# On the need for Dynamic Policy Instruments

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## THE DISCOVERY OF OXYGEN

Oxygen was discovered late in the 18th century. That discovery precipitated a fundamental change in what constituted the practice of chemistry; a change so profound it is referred to as the chemical revolution. The discovery of oxygen was important for chemistry. The details of the history of that discovery shed important light on how science advances and on the relationship between the evolution of the knowledge-base and science-based policy.

In a simplified account of the discovery of oxygen, Kuhn (1977, Chap. 7) notes that it is difficult to assign an exact time and place to the discovery (more detailed accounts only complicate the assignment). Thus it is that Kuhn argues:

> … [oxygen] had not been discovered before 1774; probably we would also insist that it had been discovered by 1777 or shortly there after. But within those limits any attempt to date the discovery or to attribute it to an individual must inevitably be arbitrary. (Kuhn, 1977, p. 171)

The element of this account which is most significant to current policy making is that oxygen was not so much discovered as its existence emerged over several years. A second important characteristic of this brief history is that it has been a little more than 200 years since those events occurred.

The discovery of oxygen was not a singular event but a process which extend over about 4 years. The period during which oxygen's existence was emerging was a period of uncertainty; definitive and true statements about what had been discovered were not possible. While all advances in scientific understanding are unique, Kuhn (1970) argues that the most important advance all share this period of disequilibrium and uncertainty. Thus the emergence of the existence of oxygen illustrates the generalization that understanding of the workings of our planet will come-to-be-known rather than discovered. That is, during any given period of time, the knowledge base will have components which are established, components which are on the verge of establishment and components which are only hinted at. Always beyond the knowledge-base is that which is real but as yet completely outside of our intellectual realm.

The formation of public policies is also not a singular event. Consider the evolution of the Clean Air Act (this material follows (Reitze, 1995)). In 1955 the first federal air pollution legislation was signed into law. That law, which operated in a policy environment which assumed that air pollution was essentially a local problem, was extended for 4 years in 1959 and from 2 more years in 1962. In 1961, with Kennedy's "Special Message on Natural Resources", the Kennedy administration assumed an aggressive stance on air pollution, elevating it to a federal level and initiating the drafting of what became the Clean Air Act (CAA) that Johnson signed into law in late 1963. The CAA has gone through several revisions, but each of those revisions occurred over a similar time period of several years.

The finite duration of periods of scientific uncertainty and of the formulation of public policies implies that science-based policy making will always need to advance in the presence of uncertainty and ambiguity. Waiting for the knowledge-base to become more firmly rooted only pushes the ambiguities to new realms.

## THE CHEMISTRY OF THE ATMOSPHERE

In the 2 centuries since oxygen was discovered a great deal has changed. In particular our technical and scientific capabilities have expanded exponentially. The discovery of oxygen occurred early in the Industrial Revolution; thus for all practical purposes the entire industrialization of the US and Europe has occurred since oxygen was discovered.

A large implication of the Industrial Revolution is that industrialized economies have become dependent upon an ever increasing source of energy. While our understanding of combustion and of how to harness the released energy has grown and lead to dramatic increases in efficiency, the demand for that energy has outstripped efficiency advances and our need to burn things continues to grow. One result of this burning is that since the late 18th century the concentration of $CO_2$ in the atmosphere has increased by about 1/3, from about 280ppm to about 360ppm.

The lifetime of a spike in $CO_2$ in the atmosphere is of the order of centuries (IPCC Working Group I, 1995). One implication of this is that carbon introduced into the atmosphere in the earliest stages of the industrial revolution has only recently completed its cycle through that system. Alternatively, the concentration of $CO_2$ in the atmosphere at any given time reflects some integral function of the forcing over the preceding centuries; thus perturbations in the atmospheric concentration of $CO_2$ will have effects hundreds of years after the forcing has been removed.

While it has lagged behind and there are still vast regions of uncertainty and ignorance, our understanding of the relationship between our burning and other Earth systems has expanded rapidly as well. We are now confident that anthropogenic changes in the composition of Earth's atmosphere the due to combustion (e.g. adding $CO_2$ and aerosols) will affect the temperature distribution and thus the climate of our planet. These changes will in turn have effects on systems which include terrestrial and aquatic ecosystems, water resources, food and fiber, human infrastructure, and human health (IPCC Working Group II, 1995).

## DYNAMIC POLICY INSTRUMENTS

It now appears that, as a planet, we will attempt to manage the chemical composition of the atmosphere (witness the success of the Montreal Protocol and the progress of negotiations related to the United Nations Framework on Climate Change (e.g. the Kyoto protocol)). In the context of managing atmospheric $CO_2$ concentration, this fact, coupled with the discussion above, implies that we must develop policy frameworks which have time scales comparable to the time between the discovery of oxygen and the present day.

Policy frameworks with century time scales have never been attempted before. Such frameworks will require the development of policy instruments and infrastructures which adapt to far-reaching changes in underlying knowledge-bases. We must formulate policies to govern our actions with the expectation that our current understanding of how Earth works is incomplete in very important ways. We must be conscious of the likelihood that by the late 22nd century our current grappling with the carbon cycle and the functioning of ecosystems will seem as ancient as Priestley's and Lavoisier's efforts to understand the chemistry of gasses.

Policy structures for the management of the composition of the atmosphere will need to be dynamic. They must have flexibility which allows consistent progress toward a relatively constant goal despite ongoing changes in the context of that progress. For instance as our understanding of the functioning of sources and sinks for carbon evolves, actions which currently seem well founded may prove to be less than optimal or even counter productive. In contrast to policies which embed methods toward a goal, dynamic policy frameworks will embed the goal with the expectation that methods will change with improvements in the knowledge base.

Contrary to my assertion above that such long term policy making has never been attempted, Simon (1996, p. 140) points out that the US Constitution is a document which has guided policy formulation over the time frame necessary for atmospheric management. In this case, the Constitution establishes a set of high level principles which guide the governance of our country. From those principles, policies are developed, implemented, tested and at times set aside. Its principles and the evolving set of rules resulting from those principles have guided the evolution of our democratic society through social and technological changes that its framers could not have imagined.

While the US Constitution provides an example of a policy document, Lindblom's notion of muddling through (Lindblom, 1959) is an example of a process approach. In Lindblom's framework, policy makers are faced with a complex set of goals, constraints and options. Constraints include such things as limitations of the current knowledge-base, political and social configurations, and budgets. Options are similarly determined by externalities to what might be construed as the rational decision environment (see for example Kingdon (1984)).

I believe we have reached a critical juncture in the history of our planet (Gilbert, 1998). Beyond the public policy issues discussed above, we are now for the first time faced with decisions which require serious thought and attention to questions such as "What sort of world do we want to live in?" and "What sort of world do we wish for future generations?" Failure to address such questions will not prevent us from forming public policies, but it may prevent us from reaching currently attainable, and perhaps more desirable, future worlds. These questions are the those of the goals we may embed in our policies. They are the ideals toward which we will muddle. Just as the Founding Fathers embedded the principles of what has come to be the archetypal democratic society, we are now faced with an opportunity articulate principles which will guide evolution of the Earth system.

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