COMMENTS OF THE ACM EUROPE TECHNOLOGY POLICY COMMITTEE ON THE PROPOSAL FOR A REGULATION ESTABLISHING A FRAMEWORK OF MEASURES FOR STRENGTHENING EUROPE'S SEMICONDUCTOR ECOSYSTEM

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The Association for Computing Machinery (ACM) is the world's largest and longest established professional society of individuals involved in all aspects of computing. It annually bestows the ACM A.M. Turing Award, often popularly referred to as the "Nobel Prize of computing." ACM's Europe Technology Policy Committee (Europe TPC)[1] is charged with and committed to providing objective technical information to policy makers and the general public in the service of sound public policymaking. ACM and Europe TPC are non-profit, non-political, and non-lobbying organizations. Europe TPC is pleased to submit the following Comments[2] in response to the Commission's above-captioned consultation on the proposed Chips Act, opened on 8 February 2022.[3]

Capsule Conclusion

> ***Europe TPC supports the Commission's intention to promote European digital sovereignty, but also see its Proposal for a Regulation Establishing a Framework of Measures for Strengthening Europe's Semiconductor Ecosystem as an important opportunity to improve the sustainability of semiconductor technologies and applications. With this goal in mind, we raise a number of environmental considerations that would need to be accounted for, noting that at present the Chips Act fails to address the substantial probability that it will produce "rebound" effects potentially significant enough to wholly negate efficiency savings or even induce net energy and emissions increases (aka "backfire"). The Framework should thus be amended to expressly identify, quantify, and mitigate such impacts, with a view to aligning semiconductor innovation with the technological and environmental objectives of the Green Deal.***

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[1] See, https://europe.acm.org/europe-tpc.

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[3] Proposal for a Regulation of the European Parliament and of the Council Establishing a Framework of Measures for Strengthening Europe's Semiconductor Ecosystem, Brussels, 8.2.2022 COM(2022) 46 final, 2022/0032 (COD). [https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13405-European-Chips-Act-package_en]

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Overview

Europe TPC recognises the geopolitical and economic factors motivating the creation of semiconductor production facilities in Europe, while at the same time noting that environmental destabilisation (*viz.* climate change and extraction of critical rare earth metals) also poses an existential threat to Europe's resilience and reduces geopolitical stability. These conflicting concerns need to be carefully balanced.

Given Europe's leadership on environmental policy, the present proceeding affords an opportunity to ultimately improve both the output and fundamental sustainability of the semiconductor industry. To meet both goals, however, the proposed Framework also must promote scrutiny and regulation of the environmental impacts of semiconductor production.

To that end, in assessing how best to finalise the proposed Chips Act, Europe TPC urges the Commission, Council, and European Parliament to consider the following observations and supporting data relating to environmental consequences of semiconductor production both within and outside the Information and Communications Technology (ICT) sector that are presently unaddressed by the proposed legislative Act:

Direct Impacts within the ICT Sector

The Chips Act may lead to rebound effects which are significant enough to induce backfire.

Semiconductor manufacture is responsible for the majority of ICT's direct emissions:

- ICT is unlike other industries, such as construction, automotive, aviation, for which the lifetime energy use is dominated by operational energy (use phase).[4,5]

- As chips advance, their manufacture incurs a greater environmental impact.[6]

- The Chips Act acknowledges that manufacture of semiconductors has a carbon footprint, but i) underestimates the proportional share of production phase energy, and ii) overestimates the energy saved by use of more efficient chips.

- These use phase efficiencies are more than cancelled out by the rising energy intensity of manufacture of advanced semiconductors – particularly when incremental efficiency improvement resulting from investment in R&D necessitates the disposal of obsolescent chips long before the use phase energy savings accrue.

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[4] Williams, E. (2011). Environmental effects of information and communications technologies. *Nature*, *479*(7373), 354-358.

[5] Gupta, U., Kim, Y. G., Lee, S., Tse, J., Lee, H. H. S., Wei, G. Y., ... & Wu, C. J. (2022). Chasing carbon: The elusive environmental footprint of computing. *IEEE Micro*.

[6] https://www.bloomberg.com/news/articles/2021-04-08/the-chip-industry-has-a-problem-with-its-giant-carbon-footprint

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- The Act's stated requirement that chips meet "energy efficiency requirements" could create a moving target (set on a rolling basis by the state-of-the-art) that drives obsolescence.

- Investment in new European production facilities entails additional up-front environmental impacts which will add to the lifetime energy attributable to semiconductor manufacturing (production phase).

Semiconductor fabrication creates hazardous waste by-products that pose human health risks and threaten ecosystems if not properly managed:[7]

- The Chips Act does not mention any hazardous waste by-products except for "fluorinated greenhouse gasses"; nor does it set out clear requirements for handling hazardous waste.

- The Chips Act downplays key opportunities for extracting critical rare earth metals from industry by-products and electronic waste.[8]

- The Chips Act further lacks a strong mandate for "cutting edge" semiconductors to be designed to better enable recyclability and thus reduce environmental impacts of the disposal phase.

Indirect Impacts within the ICT Sector

The Chips Act will almost certainly induce backfire.

Semiconductor innovation is a key driver of increased energy demand and a rising ICT carbon footprint:

- Approaching the physical limits of Moore's law[9] and Dennard's law[10] will necessitate the use of parallel computing to improve performance. This will likely result in a strong growth in energy demand.

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[7] Shen, C. W., Tran, P. P., & Minh Ly, P. T. (2018). Chemical waste management in the US semiconductor industry. *Sustainability, 10*(5), 1545.

[8] Gaustad, G., Williams, E., & Leader, A. (2021). Rare earth metals from secondary sources: review of potential supply from waste and by-products. *Resources, Conservation and Recycling, 167,* 105213.

