S T R A T E G I C H O R I Z O N
STRATEGIC BRIEF · SB-2026-13

The Signal the Models Do Not Carry

Atlantic circulation risk, and whether Europe's adequacy assessment can represent it at all

This brief takes no position on whether the Atlantic overturning circulation will collapse. That is a live scientific dispute and this organisation has no standing in it. The question here is narrower and is answerable from the published record: if the risk were real, is there any instrument in the European electricity adequacy chain shown to be capable of representing it? None was identified in the material reviewed for this brief, and the reason is not neglect. Every step in the chain now accounts for climate change, faithfully and by design. The signal is absent at the head of the chain, in the climate models themselves, and nothing downstream can reintroduce what was never there. The case is not that a ten-year adequacy assessment should treat an end-of-century mechanism as a central forecast, but that infrastructure sized within that horizon can remain in service for decades beyond it.

KEY FINDINGS

	Position at the data cut-off
The chain	ERAA 2025 models wind, solar and hydro from weather scenarios "obtained from climate projections". Those projections come through the Copernicus Pan-European Climate Database, PECD 4.2, which draws on six CMIP6 global climate models across four SSP scenarios
What the models say	Under SSP2-4.5 the CMIP6 multimodel mean gives a 32 per cent weakening of the circulation by 2091–2100, with a 90 per cent band of ±37. The band runs from no weakening to near-shutdown
What the observations say	Constraining the same models on observed South Atlantic salinity and North Atlantic temperature gives 51 per cent ±8 — about 60 per cent more weakening, with 79 per cent less uncertainty. The models are biased toward stability
Why it matters for a grid	In a model where the circulation collapses under RCP4.5, the 1-in-10-year daily minimum at De Bilt is −20.0°C. Where it recovers under the same forcing, cold extremes decline. These are different planning universes
Which way the error runs	The published work on climate change in European adequacy finds loss-of-load expectation falling by around 59 per cent, because warmer winters reduce heating demand. It treats climate change as gradual and does not address abrupt change

	Position at the data cut-off
The finding	Every instrument in the chain accounts for climate change in the direction that makes adequacy easier. The one mechanism identified in the literature reviewed here that would reverse the sign for north-west Europe is absent from the planning chain examined

Table 1. The record in summary. Each line is established below with its source and its limits.

Series	Strategic Brief SB-2026-13. Standalone
Subject	Whether the European resource adequacy chain is capable of representing an abrupt change in Atlantic overturning circulation, and what follows from the answer
Relevance	Energy Statecraft Vol. 07 on positions and shocks; the Delivery Ladder DL-2026; research architecture RA-2026-02 for the second flagship
Author	Strategic Horizon
Version	v1.3 FINAL
Data cut-off	21 October 2026

SECTION I

What the assessment actually runs on

Europe decides whether it has enough electricity through the European Resource Adequacy Assessment, which ENTSO-E prepares and ACER approves. It produces a loss-of-load expectation for each bidding zone in each target year, and that number is what capacity mechanisms, security-of-supply arguments and national adequacy decisions are built on.

The assessment is weather-driven, because the system it assesses now is. Wind, solar and hydro output and a substantial part of demand all depend on it. ERAA 2025 handles this through thirty-six weather scenarios — three possible evolutions of climate, each with twelve weather conditions — and states that the generation time series are modelled using scenarios “obtained from climate projections”. The projections reach it through the Copernicus Pan-European Climate Database. Version 4.2 of that database draws on six CMIP6 global climate models under four SSP scenarios, running continuously from 2015 to 2100.

