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The future of data centre cooling, energy consumption and climate change

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Background – Importance of Internet

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- UN (2015): Universal internet access a Sustainable Development Goal.
- WEF (2016): Four **billion** people currently with no internet access.
- Linked to economic growth, inflation, government expenditure (Pradhan et al. 2013); (Koutroumpis 2009).
- Rural US: Adoption associated with economic, income growth and lower unemployment growth (Whitacre et al. 2014).
- Improves social progress in developing countries (Lechman and Kaur 2016).

A data centre

Background - Data Centres

Applications

- McKinsey (2010): Real-time online transactions, cloud-based applications, content sharing have increased demand for data centres.
- IDC (2014): Electronic data growth from 4.4tn GB to 44tn GB (2013 to 2020).
- Gartner (2016): Global systems expenditure $173bn in 2016, $177bn in 2017.

Significant energy demand

- Ebrahimi et al. (2014): US data centres consume 1.3-2% of US electricity.
- Bawden (2016): Globally consumed 2% of electricity, 3% emissions in 2015.

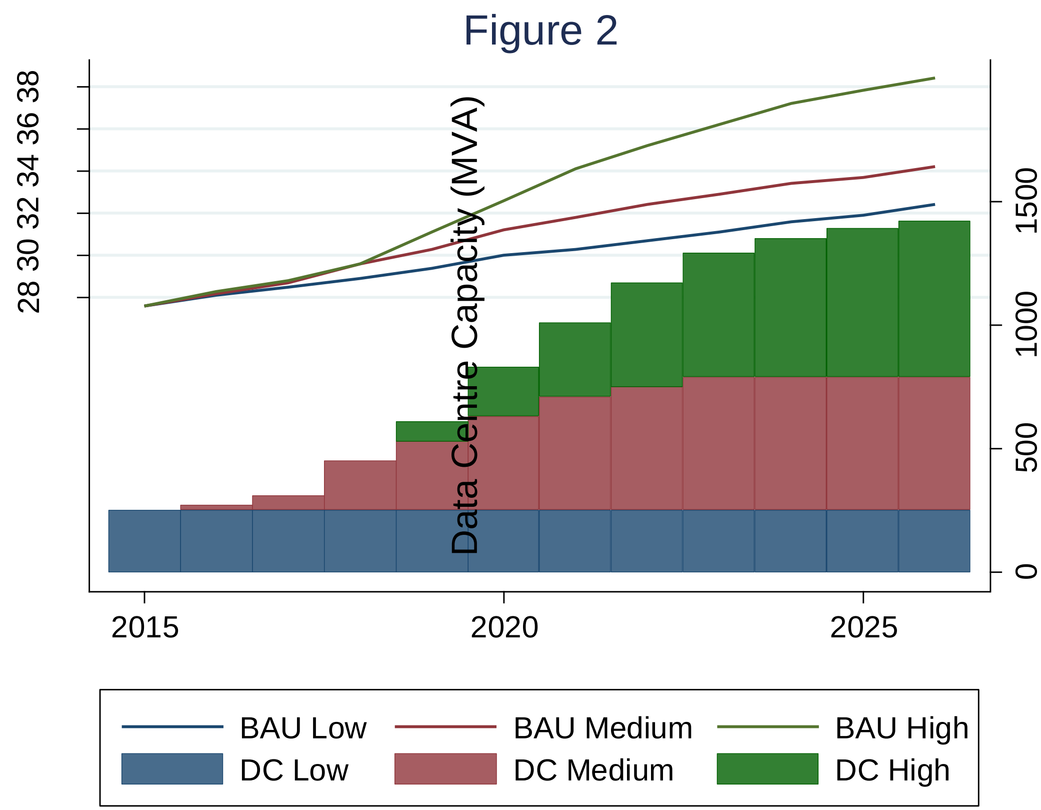
Technologies

- 'Chilled air' often used, 'Free air' more recent, experimental 'Liquid' cooling.
- Sickinger et al. (2014): Liquid cooling can mostly remove need for mechanical air chiller while reusing waste heat elsewhere.

Why is Ireland a popular destination?

- Infrastructure (Electricity, Fibre)
- Climate, FDI factors
- 75% of expected national growth attributed to growth in data centres (Oireachtas 2017).

- Forecasts depend on technology available and the rate of adoption.
- Lack of economic research, focus on modelling technology diffusion for a hypothetical liquid cooling technology.



Model Assumptions & Data

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Assumptions

- Homogenous data centres using mechanical air cooling.
- Liquid cooling lowers consumption by 33.3% (Garimella et al. 2013).
- Adoption follows the market diffusion curve.
- Data centre capacity factor of 0.75 (IWEA 2015).
- Electricity-specific emissions factor 0.556 kgCO2/kWh (Brander et al. 2011).

