A Fresh Look at Climate Change

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Recently *The Economist* (2013a), a prominent journalistic advocate of strong policies to control CO_2 emissions, expressed their puzzlement on the absence of warming over the last 15 years. They observed that this flat period of global average temperature occurred despite that CO_2 emissions from human sources continued at an increased rate. The total human-produced CO_2 emissions in that period of flat temperatures represent a quarter of all such emissions ever produced. The standard climate models, such as those used by the United Nation's International Panel on Climate Change (UN IPCC), anticipated that such massive CO_2 increases should have caused continuing increases in average global temperatures. *The Economist* noted that observed global average temperature is now at the lowest end of the predicted range, and that if the present trend continues, the actual temperatures will soon be below even the lowest forecasts. Most recently, Fyfe, Gillett, and Zwiers (2013) demonstrated that the current climate models have experienced a systematic failure—a finding very similar to Knappenberger and Michaels (2013).

Given the large difference of observed data from the forecasts that underlie much current policy, it is timely to ask if the climate debates are addressing the right questions. Comparison of forecasts to observations is the right way to start asking. If the forecasts used to set policy are not accurate, then policies based on those forecasts warrant

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review. This is important for all of the purposes for which climate policies may be set, but this article concentrates on country development policies related to energy, especially electricity. Those policies are critical, because it is widely accepted that more than one billion people have no access to reliable electric grid power and therefore must turn to other sources for heat and light (Ballonoff 2013). The cost to provide that electricity, and also meet the continued and expanding needs of developed and developing countries, is estimated in the trillions of dollars. Our understanding of climate change and how it interacts with continued expansion of use of energy resources thus has a profound effect on assuring such huge capital cost is invested in the most effective way.

The Status of Climate Science

The foundation of the modern climate change discussion is the accurate observation that human activity has significantly increased the atmospheric concentration of CO_2, and that such activity is continuing (Tans 2009). Increased CO_2 concentration, especially when amplified by predicted feedback effects thus also is assumed to predict increasing global average atmospheric temperature. Depending on the degree of warming expected, other serious and mainly undesired effects are predicted. As *The Economist* (2013a) observed, the average global temperature did rise on average over the previous century. Following a 25-year cooling trend post-World War II, temperatures increased at an especially strong rate in the quarter century ending in 1997. The trend of that warming period, the correlation with increased CO_2, and the fact of human activity causing that CO_2 increase apparently supported use of projection models extending that trend to future years. Such projections were the basis for the UN's 1997 IPCC analysis on which much current policy is based. It is thus at least ironic that 1997 was also the last year in which such measured global average temperature increase took place.

One of the key features of the IPCC forecast, and greenhouse effect forecasts generally, is the expected feedback loops. One of those is that the presumed drier and hotter conditions on the ground would cause expanded desertification and deforestation. A distinct kind of greenhouse effect is also predicted from increased CO_2 concentration—namely, the aerial fertilization effect, which is that plants grow better in an atmosphere of higher CO_2. Many analysts, such as the IPCC, clearly thought the greater effect would be from heating, not plant growth. One must assume this was an intentional judgment, as the IPCC was aware of the CO_2 aerial fertilization effect from its 1995 Second Assessment Report, which contained empirical evidence of increased greening in enhanced CO_2 environments (Reilly 2002: 19). In contrast, climate analysts such as those with the Cato Center for the Study of Science have argued since 1999 that atmospheric temperature is much less sensitive to increased concentration of CO_2 (Michaels 1999b).

While in fact heating has not occurred as the IPCC forecasted, greatly increased global biomass is indeed demonstrated. Well documented evidence shows that concurrently with the increased CO_2 levels, extensive, large, and continuing increase in biomass is taking place globally—reducing deserts, turning grasslands to savannas, savannas to forests, and expanding existing forests (Idso 2012). That survey covered 400 peer-reviewed empirical studies, many of which included surveys of dozens to hundreds of sources. Comprehensive study of global and regional relative greening and browning using NOAA data showed that shorter-term trends in specific locations may reflect either greening or browning, and also noted that the rapid pace of greening of the Sahel is due in part to the end of the drought in that region. Nevertheless, in nearly all regions and globally, the overall effect in recent decades is decidedly toward greening (de Jong et al. 2012). This result is also the opposite of what the IPCC expected.