[9] "The statement that the number of transistors that can be placed on an integrated circuit doubles every two years. This statement was first made by Gordon Moore (1929–), the president of Intel, in 1965 and it has remained valid for the first fifty years of the existence of integrated circuits. However, there are various reasons for thinking that this will come to an end in the future. For example, as circuits become smaller, the quantum effects associated with individual atoms and electrons become more significant." *See*, www.oxfordreference.com

[10] According to Semiconductor Engineering, "Dennard's Law states that as the dimensions of a device go down, so does power consumption. While this held, smaller transistors ran faster, used less power, and cost less. But there was a limit to how long this would last. Smaller devices with thinner dielectrics and shorter channels are more prone to leakage. Leakage, while negligible for much of the industry's history and ignored in Dennard's original paper, now approaches the same order of magnitude as the circuit's dynamic power." *See*, www.semiengineering.com

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- The Chips Act aims to increase semiconductor production to accommodate unrestrained growth in demand for computation. This rising demand for computation underlies continuous growth in the ICT sector's carbon emissions, which in turn requires greater emissions reductions across the economy to meet climate targets.

- To the extent that limits in semiconductor supply currently act as a constraint to (or as "brakes" on) some of these excesses, the Act's investment in semiconductor production will necessarily increase the rate of growth of ICT's emissions in Europe.

Indirect Impacts across the Economy

The Chips Act will lead to significant rebounds (if not backfire) if technology is leveraged in pursuit of economic growth to the exclusion of environmental considerations.

Semiconductor innovation enables new capabilities that induce new energy demands:

- The Chips Act rightly notes that, e.g., 5G enables expansion of Internet of Things and edge computing technologies, which in turn drives the need for more and more advanced semiconductors. This is a useful illustration of the positive feedback between innovation and growth in markets. Digital infrastructure growth drives innovation in semiconductors; in turn, innovation in semiconductors can be expected to enable further infrastructure growth, driving greater demand in an endless cycle, undermining environmental gains that could be enabled by ICTs.

- Ultra-low power energy efficient processors are critical enablers of transformation in how societal needs are met. The Chips Act frames these transformations as massively economically advantageous to Europe. We note that environmental costs are not fully valued in the market, although the EU Emissions Trading System is a welcome step towards this. Taking the long view, if constraints (e.g., carbon, emissions) become priced, the economic gains resulting from unrestrained growth may be materially overestimated.

Recommendations

Semiconductor innovation will be critical to enabling Europe to achieve its environmental goals but succeeding will require that innovation be steered into alignment with the Green Deal.[11]

[11] See ACM's Europe Technology Policy Committee's formal comments in response to the Green Deal: https://www.acm.org/binaries/content/assets/public-policy/europe-tpc-green-deal-comments.pdf

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There is a need for investment in innovation which will deliver reductions in the direct environmental impacts of semiconductor production and disposal:

- A stronger focus on lower power consumption (specifically maximum TDP)[12] in chip development would be very desirable to help mitigate rebound.

- In conformity with the Circular Economy Action Plan,[13] a portion of Europe's semiconductor investment should include funding of materials and process innovation that increases the recovery of materials from electronic waste and improves recyclability of chips, with a view to mandating recyclability requirements.

- While creating facilities for the manufacture of semiconductors, Europe should also take responsibility for their disposal as a matter of social justice[14] and to incentivise innovation of more responsible practices.

- Funding should be prioritised for companies which have made the strongest environmental commitments regarding renewable energy, water, and waste.

In conformity with the EU Emissions Trading System and in accordance with international climate agreements (*viz*. European commitments at COP26), rigorous accounting of emissions impacts is needed:

- Projections of the efficiency savings enabled by semiconductor innovation should account for the full lifecycle (production, use, and disposal) of the semiconductors themselves.

- Accounting for the changing carbon intensity of energy, these projections should include implications for carbon emissions impacts, with a view to aligning these with emissions reductions timelines.

- All initiatives funded through Chips Act investments should be required to account for their real (actual) direct emissions as a condition of their funding. This will enable refinement of projections against emissions reductions targets.

- A working group and/or oversight body should be created in Europe to monitor and address issues of rebound and backfire as identified above.

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[12] "Thermal Design Power" is defined, for example, by Intel (a major chip manufacturer) as "power consumption under the maximum theoretical load."

[13] https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en

[14] Electronic waste disposal involves exposure to harmful chemicals and dangerous working conditions, the consequences of which are disproportionately felt by poor and racially marginalised people.

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In conformity with the Green Deal, there must be up-front investment technologies which enable sustainable transformation across the economy:

- Clearer specification is needed regarding the use of chips to enable concrete environmentally beneficial transitions as detailed in the Green Deal. For example, as the Chips Act notes, more semiconductors are needed to enable the transition to electric vehicles; they are also needed for photovoltaic modules, which are essential to Europe's climate strategy.

- Each of these concrete items should include specification of a minimum viable product (necessary power and performance characteristics) needed to enable the given sustainability improvement. This can be used as a fixed target to prevent unnecessary obsolescence and thus net the efficiency gains delivered by the more advanced semiconductors.

- European technology policy should challenge unrestrained demand for computation due to its incompatibility with environmental commitments.

- Investment in semiconductor innovations or applications which spur environmentally disadvantageous economic growth should be limited. Investment should prioritise profitability of attending to the demands entailed by a more sustainable economy.

Conclusion

Europe TPC strongly supports semiconductor innovation, recognising its potential to fundamentally revolutionise society. We also recognise our responsibility to ensure that innovation delivers social and environmental good. Accordingly, Europe TPC strongly encourages harmonisation of the Chips Act with other European policy initiatives to harness innovation to realise a *sustainable* Digital Decade.

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