EirGrid Data

- Data centre installed capacity (in MVA)
- National electricity demand (in TWh)
- Three scenarios (Low, Median, High) from 2015-2026.

Two diffusion scenarios

- 'New Only': Only new data centres from 2017 follow adoption curve
- 'All Diffusion': New and existing data centres follow adoption curve

Methodology – Technology Diffusion

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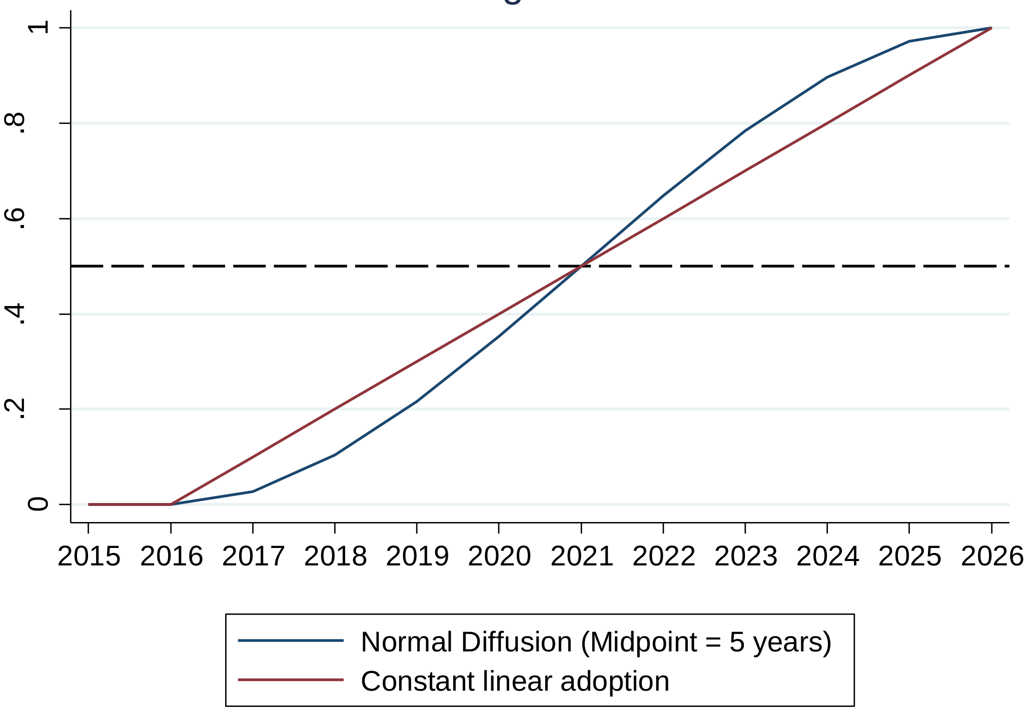
- Builds on Yin et al. (2003), who adapted the sigmoid ‘Gompertz’ function to better reflect market adoption within a specific timeframe (t_e).

- Given the lack of public data, a study of technology diffusion is helpful for industry and policy stakeholders.

