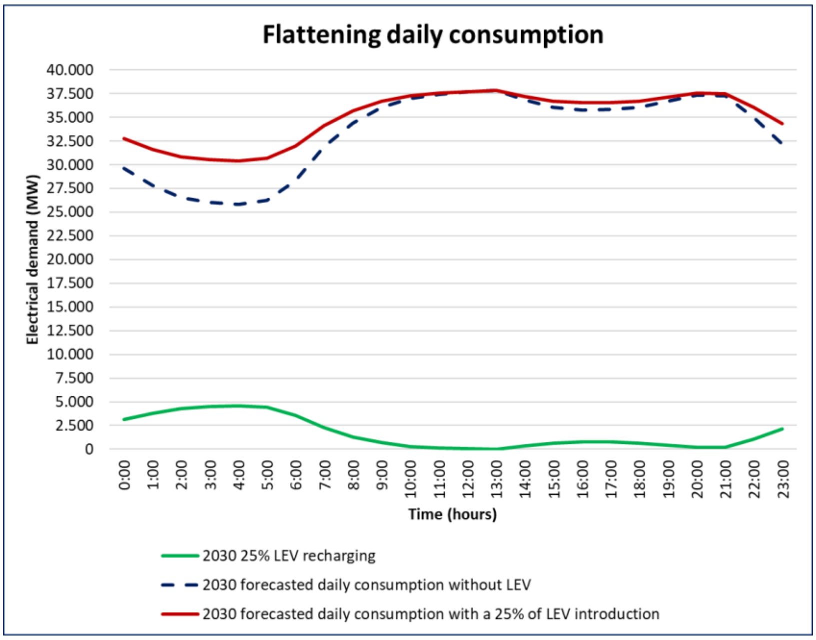

Image 3. 2030 Spanish forecasted daily consumption with a 25% of LEV introduction.

Recharging options contribution

Three different recharging strategies have been considered in this study: home, public buildings and electrical stations points [12]. Taking into account their different daily probabilistic curves, previous methodology has been applied in order to quantify their contribution. Results for the fraction of the total recharge to be made in a 25% LEV scenario are deduced. Therefore, 54% of the daily electricity demand for LEV recharge should be supplied by home recharging points, 23% by public buildings recharging points and 23% by electrical stations points.

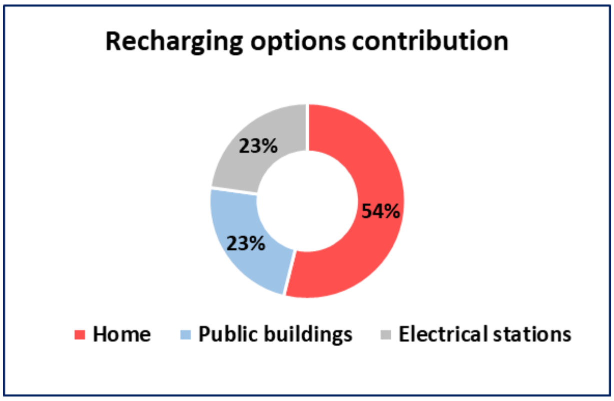

Image 4. Recharging options contribution

3. Conclusions

This paper presents a methodology that allows flattening daily electrical demand curve when consumption perturbations are introduced. In particular, the method is applied to the Spanish case, where a penetration of 25% of LEV by 2030 is analyzed.

First observation relates to the evident energy increase that LEV introduce to the network. Comparing with 2030 Spanish electricity demand without LEV insertion, the concerned penetration means a 5% of increment. Rightly distributing the consumption growth is essential to avoid worrisome network incidences. Therefore, present methodology distributes the demand rise among temporal valleys of the daily consumption curve, so that an almost flat curve is obtained.

Moreover, LEV could use different recharging points: home, public buildings and electrical stations. To ensure a flat demand curve with the LEV introduction, existing method has also balance the contribution of each strategy. Hence, home recharging points would face around a 54% on the electrical increase, public buildings points around a 23% and electrical stations a 23%.

Two lines of action will be taken in future researches. One the one hand, future works will explore how this penetration would affect Spanish society in a very long term (2040, 2050). On the other hand, coming investigation will also analyze how highest percentage of LEV penetration would affect Spanish network.

4. Acknowledgment

This work was supported in part by the regional public administration of Valencia under the grant ACIF/2018/106.

5. References

[1] J. W. Akitt, “Some observations on the greenhouse effect at the Earth’s surface,” *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.*, vol. 188, pp. 127–134, Jan. 2018.

[2] A. Danesin and P. Linares, “The relevance of the local context for assessing the welfare effect of transport decarbonization policies. A study for 5 Spanish metropolitan areas,” *Energy Policy*, vol. 118, pp. 41–57, Jul. 2018.

[3] L. Canals Casals, E. Martinez-Laserna, B. Amante García, and N. Nieto, “Sustainability analysis of the electric vehicle use in Europe for CO2 emissions reduction,” *J. Clean. Prod.*, vol. 127, pp.