Global greening in response to increased CO_2 concentrations was clearly predicted by a controlled experiment of the U.S. Water Conservation Laboratory conducted from 1987 through 2005 (Idso 1991).[1] In that study, half of a group of genetically identical trees were grown in natural conditions and the other half in the same conditions but in an atmosphere of enhanced CO_2 concentration. By 1991 the Agricultural Research Service (ARS) reported that the trees in the enhanced CO_2 environment contained more than 2.8 times more sequestered carbon than the natural environment trees (i.e., were 2.8 times larger). By 2005, when the experiment was ended, the total additional growth of the enhanced CO_2 trees was 85 percent more than that of the natural-condition trees, both in woody mass and in fruit.

One reason for expanded growth even into dry environments is a seldom remarked propensity that CO_2 induced growth due to aerial

[1]See USDA, "Long-term Sour Orange Tree CO_2 Enrichment Project" (www.ars.usda.gov/Main/docs.htm?docid=9723).

fertilization also greatly increases a plant's efficiency of use of water. The ARS further documented this effect in a 2011 study, citing the extensive literature demonstrating that enhanced CO_2 environments "impact growth through improved plant water relations" (Prior et al. 2011). Similar results, both as to aerial fertilization effect and increased efficiency of water use, were found by the joint study of the USDA and the U.S. Department of Energy on the effects of CO_2 on agricultural production in the United States (Reilly 2002). In that study, the effect of forecasted increased CO_2 concentration, together with the increased warming forecasted, was shown to cause up to 80 percent increases in agricultural productivity, and *decreased* use of water since the growth would occur faster and with more efficient water use by plants. While different crops were forecasted to respond differently, most crops were positively affected, with a range from 10 percent reduction in yield up to 80 percent increase. Even considering the complex interactions with market conditions, the overall effect was certainly found to be favorable.

Using demonstrated experimental data, the 1991 ARS study also predicted effects of further or even greatly enhanced atmospheric CO_2 concentrations, such as from the expected large increase that might come (and subsequently did come and is continuing) especially from developing and newly industrializing countries. Comparing demonstrated warming to that date to the evidence, the ARS study concluded:

> If past is prologue to the future, how much more CO_2 induced warming is likely to occur? Very little. . . . The warming yet to be faced cannot be much more than what has already occurred. . . . A doubling of current emissions, for example, would lead to an atmospheric CO_2 content on the order of 700 ppm, which would probably be climatically acceptable, but only if the earth's forests are not decimated in the meantime [Idso 1991: 964–65].

The 1991 study noted that expanded forested areas would allow even greater atmospheric CO_2 concentrations. To assure the measured results were accurate and a reasonable basis on which to infer the effect of global-scale CO_2 concentration, the ARS also published results of eight additional distinct empirical studies of natural processes, each of which independently verified that the measured results found by direct experiment were a reasonable basis for such extrapolation (Idso 1998). The effects were recently further verified by models whose results were compared to empirical data on Australian and other arid regions. Modeling water use by plants in enhanced CO_2 environment, the study predicted the effect on plant growth in dry regions and verified the result empirically compared to actual measurements over a 30-year period (AGU 2013). The data verified the prediction both in the direction and in the quantity of effect observed: Enhanced CO_2 improves water use by plants and reduces, not increases, dry regions by making them greener.

Thus, evidence to date implies that the view that global temperature is far less sensitive to CO_2 than many fear, is likely correct. Simultaneously, demonstrated experimental evidence on plant growth predicted exactly what the now extensive empirical literature shows: Enhanced CO_2 is associated with greatly increased biomass production, even in dry climates. The extent of increased CO_2 sequestration both in soil and in biomass associated with increased atmospheric concentration has also been documented (Pan et al. 2011). Those results, while not what the IPCC predicted, do not imply we should have no concerns about climate policy.

The Status of Climate Policy

Clearly, there is an imperative to rethink climate policy. The issues are real. Even the 1991 ARS study that predicted stable temperatures despite large increases in CO_2 argued for avoiding deforestation and allowing expanded forest coverage. That same study also shows why crafting a proper policy must be based on evidence.