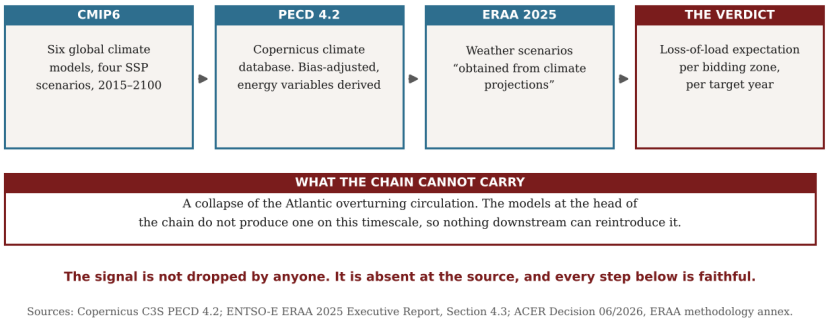


Figure 1. The chain from climate model to adequacy verdict. Each step is documented and each is faithful to the one above it. Sources as shown.

This is a considerable improvement on where European adequacy assessment stood a few years ago, and it should be said plainly before anything critical is. The chain is no longer assuming that

the past is a guide to the future. It carries a forward climate signal, bias-adjusted, across four scenarios, to 2100. The criticism that European planning ignores climate change is out of date.

SH ASSESSMENT I/1

The chain is not defective. It is faithful, and that is precisely the problem this brief is about.

A bias adjustment improves the fit between a model and the observed record. A scenario selection picks representative years from what the models produced. A weather-year sampling draws from that set. None of these operations can add a physical behaviour the source models did not generate. They are all, correctly, downstream.

The question therefore moves upstream, to what the six models at the head of the chain contain. That is a question about climate models and not about European energy policy, and it has an answer in the literature.

SECTION II

What the models contain, and what they are missing

The Atlantic overturning circulation carries warm surface water north and cold deep water south, and it is the principal reason north-west Europe is warmer than its latitude. Whether it weakens, by how much, and whether it can cross a threshold into an abrupt and self-sustaining shutdown is a genuine and unresolved scientific question. This brief does not attempt to settle it.

What can be reported is what the models used in the planning chain say, and how that compares with the observational record. Under SSP2-4.5, the CMIP6 multimodel mean projects a weakening of 32 per cent by 2091–2100 against the 1850–1900 baseline, with a 90 per cent band of plus or minus 37 percentage points. In April 2026 a study in Science Advances constrained the same model ensemble on observed South Atlantic surface salinity and North Atlantic sea surface temperature, and obtained 51 per cent plus or minus 8 — about sixty per cent more weakening than the unconstrained mean, with model uncertainty reduced by seventy-nine per cent. The authors attribute the gap to two specific model biases: a fresh bias in South Atlantic surface salinity and a cold bias in North Atlantic sea surface temperature, both of which make the modelled circulation more stable than the observed one.

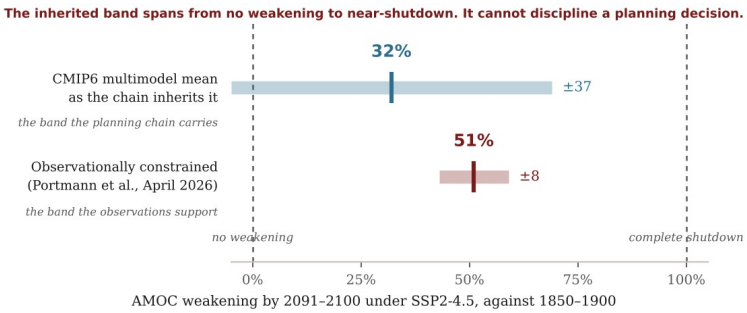


Figure 2. The two estimates. Source: Portmann, Swingedouw, Khattab and Chavent, Science Advances, 15 April 2026. The percentages are weakening of the circulation, not probability of collapse; the two should not be confused.

SH ASSESSMENT II/1 — THE FINDING THIS BRIEF TURNS ON

The planning chain inherited the wide band rather than the narrow one, and a band that wide cannot discriminate between the decisions a planner is choosing among.