Figure 1



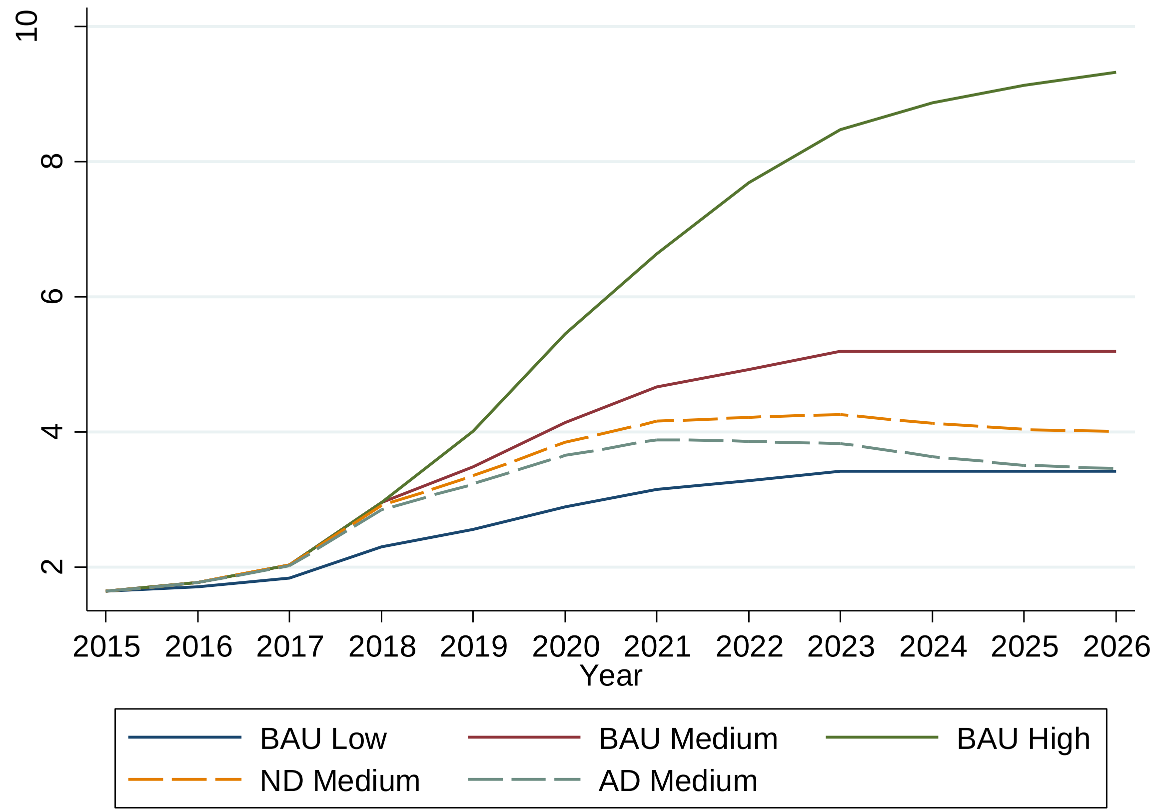
$$\lambda_{it} = \left(1 + \frac{t_{ie} - t_i}{t_{ie} - t_m}\right)\left(\frac{t_i}{t_{ie}}\right)^{\frac{t_{ie}}{(t_{ie} - t_{im})}}$$

Sectoral Results

‘New Only Diffusion’: Over 12 year period, data centre electricity demand is 12.9% lower relative to Business as Usual (BAU) median scenario.

‘All Diffusion’: Electricity consumption is expected to be 19.5% lower over the 12 year period.

Almost brings demand back in line with the ‘BAU low’ scenario, a reduction of **half of the new connections** (red bar from earlier).



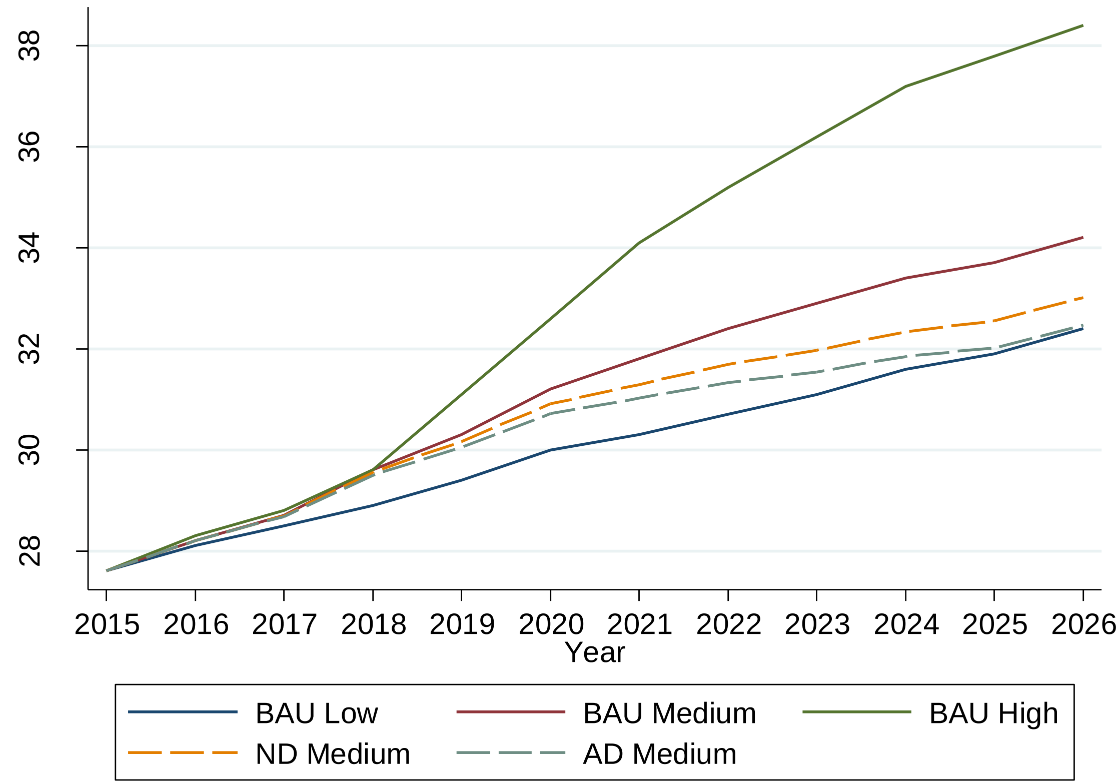
National Results

Electricity Demand in 2026

- 'New Only Diffusion': National electricity demand is 3.5% lower relative to BAU.
- 'All Diffusion': 5.2% lower.