A common belief that deforestation was taking place widely and destructively apparently motivated the ARS discussion in 1991. Massive uncontrolled forest fires in Indonesia, parts of the Amazon Basin, and Southeast Asia, as well as overgrazing and firewood collection in sub-Saharan Africa reinforced that impression, and clearly demonstrated a need for improved forestry management. Climate policies were never intended as a substitute for good basic resource stewardship; done well, they enhance it. But unfortunately, certain climate policies have caused the opposite of good stewardship. Simply allowing markets to determine the result would have been far better.

First, increased biomass is taking place exactly as predicted by the more complete CO_2 analysis. However, localized deforestation exists. The climate change literature clearly documents that over 50 percent of all wood use is for energy production, and over half of all deforestation is due to clearing to expand biofuel production (Klenk et al. 2012). This is an unintended result of policies that subsidize biofuels to reduce CO_2 emissions from use of coal or oil for electricity generation, or oil for vehicle fuel. The next largest source of deforestation is for harvesting forest products (charcoal and wood) for household heating and cooking fuels. Such products are demanded especially by populations that do not have access to reliable grid electricity (Ballonoff 2013). A classic demonstration of this fact is the Google Earth view of the island of Hispaniola, which shows a green and vibrant Dominican Republic that has relatively reliable grid electricity next to a brown and deforested Haiti that does not.

As *The Economist* (2013b) also noted, unintended consequences are not limited to the developing world. The largest and most rapidly growing source of renewable energy in Europe—wood—is highly favored by subsidies intended to promote renewable sources. Wood can be used in power plants designed for coal with minimal modification of the plants, and it can be dispatched as a fuel like coal. In sharp contrast to other renewables, wood can be used for base-load power, backup, and grid regulation. However, paying high subsidies to substitute wood for coal seems counterproductive: aerial fertilization is absorbing the added CO_2 and thus avoiding predicted warming.

The absence of reliable, lower-cost grid power has motivated consumers of forest products for energy to be among the cash buyers of kerosene (Ballonoff 2013). However, kerosene is a major source of indoor and outdoor air pollution. The desire to replace kerosene with cleaner sources is not affected by whether CO_2 sequestration arguments are accurate. Both a large share of deforestation and the expanding use of noxious kerosene are important (and unintended) results from carbon policies, as well as from other practices that prevent operation of lower-cost grids. Projects that might rapidly expand comparatively lower-cost grid energy and improve economic development through traditional fuels are often opposed due to their carbon impacts. Counterintuitively, expanding competently operated electricity grids—even if operated to some extent from carbon fuels—may better preserve forests and have more favorable impacts on carbon. The clearly demonstrated evidence of the actual effect of higher atmospheric CO_2 concentration ought to significantly change the way such issues are analyzed and policies set.

Cost of energy efficiency compared to cost of capital for new capacity, and to the cost for use of existing capacity, is critical even if the climate change CO_2 damage arguments are wrong. Private capital, which is the only source which can cover the massive capital requirements forecasted to meet global requirements for energy, requires that the capital is applied effectively (Ballonoff 2013). Comparative cost is critical to such analysis. All of such judgments are enhanced when the use is also shown to be the least cost and thus most easily repaid. If warming is not the threat expected, CO_2-based constraints on form of capital expansion for energy generation may be counterproductive. Thus, carbon-based fuels, which often allow lower-cost capital, and which frequently are operated from larger-scale generation attached to relatively extensive transmission and distribution grids, remain serious candidates for least-cost planning. A recent study by the World Bank found that "scenarios, based on realistic unit costs, also show that for a majority . . . decentralized power supply is unlikely to be cheaper than grid supplies any time soon" (Deichmann et al. 2010). Thus, when capital is used more effectively for generation, as may occur in central grids using larger-scale thermal sources (assuming the grid is competently, and not corruptly, operated) this also frees capital for expanding investments in efficiency. Climate policies that have often sought to force the limited capital available in developing economies for electricity development into the highest-cost and least reliable generation sources, have also made effective economic development of those least-developed economies much more difficult.