A central estimate of 32 per cent with a band of ±37 spans from a circulation that has not weakened at all to one that has nearly stopped. That range is too wide to separate the options: materially different capacity, interconnector, strategic-reserve and winter-margin choices all remain consistent with it. The constrained estimate of 51 ± 8 is a different kind of object: it is narrow enough that a planner could ask what it implies and get a different answer depending on the number.

This is not a claim that ENTSO-E chose wrongly. PECD 4.2 was assembled from the standard ensemble, which is the defensible choice and the one any reviewer would have required. The observational constraint was published in April 2026, after the database was built. The point is about what the chain now contains, not about who should have known.

SECTION III

Why a grid should care about an ocean current

An adequacy assessment is not interested in annual mean temperature. It is interested in the coldest plausible period, because that is when demand peaks and when a system either holds or does not. The relevant variable is something like the one-in-ten-year daily minimum, and the relevant season is winter.

A 2025 study in Geophysical Research Letters ran the Community Earth System Model under several circulation states and reported European temperature extremes for each. At De Bilt in the Netherlands, the one-in-ten-year daily minimum in the pre-industrial control is −4.4°C with the circulation running and −37.6°C with it off. Under RCP4.5 with a collapse, it is −20.0°C. Frost days rise from 12.4 a year to 153.2. Under the same forcing with the circulation recovering, cold extremes decline instead.

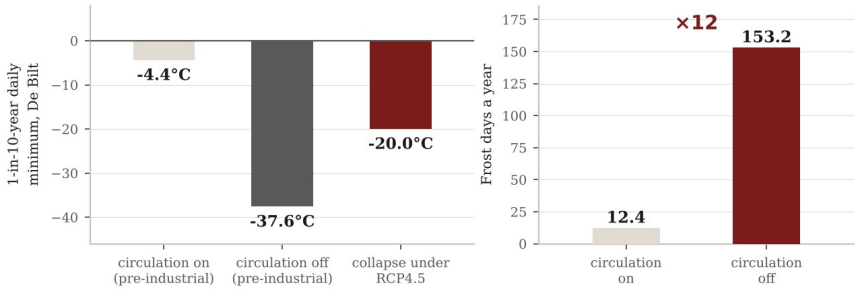


Figure 3. The planning variable under different circulation states. Source: van Westen and Baatsen, Geophysical Research Letters, 28 June 2025, using CESM 1.0.5. The first two bars are pre-industrial control runs and demonstrate the mechanism; the third is the planning-relevant case. Under the same RCP4.5 forcing with the circulation recovering, cold extremes decline instead, and the study gives no single comparable figure for that case.

One feature of that study cuts against the intuitive reading and must be carried rather than dropped. The strong cooling appears under intermediate warming, around two degrees by 2100, and vanishes under the high-emissions scenario, where greenhouse warming overwhelms it. In this model experiment the cold-risk response is therefore not monotonic in emissions: the strongest cooling appears under the intermediate-warming case closest to the trajectory European policy is explicitly seeking. That is not an argument against the target. The high-

emissions path has its own consequences for the same system, which this brief does not examine; the comparison here is between two mitigation outcomes, not between mitigating and not.

SH ASSESSMENT III/1

The difference between the two cases is not a margin. It is the difference between a system planning for milder winters and one planning for winters it has never seen.

A one-in-ten-year minimum of −20°C in the Netherlands, with heating demand increasingly electrified, is a different peak-demand problem from the one European adequacy currently solves. It would arrive alongside higher day-to-day variability from a more active storm track, which is a different problem again for a system balancing wind.

The non-monotonicity deserves its own line, because it inverts the usual framing. On this model's evidence the cold risk is concentrated in the successful-mitigation case. For this mechanism the relationship can run the other way: on the evidence of this experiment, meeting a warming target does not of itself remove the power-system risk associated with it.