12 year total

- 'New Only Diffusion': Demand would be 1.7% lower.
- 'All Diffusion': 2.5% lower.



CO2 Emissions

BAU_{MED}:

- Data Centres consume 1 Mt CO2 equivalent in 2016, would almost triple by 2026.
- 1.7% of national emissions (as a fraction of 2015 EPA estimate).
- Would rise to 4.9% in 2026, holding total emissions constant.

12 year total:

- ‘New Only Diffusion’ sectoral emissions 13% lower than BAU over the entire sample.
- This rises to a 19.5% reduction for the ‘All Diffusion’ scenario.

	BAU MED	ND MED	AD MED
2015	.929	.929	.929
2016	1.00	1.00	1.00
2017	1.15	1.15	1.14
2018	1.67	1.64	1.61
2019	1.97	1.89	1.82
2020	2.34	2.17	2.06
2021	2.64	2.35	2.20
2022	2.78	2.38	2.18
2023	2.93	2.41	2.16
2024	2.93	2.33	2.06
2025	2.93	2.28	1.98
2026	2.93	2.26	1.95
Total	**26.20**	**22.79**	**21.09**

*Note: Values are in units of million tonnes of CO2 equivalent (Mt CO_2eq), based on electricity demand in terms of TWh. Assumes a data centre capacity factor of 0.75.

Conclusions

- As our society become more connected, data centre electricity consumption becomes more prominent.
- We apply a model of technology adoption to chart how a new technology might diffuse in the market over time.
- Results note how the rate of electricity (and CO2) savings depends on the **type** of technology in question and the **rate** of adoption.
- This approach is ideal where public data are limited.

Thank You

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References

UN, 2015. Transforming our world: The 2030 agenda for sustainable development

World Economic Forum, 2016. Internet for All: A Framework for Accelerating Internet Access and Adoption.

Pradhan, R.P., Bele, S., Pandey, S., 2013. Internet-growth nexus : evidence from cross-country panel data. Appl. Econ. Lett. 20

Koutroumpis, P., 2009. The economic impact of broadband on growth: A simultaneous approach. Telecomm. Policy 33

Whitacre, B., Gallardo, R., Strover, S., 2014. Broadbands contribution to economic growth in rural areas: Moving towards a causal relationship. Telecomm. Policy 38

Lechman, E., Kaur, H., 2016. Social Development and ICT Adoption . Developing World Perspective. 9

McKinsey, 2010. Energy efficiency : A compelling global resource, McKinsey Sustainability & Resource Produtivity.

IDC, 2014: https://www.emc.com/leadership/digital-universe/2014iview/executive-summary.htm

Gartner, 2016. Gartner Says Global IT Spending to Reach $3.5 Trillion in 2017. http://www.gartner.com/newsroom/id/3482917

Bawden, T., 2016. Global warming: Data centres to consume three times as much energy in next decade, experts warn. http://www.independent.co.uk/environment/global-warming-data-centres-to-consume-three-times-as-much-energy-in-next-decade-experts-warn-a6830086.html

Ebrahimi, K., Jones, G.F., Fleischer, A.S., 2014. A review of data center cooling technology, operating conditions and the corresponding low-grade waste heat recovery opportunities. Renew. Sustain. Energy Rev. 31

Sickinger, D., Geet, O. Van, Ravenscroft, C., 2014. Energy Performance Testing of Asetek's RackCDU System at NREL's High Performance Computing Data Center

Oireachtas, 2017. Joint Committee on Communications, Climate Action and Environment Debate - 9/5/2017 http://beta.oireachtas.ie/en/debates/debate/joint_committee_on_communications_climate_action_and_environment/2017-05-09/2/

Yin, X., Goudriaan, J., Lantinga, E.A., Vos, J., Spiertz, H.J., 2003. A flexible sigmoid function of determinate growth. Ann. Bot. 91

IWEA, 2015. Data Centre Implications for Energy Use in Ireland: Irish Data-Centre Load Projections to 2020.

Garimella, S. V., Persoons, T., Weibel, J., Yeh, L.T., 2013. Technological drivers in data centers and telecom systems: Multiscale thermal, electrical, and energy management. Appl. Energy 107

Brander, M., Sood, A., Wylie, C., Haughton, A., Lovell, J., 2011. Electricity-specific emission factors for grid electricity, Ecometrica