The California Zero-Emission Vehicle Mandate: A Study of the Policy Process, 1990-2004

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DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Transportation Technology and Policy

in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA
DAVIS

Approved:

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Committee in Charge

2006

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ABSTRACT

The Zero-Emission Vehicle (ZEV) mandate, one of the most daring environmental policies related to transportation, was implemented in September, 1990, by the California Air Resources Board (CARB). It originally required that, starting in 1998, 2% of the in-state new light duty vehicle sales of major automakers had no emissions of criteria pollutants. The required ZEV percentage would be increased to 5% in 2001 and to 10% in 2003. CARB organized biennial reviews of the programs, to elicit stakeholder participation and monitor the evolution of the program. Through this review schedule, the program underwent several revisions resulting from intense policy debates.

This dissertation research is concerned with the study of the policy process over the ZEV mandate, from its conception, through its inception, and the biennial reviews, until 2004. The study is structured as three core chapters. The first chapter studies the origin of the ZEV mandate, trying to understand the conditions that favored and the factors that resulted in its implementation. To guide the study in this chapter, I use the Multiple Streams theoretical framework. The second chapter presents an empirical study of the policy process during the biennial reviews. This study aims at understanding the dynamics of policy change and coalition stability, identifying the policy dimensions that dominated the debate over time. I use the Advocacy Coalition Framework to frame the study in this chapter theoretically. The third core chapter presents a theoretical study of the strategic policy behavior of the main actors in the policy process. I develop a game-theoretical model of an environmental regulator (CARB) that needs to set emission standards in the presence of multiple industry players (automakers), who in turn need to

decide on their level of compliance in the presence of a competitor. The model presented improves over previous published work in the subject.

The results of these studies yield numerous conclusions with both theoretical and practical implications. I find that Multiple Streams is useful to understand the origin of the ZEV mandate, while I identify and/or confirm arguments by other scholars about significant limitations in the framework. Through the analysis of the public testimonies given by stakeholders at the biennial reviews, I identify the policy areas of major concern at different points in time along the policy process. I also identify the policy positions of each stakeholder and obtain estimates of the groups of stakeholders with similar policy beliefs (belief coalitions.) I find that these belief coalitions show some stability over time, though less than what was found by previous studies. One of the major conclusions from the model of strategic behavior is that the competitiveness of the auto industry tends to preclude collusion. The regulator may use this industry competitiveness to its advantage and achieve higher social benefits.

INTRODUCTION

The late 1980's was a fascinating time for the students of air-quality policy in the United States. Political realities, scientific discovery, and public awareness converged at that point in time to create a generalized sense that "something had to be done" to deal with increasingly pressing issues like urban air pollution, acid rain, and global warming. A period of uniquely intense regulatory and legislative activity ensued.

Major policy initiatives included the federal Clean Air Act Amendments (that were passed in 1990, after 13 years of failed attempts), the California Clean Air Act (also known as the Sher Act, passed in 1988), the Ozone Transport Coalition in the Northeast (established in 1990 through the Clean Air Act Amendments, although the northeastern states had already agreed to work together), and the California Low Emission Vehicle and Clean Fuels regulation (approved in 1990.) The latter was a particularly innovative regulatory piece. It introduced the notion of regulating vehicle and fuel as a system, whereby standards were not only specified for tailpipe emissions but also for the ozone-forming characteristics of fuels. It also included a provision that would become the most daring—and controversial—program in the history of vehicle emissions regulation: the Zero-Emission Vehicle (ZEV) mandate.

The ZEV mandate, as passed originally, required major auto companies to manufacture and sell vehicles with no criteria-pollutant tailpipe emissions starting on 1998. An intense policy process, characterized by biennial reviews resulted in a sequence of amendments to the program. The next review of the program is scheduled for late 2006.

Because of its implications to the auto industry, its technology-forcing nature, the complex dynamics of its policy process, and its potential impacts on air quality in California and the rest of the Union, I decided it was certainly worthwhile to engage in a rigorous study of the ZEV mandate. Such a study should result not only in a valuable chapter in the history of environmental regulation, but also a case study to test theories of the policy process, and, most importantly, a set of policy lessons that could be used in future environmental and/or energy policy debates.