Many clean-energy generation policies, including distributed generation, use of renewable generation, use of natural gas, and applications of clean coal, have their own relative merits, for reasons quite independent of CO_2 issues. Improved air quality such as lower nitrox, lower sulfur, lower soot, and fewer noxious fumes, from substituting those for less clean fuels, are not affected by whether CO_2 sequestration is effective. Distributed generation also may have benefits for efficiency of operation of power systems, provided the associated reliability issues are properly managed and paid for. The ability to manage power system reliability when additional renewables are added is enhanced if more traditional generation, which can be more flexibly dispatched, can be considered as a source of providing reliability and system backup. Also, renewable generation is often desired for a different aspect of energy security: avoidance of foreign supply and avoidance of price volatility for imported fuels. Especially when combined with the commonly used device of a fixed price for a long term, which is more feasible when the principal costs are capital, not fuels, renewables can provide more stable prices for future electricity generation. None of those factors are removed by the status of CO_2 sequestration arguments. Indeed, if demand for traditional fuels returns, then the associated market conditions which allow their price volatility may increase, and may thus induce increased demand for renewables, precisely to avoid such enhanced price risks in adjacent markets. All of those effects, however, will result from the normal operations of market economics and from least-cost system reliability planning and operation.

CO_2 itself is also a potential resource of economic value, both for the fertilization effect and for other uses. A creative use of the massive amounts of CO_2 expected from direct and indirect coal liquefaction and subsequent conversion to Fischer-Tropsch liquid fuels, which have no entrained heavy metals and therefore command a large premium in the marketplace, is to pipe the CO_2 for reinjection in oil fields to facilitate enhanced oil recovery. For example, the new owners of the Great Plains Coal Gasification Project in North Dakota financed and constructed a 200-mile pipeline to Canada and sold CO_2 for use in enhanced oil recovery. Similar projects are being considered in both the developed and developing world. CO_2 capture for use in commercial greenhouses to grow biomass products—whether for agriculture, medical products, flower industry, or others—is already established technology. Such projects can and should be considered as part of the economics of developing-country electrification projects, as one means of expanding the economic value of those projects. The argument is similar to that for cogeneration, or for district heating systems, namely, use of a by-product from a thermal plant for a joint output—heat, in the case of cogeneration, and extracted CO_2 for the aerial fertilization or liquid injection source.

While expanded use of renewables can be a desirable policy for the reasons just summarized, expanded renewable generation also affects operations required for assuring power system reliability, and especially for assuring adequate supply is available when demanded. The U.S. National Energy Technology Laboratory has demonstrated that additional cycling of thermal plants needed to compensate for nondispatchability of renewable generation also damages those thermal plants and induces additional system costs (US DOE 2012). In developing countries, such effects exacerbate the condition of often already poorly maintained grid generation capacity. But very often only thermal units can provide the needed added dispatchable reliability. This is also true even in developed countries that have advanced renewable generation programs. Thus, in late 2012, the German government, having realized that massive increases in wind generation were making the transmission grid less stable, that nuclear was no longer a politically acceptable option for base load, and that added wind was also not a base-load resource, quietly began immediate construction of 23,000 MW of new coal capacity. The funds for that came in part from Germany's green energy surcharges on consumers. In general, compensating for renewable energy generation profile characteristics raises both the capital and operational cost of providing reliable power.

Since developing countries have often been more focused on effects of actions on people in the shorter term, many such countries are already more sensitive to concrete actions with real effects, than on more abstract climate arguments. Some, such as the recent Vietnamese National Green Growth Strategy, have already focused on practical policies and their real economic costs and consequences, including effects on clean environments for reasons other than beliefs about carbon, such as practical effects of distributed renewable generation, or the economics of liquefied CO_2 irrespective of temperature arguments. Such practical policies may be unaffected by beliefs about CO_2 sequestration effect on global temperatures.

An enhanced CO_2 atmosphere also portends changes in agriculture. A naive expectation is that more green means better growth for existing products, expansion of productive agricultural environments, faster growing forests and thus better product harvests, reduced desertification, and other—mainly beneficial—economic consequences. Such predominantly beneficial effects on growth due to the aerial fertilization effect are exactly what a special panel of the U.S. Department of Agriculture found when they examined the effects of increased CO_2 on U.S. agriculture (Reilly 2002). But details of effects on specific species and specific environments may differ. And, like the cited USDA study, nearly all such analysis in the past several decades has assumed that continued warming was taking place. The analyses thus also typically assume presence of environmental harms due to warming, but which warming is not occurring. Analysis of effects of enhanced CO_2 concentrations without assumed warming, as well as careful examination of how aerial fertilization effects interact with developing-country agricultural as well as other economic aid programs seems called for.