SECTION IV

The direction of the error

There is published work on bringing climate change into European adequacy assessment, and it is worth reading closely because of what it finds and what it excludes. The method takes ENTSO-E's own adequacy model and modifies its inputs: demand is shifted along each market zone's temperature-sensitivity curve, and hydro inflow profiles are reshaped and rescaled. With demand effects alone, average loss-of-load expectation across market nodes falls by about fifty-nine per cent, and unserved energy by about thirty. Adding hydro effects brings the fall to about fifty-six per cent. Warmer winters reduce heating demand, and adequacy gets easier.

The authors are explicit about the limits of this. They describe the demand results as an upper bound, and record that they do not model extreme events, the seasonal coincidence of low hydro with peak demand, or changes in the frequency of extremes. Abrupt change and ocean circulation are not addressed; the treatment is of gradual, year-round warming.

SH ASSESSMENT IV/1

Everything the apparatus knows about climate change points the same way, and it is the reassuring way.

That is not a conspiracy and not a bias in the ordinary sense. It is what follows from representing climate change as monotonic warming: in a heating-dominated system, monotonic warming reduces the peak. The result is correct given the representation. The representation is what omits the only mechanism that would reverse the sign.

The asymmetry is what makes this worth publishing. If the chain simply could not see climate change, a planner would know to be cautious. A chain that sees climate change and reports that the problem is shrinking by more than half invites the opposite posture, and does so on a representation in which this abrupt-change mechanism is not carried, and which therefore cannot produce it in the adequacy signal.

SECTION V

The case against this reading

Four objections stand up.

The first is that a collapse on this timescale is unlikely, and that planning instruments are not obliged to represent every low-probability outcome. Adequacy assessment is already a tail-risk exercise with its own conventions, and loading it with a contested geophysical scenario would degrade rather than improve it.

The second is that adequacy assessment runs to a ten-year horizon and this risk, on the literature cited here, is an end-of-century one. A planning instrument that looks a decade ahead has no business carrying a 2100 mechanism, and would be criticised if it did.

The third is that the constrained estimate is one study, published six months ago, and that a single paper does not overturn an ensemble. Treating it as the better number is exactly the error this organisation warns against elsewhere.

The fourth is that this brief has chosen a dramatic case and then measured the apparatus against it. The same argument could be made about any number of mechanisms absent from climate models, and an institution that acted on all of them would plan for nothing in particular.

SH ASSESSMENT V/1

The second objection is the strongest and it narrows the finding considerably. The first and fourth are answered. The third is accepted.

On the second: it is correct that a ten-year adequacy horizon does not need a 2100 mechanism, and the recommendation in Section VI is written to respect that. What a ten-year instrument does determine is infrastructure with a forty-year life — interconnectors, reserves, network reinforcement — and the question of whether those assets were sized against a climate that can only get milder is a legitimate one to put even on a decadal horizon.

On the first: the brief does not ask that the scenario be put into the central case. It asks whether the apparatus is capable of running it at all, which is a different and cheaper request. On the fourth: the distinguishing feature here is not drama but direction. This is the only identified mechanism that reverses the sign of the climate effect on north-west European winter peak demand, and a single mechanism that inverts a headline result is worth more attention than a long list that does not.

On the third, the objection is accepted without qualification. One paper is one paper. This brief does not treat 51 ± 8 as the correct number; it treats the existence of a credible constrained estimate well outside the ensemble mean as evidence that the ensemble’s band is doing less work than its width suggests.

SECTION VI

Recommendation

RECOMMENDATION SB-13-R

Run one weather scenario the models cannot produce, and publish what happens. One measure, addressed to ENTSO-E and to national system operators, and deliberately small.

The adequacy machinery already accepts weather scenarios as inputs. A circulation-collapse winter is a weather scenario: a set of temperature, wind and precipitation series over a European domain, and published model runs of the kind cited in Section III can supply one. Constructing it requires no change to the adequacy model, no new methodology and no position on how likely the scenario is. It requires one additional run and the publication of the loss-of-load expectation it produces, labelled as a sensitivity and excluded from the central case.