The chapters that follow are the product of my study of the ZEV mandate. On the course of this study, I was supervised and patiently advised by my two mentors: Professor Paul Sabatier and Professor Dan Sperling. I decided to structure the study as three individual analyses, each concentrating on particular aspects of the ZEV policy process. Each of the analyses also employs a different theoretical framework.

Chapter 1 presents an analysis of the origin of the ZEV mandate. This chapter focuses on the question of how the mandate was implemented, not only as a historical account of events but also as an analysis of the direct and contextual causes of the implementation. For this analysis I use the Multiple Streams framework.

Chapter 2 presents an analysis of policy dynamics and coalition stability along the policy process. In this chapter, I focus on understanding what the main policy issues that dominated the debate were and how these changed over time. In the process, I identify the policy positions taken by the different stakeholders at the biennial reviews. To guide the analysis in this chapter, I use the Advocacy Coalition Framework.

Chapter 3 presents an analysis of stakeholders' behavioral strategy. In this chapter uses information learned in the preceding chapters about the ZEV policy process and try to uncover possible mechanisms of policy behavior adopted by the regulating agency and the regulated industry. Essentially, I focus on the question of what factors drive the behavior of policy actors and how this behavior can be affected by the interaction with other stakeholders. I use game theory to guide this analysis.

The nature of the methodologies chosen for each chapter differs in some fundamental aspects. Assembled in a Multiple Streams (MS) frame, Chapter 1, it could be argued, bears closer resemblance with a piece of history research. MS has been charged with lacking key elements of a scientific theory, like falsifiable hypotheses. MS in fact is a direct offspring of the family of "garbage can" models originated in administration science, which accepts certain randomness as a part of life. The study of policy dynamics in Chapter 2, embedded in the Advocacy Coalition Framework (ACF), moves a few steps closer to the scientific method. While recognizing a boundedly-rational model of the individual, ACF believes in the measurability of unobservable variables and use them to help explain social behavior. Finally, the study of policy strategic behavior in Chapter 3 builds on a methodology intimately related to rationalism. Here, individual or group behavior is assumed to follow a path of utility maximization. Thus, once the form of the utility is defined, all subsequent behavior is predictable and the system becomes deterministic.

This diversity of approaches is not coincidental. With a training originated in the engineering sciences, I have long become a devout believer in eclectic approaches to

research, appreciating the contribution that all venues can make in adding knowledge. Edward Hallett Carr expressed much of this idea simply and eloquently 45 years ago:

> "Scientists, social scientists, and historians are all engaged in different branches of the same study: the study of man and his environment, of the effects of man on his environment and of his environment on man. The object of the study is the same: to increase man's understanding of, and mastery over, his environment. The presuppositions and the methods of the physicist, the geologist, the psychologist, and the historian differ widely in detail; nor do I with to commit myself to the proposition that, in order to be more scientific, the historian must follow more closely the methods of physical science. But historian and physical scientist are united in the fundamental purpose of seeking to explain, and in the fundamental procedure of question and answer. The historian, like any other scientist, is an animal who incessantly asks the question: Why?" (Carr, 1961, pp. 111-112.)

I want to thank my mentors, Dan and Paul, for allowing me to reflect my love for eclecticism in my dissertation work.

A comment is in order on Carr's perspective on "the object of the study," as it is directly related to the question of what the role of the scientist—in this case, I—should be. Is the student of policy to remain neutrally circumscribed to observing and explaining events? Or can he move further and try to draw lessons and present recommendations, thereby becoming a policy actor himself who can potentially influence current and future policy processes? I do not believe—does really anyone?—that objective scientific

recommendations are possible. Recommendations are always tainted, to a larger or lesser extent, with subjectivity—and subjective recommendations are, in my own personal view, advocacy.

Bertrand Russell observation that

> "Every advance in a science takes us further away from the crude uniformities which are first observed into a greater differentiation of antecedent and consequent and into a continually wider circle of antecedents recognized as relevant." (Russell, 1918, p. 188.)

links the role of science to improving our understanding of causal mechanisms (where causality is to be understood in its broadest sense and not associated to determinism). This view of science suggests that the scientist—as a scientist—has no role as a policy actor, and consistent with Carr's position.

I hope, in the course of the following chapters, to reflect an eclectic observation, description, and explanation of the policy process over the ZEV mandate. I intend thus to refrain from turning this research in any form of advocacy. I rather hope that this document is studied by those who are or will be involved in this or similar policy processes, and that they can draw useful lessons to improve—whenever possible—the way policy is done. If such hope is realized, I will feel that the last few years of hard work on this research have been worthwhile.