425–437, Jul. 2016.
[4] “Emisiones de CO2 originadas por el transporte (% del total de la quema de combustible) | Data,” *Banco Mundial*. [Online]. Available: https://datos.bancomundial.org/indicador/EN.CO2.TRAN.ZS?locations=ES. [Accessed: 30-Dec-2018].
[5] “Statistics | Spain - Total CO2 emissions (chart),” *International Energy Agency*. [Online]. Available: https://www.iea.org/statistics/?country=SPAIN&year=2016&category=Key indicators&indicator=TotCO2&mode=chart&categoryBrowse=false&dataTable=INDICATORS &showDataTable=false. [Accessed: 30-Dec-2018].
[6] Ministerio para la Transición Ecológica, “El Consejo de Ministros da luz verde al anteproyecto de Ley de Cambio Climático,” 2019. [Online]. Available: https://www.miteco.gob.es/es/prensa/ultimas-noticias/el-consejo-de-ministros-da-luz-verde-al-anteproyecto-de-ley-de-cambio-climático-/tcm:30-487294. [Accessed: 12-Apr-2019].
[7] H. R. Galiveeti, A. K. Goswami, and N. B. Dev Choudhury, “Impact of plug-in electric vehicles and distributed generation on reliability of distribution systems,” *Eng. Sci. Technol. an Int. J.*, vol. 21, no. 1, pp. 50–59, Feb. 2018.
[8] P. Deb, Sanchari ; Tammi, Kari ; Kalita, Karuna ; Mahanta, “Impact of Electric Vehicle Charging Station Load on Distribution Network,” *Energies*, vol. 11, no. 1, p. 178, Jan. 2018.
[9] J. Su, T. T. Lie, and R. Zamora, “Modelling of large-scale electric vehicles charging demand: A New Zealand case study,” *Electr. Power Syst. Res.*, vol. 167, pp. 171–182, Feb. 2019.
[10] R. Baran and L. F. L. Legey, “The introduction of electric vehicles in Brazil: Impacts on oil and electricity consumption,” *Technol. Forecast. Soc. Change*, vol. 80, no. 5, pp. 907–917, Jun. 2013.
[11] Z. Liu, Q. Wu, A. Nielsen, and Y. Wang, “Day-Ahead Energy Planning with 100% Electric Vehicle Penetration in the Nordic Region by 2050,” *Energies*, vol. 7, no. 3, pp. 1733–1749, Mar. 2014.
[12] O. Tecnológico de la Energía, “Observatorio Tecnológico de la Energía MAPA TECNOLÓGICO MOVILIDAD ELÉCTRICA,” *IDAE*. [Online]. Available: http://www.idae.es/uploads/documentos/documentos_Movilidad_Electrica_ACC_c603f868.pdf. [Accessed: 07-Jan-2019].
[13] J. Martínez-Lao, F. G. Montoya, M. G. Montoya, and F. Manzano-Agugliaro, “Electric vehicles in Spain: An overview of charging systems,” *Renewable and Sustainable Energy Reviews*, 01-Sep-2017. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1364032116310152. [Accessed: 07-Jan-2019].
[14] L. Gong, W. Cao, K. Liu, J. Zhao, and X. Li, “Spatial and Temporal Optimization Strategy for Plug-In Electric Vehicle Charging to Mitigate Impacts on Distribution Network,” *Energies*, vol. 11, no. 6, p. 1373, May 2018.
[15] G. (Gianfranco) Pistoia, *Electric and hybrid vehicles : power sources, models, sustainability, infrastructure and the market*. Elsevier, 2010.
[16] A. C. R. Teixeira and J. R. Sodré, “Impacts of replacement of engine powered vehicles by electric vehicles on energy consumption and CO2 emissions,” *Transp. Res. Part D Transp. Environ.*, vol. 59, pp. 375–384, Mar. 2018.
[17] V. Tietge, Uwe; Mock, Peter; Zacharof, Nikiforos; Franco, “Real-world fuel consumption of popular European passenger car models | International Council on Clean Transportation,” 2016.
[18] “Km medios recorridos al año por los vehículos para uso personal, por relación con la actividad económica de la persona de referencia y antigüedad del vehículo,” *Instituto Nacional de Estadística*. [Online]. Available: http://www.ine.es/jaxi/Tabla.htm?path=/t25/p500/2008/p10/l0/&file=10020.px&L=0. [Accessed: 30-Dec-2018].
[19] “Series históricas parque de vehículos,” *Dirección General de Tráfico*. [Online]. Available: http://www.dgt.es/es/seguridad-vial/estadisticas-e-indicadores/parque-vehiculos/series-historicas/. [Accessed: 02-Jan-2019].
[20] “Demanda de energía eléctrica en tiempo real, estructura de generación y emisiones de CO2,” *Red Eléctrica Española*. [Online]. Available: https://demanda.ree.es/visiona/peninsula/demanda/total/2018-10-16. [Accessed: 27-Dec-2018].