The value is in the number, whatever it turns out to be. If the system holds, that is a finding worth having and it costs one run to establish. If it does not hold, Europe has learned something about assets it is sizing now on an assumption that winters get milder. The published record reviewed for this brief does not establish the answer, because no adequacy run using such a scenario was located.

What would refute this brief: an adequacy assessment, at European or national level, that already runs an abrupt-change or circulation-collapse weather scenario, or a demonstration that the PECD scenario set contains a member in which the circulation weakens sharply enough to reverse the sign of the winter demand effect. Either would show the apparatus can represent the risk after all. Neither was located; the search is described in the limits.

This recommendation does not require anyone to accept that a collapse is likely, or that the constrained estimate is the right one. It is a request to measure a sensitivity that the existing machinery can already measure.

Limits

This brief makes no claim about the likelihood of an Atlantic circulation collapse and should not be cited as supporting one. The description of the ERAA chain is taken from the ERAA 2025 Executive Report and from the methodology annex to ACER Decision 06/2026; the statement that generation time series are modelled from scenarios "obtained from climate projections" is quoted from Section 4.3 of the Executive Report. The methodology annex sets out thirty-six weather scenarios as three evolutions of climate with twelve weather conditions each, and does not, in the text located, define how the three evolutions are derived or state which PECD version is used; the link from ERAA to PECD 4.2 and from PECD to the six CMIP6 models therefore rests on the Copernicus documentation and on the Executive Report's data list rather than on a single document stating the whole chain. PECD 4.2 contents are from a Copernicus training document of 30 June 2025, which gives six models and four SSPs without naming them. The circulation projections are from Portmann and others, Science Advances, 15 April 2026, which post-dates the construction of the database. The European temperature extremes are from van Westen and Baatsen, Geophysical Research Letters, 28 June 2025, and are from a single model, CESM 1.0.5, at a single station; they demonstrate a mechanism rather than forecasting one, and no multi-model equivalent was located. The adequacy post-processing results are from Harang, Heymann and Stoop, published December 2020 for target year 2025, and are therefore the state of the published method rather than of current practice. The claim that no adequacy assessment runs an abrupt-change scenario is a negative, established by searching the published ERAA material and the literature reachable from it; such work may exist internally or in a source not located. This is a planning-capability brief and not a position paper for the thirty-first Conference of the Parties, which opens on 9 November 2026; it takes no view on any matter before that conference. The Portfolio.hu article of 20 October 2026 that prompted this work is not used as a source anywhere in it: it names no study, quotes no dissenting view, and records that it was prepared with the assistance of an AI tool. On its own account it reports remarks made by the director of the Potsdam Institute for Climate Impact Research at a Reuters conference, as carried by Reuters; the Reuters report itself was not consulted. The account is therefore at least three removes from any study, which is why the question it raised was pursued through primary sources rather than from it.

Principal sources: ENTSO-E, European Resource Adequacy Assessment 2025, Executive Report, December 2025; ACER Decision 06/2026, Annex Ic, ERAA 2025 methodology; Copernicus Climate Change Service, Pan-European Climate Database 4.2 documentation, 30 June 2025, and the PECD 4.1 product user guide; V. Portmann, D. Swingedouw, O. Khattab and M. Chavent, “Observational constraints project a ~50% AMOC weakening by the end of this century”, Science Advances, 15 April 2026; R. M. van Westen and M. Baatsen, “European Temperature Extremes Under Different AMOC Scenarios in the Community Earth System Model”, Geophysical Research Letters, 28 June 2025; I. Harang, F. Heymann and L. Stoop, “Incorporating climate change effects into the European power system adequacy assessment using a post-processing method”, Sustainable Energy, Grids and Networks 24, December 2020; Strategic Horizon Energy Statecraft Vol. 07 and the Delivery Ladder DL-2026. © Strategic Horizon 2026. Strategic Brief SB-2026-13, v1.3 FINAL. Open access. Reviewed by Cassandra, Ciceró and the Chief Strategy Officer; approved by the Founder.