CHAPTER 1: THE ORIGIN OF THE ZEV MANDATE

1. Introduction

The California Zero-Emission Vehicle (ZEV) rule is probably the most daring air-quality policy initiative directed at the transportation sector in the United States, and possibly the most controversial. Adopted in 1990, and subsequently known as the ZEV Mandate, it required major auto companies to manufacture and sell vehicles with no criteria-pollutant tailpipe emissions. Some consider the ZEV mandate a policy failure; others credit it with stimulating a revolution in automotive technology.

Various assessments of the ZEV program have been conducted.(e.g. Shnayerson (1996), Doyle, Dixon et al. (2000), Shaheen and Sperling, Burke and Kurani), but no comprehensive scholarly review. As noted in Kemp (2002), "[t]here does not exist a detailed analysis of the genesis of the LEV programme" (p. 9.) The goal of this paper is to document and explain the origins and implementation of the ZEV mandate. I investigate how this revolutionary policy piece act came into being, focusing on the role of particular stakeholder groups and the regulatory process itself. My goal is not to judge the merits of the rule (and subsequent modifications), but rather to describe and explain the interplay of interest groups and policymakers. I explain how and why the ZEV mandate unfolded as it did, and elicit lessons learned.

I organize this paper as follows. In Section 2, I include a description of methodological issues related to the study, particularly the process of data acquisition, and the general

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approach I use to answer the research question. In Section 3, I present a detailed discussion of the theoretical framework guiding this paper. In Section 4, I describe the general environment preceding the implementation of the ZEV mandate, including the contemporary regulatory activity, the public opinion at the time, and the language of the Mandate itself. Sections 4, 5, 6, 7, and 8 address different aspects of the research question. Finally, in Section 9, I present a discussion of my findings.

2. Research Approach

To guide my analysis of the ZEV policy adoption, I use the Multiple Streams (MS) theoretical framework, first introduced by Kingdon (1986). The key feature of this framework, which makes it well suited to the ZEV policy debate, is its emphasis on the (occasional) intersection of three essentially independent "streams" of processes: *problems*, *policies*, and *politics* (the 3P's). Kingdon refers to these occasional intersections as "policy windows"—opportunities for actors to push for certain proposals or conceptions of problems, to elevate them to the decision agenda. It will be shown that such was the case with the ZEV mandate in 1990.

While Multiple Streams will guide my study, I will avoid the limitations of this theoretical framework to affect the scope of my results. For a comprehensive understanding of the process that resulted in the implementation of the ZEV mandate, this study will address the following set of research questions:

1- What was the general socio-political context preceding and surrounding the development of the program?

2- What was the statutory context and how did ARB regulatory goals fit in them?

3- What was the role of technical information?

4- How did the ZEV mandate enter the regulatory language?

5- How did the Mandate survive the implementation process?

Question 1 is related to the streams of problems and politics, question 2 relates to the stream of politics, question 3 involves the stream of policy (or solutions), and question 4 mostly relates to the crossing of the streams and the creation of a window of opportunity. Question 5, which I believe is of great importance to the goals of this study, is not related to any aspect of Multiple Streams. A deeper analysis of the theoretical framework is presented in Section 3.

The data used in this study came from two main sources:

a- Public documents of the policy process. I studied official transcripts of the public hearing of September 27 and 28, 1990, when the LEV program was adopted, along with written documents submitted by different stakeholders to the Air Resources Board.

b- Interviews. The corresponding author conducted a set of 50 interviews with individuals who were involved in the policy process. My sampling scheme aimed at interviewing at least one individual from every major stakeholder organization. Interviewees' organizations fall in one of three broad categories: government (primarily the Air Resources Board), regulated industry (automakers), environmental non-profit organizations, electric utilities, and the scientific community. A central component of my research design was to ensure the confidentiality of my

interviewees, and therefore I cannot disclose their names. I feel I have been very successful in obtaining interviews with most of the key policy actors in the ZEV debate.

Structured interviews are very useful when the main objective is to capture interviewees' positions on a given set of questions—this is analogous to the objective sought with surveys. Toward this goal, I developed a comprehensive interview schedule, which is shown in Appendix A. This paper is part of a broader project to study the ZEV program over its entire lifespan, and thus the questions in my interview schedule are not constrained to the beginning of the program.