On that line, a tantalizing hint of an additional greenhouse feedback effect is suggested by the conclusion of de Jong et al. (2012: 653) on the relative distributions of global greening and browning: "In general greening prevails in all land cover classes. . . . The strongest indication for this was found in croplands and the weakest in needleleaf forests." But croplands of course are also intensely managed. And in general, human care of cropland precisely because it is market driven, requires the most intense and responsible management of both short term and longer term (meaning also, capital) risks. In a forecast made in May 1999, Ballonoff (2000) predicted that there would be no Y2K failure of the North American electricity grid on midnight of December 31 of that year. Using the power grid as an example, he reasoned that human responsible management in systems of diverse ownership in a market system are a significant part of making markets more reliable and allowing them to better adapt even to potential major operational risks. The fact that private ownership and management demonstrably has such effects has hardly been accounted for in the climate policy literature. Even if warming were a real risk, the case that only government action forcing changes in investment policies is the required solution has not been demonstrated. Indeed, the 2002 USDA study found that markets will adapt to such changes in their normal course (Reilly 2002).

Many other arguments have been made on the consequences of the expected effects of heating due to higher CO_2 concentrations. I leave for others to debate those issues, simply noting that in doing so one hopes they consider both the heating issues and the enhanced CO_2 issues, and recognize that either could have outcomes not realized by simple projections of trends. More accurate prediction and more careful attention to empirical evidence will help ensure better use of scarce energy resources.

Conclusion

Climate science, and especially understanding the interaction of human activity with climate, remains one of the key scientific challenges of our time. Humans have profoundly affected vast swaths of Australia, Eurasia, and the Americas, at least in the immediate term, by agricultural and other practices. But understanding long-term effects is not so easily guided by seemingly simple projections from short-term observations. For example, it is widely accepted that in the 50,000 years that humans have occupied the continent of Australia, the flora and fauna have been changed profoundly (Gammage 2012). Yet, even with a century of very detailed research, it is not known for certain that the seemingly obvious inference that use of fire for clearing land over that long period has had any long-term effect on the natural climate of Australia (Smith 2013, Mulvaney and Kamminga 1999: 60–62).

It is therefore not speculation that humans can have large-scale effects on the environment. It is critical we take the risks seriously. Global climate has a profound effect on human viability. Geologically, we are at the warm cusp of an interglacial period. The period of human recorded history has occurred within a period of warming generally. Glaciation historically has occurred rather rapidly on geological time scales. The risk of severe cooling does not seem imminent, nor does the risk of severe human-induced warming.

If we can find scientifically demonstrated ways to regulate the global thermostat, we certainly want to know what those might be. The extravagant claims made by many in the climate change community have not advanced that effort, and may have contributed a widening mistrust of use of science for determining policy. Real science is not simply the application of ad hoc models to predict pending disasters; it also compares the results of predictions to actual events. The technical community that has produced false predictions of global warming, by failing to compare predictions to subsequent actual events, adds an unfortunate chapter to a long history of abuse of the appearance of science for political purposes (Michaels 1999a, 1999b).

The empirically demonstrated evidence on water use by plants in an enhanced CO_2 environment is the opposite of the commonly claimed effect from models that look only at assumed increased heating due to CO_2 increases. Empirically, CO_2 has recently been associated with warming only until increased green growth set in. That increased growth however continues so long as the extra CO_2 is present. Despite reluctant rhetoric, other climate modelers recently studying the process have also created models that show higher CO_2 concentration increases biomass. (Cox et al. 2013, Huntingford et al. 2013). But like the IPCC, many such authors seem to regard the model, not the reality against which compared, as the primary evidence. That attitude is unique in the physical or biological sciences, where reliability of prediction is judged by correspondence to empirical evidence. Reflecting a similar error, much climate policy relies heavily on projecting assumed trends. NASA, for example, has recently displayed the results of an entire set of models that *assume* continued warming and then predict its effects.[2] But the prediction is meaningful only if the future warming exists. Trend data are only reliable for forecasts if the underlying conditions assumed remain constant and are a relatively complete description of the underlying real processes. Climate trend models have not fully accounted for the ability of plants to use water more efficiently at higher CO_2 concentrations and have underrated the capacity for aerial fertilization to sharply improve sequestration via plant growth. Had they done so, like the 1991 ARS study or the 2012 Australian analysis, they may have predicted temperature and other effects more accurately.