While I used the interview schedule to guide my interviews, it is fair to say that the interviews were in actuality *semi*-structured. Structured interviews are most efficient when the researcher knows all the questions that should be asked. Often, however, the researcher learns about new important questions as her research progresses—such was my case as well. One way to deal with this issue is to do two rounds of interviews with the same sample (e.g. Weible and Sabatier, 2005). Such a strategy proved impractical with a sample of busy people as ours.

Another issue with structured interviews is that they may limit the researcher's ability to keep the interviewee engaged. In my experience, interviewees stay more engaged when they feel they are holding a conversation than when they feel they are being interviewed. The more engaged the interviewee is, the longer she will stay and the more comfortable she will be sharing information. Conducting a structured interview requires the formulation of questions using the same wording across interviews

(which doesn't help the interviewee "forget" that she is being interviewed), and may require stopping answers short to be able to fit all the questions in the limited time of the interview. Taking these issues into account, I allowed for some flexibility in directing the questions to areas that the interviewee was more knowledgeable of or felt more comfortable and/or enthusiastic talking about.

Interviews were recorded, notes were taken from the recordings, the notes were sent to interviewees for comment, and comments were incorporated into final versions of my notes.

3. Theoretical Framework: Multiple Streams

To guide my analysis of the ZEV debate in the context of existing theories of the policy process, I use the Multiple Streams (MS) framework, first introduced by Kingdon (1986). The central argument of MS is that agendas are set and policy alternatives are specified by the dynamics of three "streams" of processes that are essentially independent of each other: a stream of *problems*, a stream of *policies*, and a stream of *politics* (the 3P's). Although the permanent "flow" of the 3P's is mostly independent of each other, there are moments when they intersect. Kingdon refers to these moments as "policy windows"— opportunities for actors to push for certain proposals or conceptions of problems, to elevate them to the decision agenda.

Kingdon understands an agenda as "the list of subjects or problems to which government officials, and people outside of government closely associated with those officials, are paying some serious attention at any given time." (p. 3). Important to his and my analyses

is the distinction he makes between governmental and decision agendas. Quoting him: "A governmental agenda is a list of subjects to which officials are paying some serious attention at any given time." (p. 196.) The decision agenda is defined as "the list of subjects within the governmental agenda that are up for an active decision." (p. 4)

These definitions are somewhat vague in that they allow for different levels of specificity. From the broader spectrum of "governmental officials," I choose to concentrate on officials at the decisionmaking level of the problem in question. In the context of the ZEV mandate policy process, these officials are the Board Members of the California Air Resources Board. Allowing for a less restrictive definition—for example the set of individuals working as staff of CARB—would preclude the understanding of how the internal organization behavioral dynamics affect the ultimate decision made by the Board.

The scope of the "subjects" referred to in Kingdon's definitions is not a-priori defined either. For the US Senate, the subjects could be the broadest policy areas, like energy, health, and foreign relations. For a state agency with a defined regulatory mission, the interest is restricted to a specific policy area. Defining the subject at this broadest level for CARB would be trivial, as the agency's regulatory mission resides exclusively in the area of air-quality. A better interpretation of the concept of "subject" would be that of particular sources of airborne pollutants, or particular cleaner technologies.

The processes of agenda setting and alternative selection, according to MS, are "highly fluid", meaning that while they have an underlying distinguishable structure, they behave to some degree as chaotic systems. In other words, there is a great deal of randomness

alongside with a structure. This structure is provided by the constraints acting upon the processes, as well as by the factors affecting the dynamics within and between each of the streams. To Multiple Streams, the 3P's are incoherent to some degree, and such nature could preclude their explanation by means of a rigidly structured theory.

Active in these processes there is a set of actors, or participants, who do not necessarily have control over the processes. These actors play active roles in—though not necessarily have complete control of—setting the agenda and defining alternatives. They are categorized into those within and those outside the pertinent governmental body. To Kingdon, who was interested in policymaking at the federal level, actors within government comprise those in the executive branch (the president and his staff, political appointees in departments and bureaus, upper-level civil servants, and regulatory agency people) and those in the congressional branch (legislators and their staff). This can be easily adapted to state-level policymaking. Actors outside of government include lobbyists, the media, academics, researchers, interest groups, political parties, consultants, and the general public.