The misuse of modeling as a surrogate for science, which superficially allows advocacy to claim science without looking at actual evidence, has not been unique to climate warming. The new ice age foreseen in the 1950s to early 1970s did not visit us. The U.S. National Center for Atmospheric Research, one of the more prominent prophets of the new ice age, later switched to prophecy of global warming—presumably for political rather than scientific purposes. The forecasted population explosion and exhaustion of physical resources did not carry the earth past a presumed inherent carrying capacity by the early 1990s, foretold in well-known studies led by the Club of Rome and the American Association for Advancement of Science (Hardin, Lyons, and Edelson 1973; Meadows, Singer, and Perlman 1973; Meadows et al. 1974), and which were criticized even at the time (Cole et al. 1973). A 2004 update (Meadows et al. 2004) to the forecast changed the dates but not the methods, and did not improve the forecast. Instead of explosive growth, world population growth slowed, itself unpredicted by all but one theory (Ballonoff 1998). Moreover, as mineral prices were falling in real terms, efficiency of use increased, and absolute remaining known resources have generally grown in both relative and absolute terms. This is especially true for energy resources: known reserves have grown, despite that total use has far outpaced forecasts, and real price (as opposed to nominal dollar price) has fallen, not exploded to the predicted heights forecasted by the U.S. Department of Energy and others (Ballonoff and Moss 1991, Ballonoff 1997). The technology-driven mechanisms of expanding reserves also characterize the current expansion of

[2]See www.nasa.gov/topics/earth/features/wetter-wet.html.

energy reserves through fracking. What all of these examples show is that models alone, without comparison of their results to actual evidence and without embodying what is known from experimentally demonstrated behavior of nature, are not science, and may be extremely misleading foundations on which to base policy.

This article has focused on the empirical effects of climate policy related to effects of atmospheric CO_2 concentration on energy development policy, especially for electricity. Some policies are not affected by the evidence on CO_2 concentration. Energy efficiency remains a compelling goal in all climate scenarios because it leads to the most effective use of all energy capital investment and is readily achieved by normal market forces. Renewable generation remains a desired option for certain purposes of energy security, as well as for aspects of grid supply (assuming the grids are competently operated, reliable, and paid for), for potentially reducing grid losses, and as a substitute for other fuels. Such purposes, as well as programs such as "sustainable landscapes" that encourage preservation and expansion of green areas, seem justified by the demonstrated empirical effects of CO_2.

But many of the documented effects of current climate policies show a counterproductive effect on development. Efforts to reduce CO_2 emissions by subsidizing biofuels, including subsidizing wood itself as an electricity generation fuel, appear instead to be the principal cause of deforestation. Policies to avoid carbon fuels may be inhibiting development of more economically efficient central grids and degrading the operation of existing grids, thus making more difficult the task of serving the underserved with reliable and low-cost electricity. That result, in turn, paradoxically causes expanded use of hydrocarbons in the form of kerosene, with its own soot and air pollution effects, as kerosene is available where grids are not. Forest products are also harvested to substitute for unavailable reliable electric power and, as a result, contribute to deforestation. The empirically demonstrated ability of global greening to absorb greatly enhanced CO_2 concentrations and mitigate warming would seem to make policies to avoid carbon fuels in developing countries unnecessary. The demonstrated natural sequester of CO_2 in plants as atmospheric CO_2 concentration increases seems to obviate the need for foreign development capital projects to artificially sequester CO_2. In sum, the rather extensive funds dedicated to such uses by multilateral and national sources of development capital would be more effective in meeting development goals if used to increase least-cost reliable supply.

It is apparent that the demonstrated science of the direct and indirect effects due to increased CO_2 concentration is rather different from that expected by many. Past climate policy has very often been based principally on models that have not been borne out by experience. Models alone are not science; models merely reflect the assumptions embedded in them. In climate models, and climate policy generally, those assumptions have apparently not reflected demonstrated evidence. Climate policy should reflect what experimental and empirical evidence show to be true.

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