The concept of advocacy, however, is not central to Kingdon—it is a result of strategic or tactic moves of individual actors. In the policy stream, one actor may persuade others to favor a certain solution while, in the political stream, agreement can be built through bargaining without persuasion. Members of coalitions, to Kingdon, do not necessarily share common beliefs or attitudes.

To understand the causal structures underlying the MS framework, I inspect its perspectives on the processes involved and on the participants of those processes.

Multiple Streams is based on an adaptation of the "garbage can model" of organizational choice, introduced by Cohen et al. (1972). MS sees government as an "organized anarchy," where some level of fuzziness exists within the limits of general structures. Three process streams are postulated to exist on their own right within government: problem recognition, elaboration of policy solutions, and politics. According to Kingdon: "[o]nce we understand these streams taken separately, the key to understanding agenda and policy change is their coupling." These relatively-independent streams come together at critical points in time. A problem is recognized, a solution is available, the political climate at that point in time welcomes change, and the constraints (institutional or otherwise) do not inhibit policy action.

The reasons why the three streams would be independent is not clear from Kingdon's exposition—it is then unsurprising that this assumption has been criticized in the literature. An argument that policies or solutions are inherently independent of problems and politics seems very difficult to defend. The solution to this controversy is found in Olsen (2001). Olsen points out that the garbage can model presented in the initial paper (Cohen et al., 1972), and which he co-authored, is one of many possible forms of a garbage can model and that variations on it are possible. One such variation could be to propose different degrees of interdependence between the streams.

Multiple Streams adopts no formal behavioral model of the individual. In MS, participants are described, not modeled. Individuals are accepted as different from each other, adapting their behavior to the circumstances, pursuing different goals. MS allows beliefs and preferences to vary not only across individuals, but also within individuals.

Actors may make moves without fully recognizing what their preferences are. MS does not necessarily characterize participants of the policy process as rational optimizers. The amount of information that they are exposed to is in excess to what they are able to process, and thus behavioral paths are often chosen without full understanding of the potential consequences. Information plays a more significant role in the policy stream, where the merits of alternatives usually rank according to how well they fit a certain problem. In the stream of politics, understanding policies is not so central to decision makers.

The lack of a model to explain individuals' behavior limits the predictive capabilities of MS, but this concern may be more formal than substantial. Although Kingdon does not refer to his methods in these terms, what MS essentially does is to present processes and behaviors in probabilistic terms. An econometric model of human behavior/choice would base any explanatory power on the factors that contribute to a "deterministic" portion of utility (the factors more frequently observed), and would attribute to a random term all the variance that remains "unexplained." My interpretation of Multiple Streams is that it endeavors to find and explain the more recurrent patterns (the "deterministic" part), as well as exploring the less predictable mechanisms at work (the "random" part). For all scientific study purposes, randomness is inherent to the behavior of all social systems. Whether the research approach ignores it, packages it into an error term, or attempts to understand it (qualitatively or probabilistically), will certainly make a difference as to how tractable and empirically testable a model will be.

The garbage can model is concerned with decisions in organizations characterized by (1) problematic preferences, (2) unclear technology, and (3) fluid participation, which the authors call organized anarchies. These organizations have trouble defining the hierarchy of preferences in decision-making situations required by standard choice theory. Instead, organizations discover their preferences through action. Unclear technology refers to the inability of organizations to understand their own processes—they often ignore the best way to approach a problem and they learn through experience. The third characteristic—fluid participation—refers to the fact that organization members invest different amounts of time and effort in different situations. This fluidity results in relatively capricious changes in the subset of the organization involved and in their involvement intensity. The model metaphorically sees choice opportunities as garbage cans into which participants throw different problems and solutions as they are generated. Decisions are modeled as the confluence of four partially-independent streams: problems, solutions, participants, and choice opportunities. In particular, solutions are not necessarily defined to particular problems—they are rather seen as answers looking for questions. For example, zero-emission vehicles are not necessarily a solution only to the problem of air pollution—their advocates could present, and have presented, them as a solution to other problems "thrown in the garbage can," like energy security or climate change. Choice opportunities are instances when organizations are expected to—or simply have the chance to—make a decision. Expectations and chances may be borne on regulatory requirements, social pressure, etc. For example, the inception of the ZEV program was facilitated by a choice opportunity determined a number of factors.

Garbage cans stood over the years as an alternative to the rational and boundedly-rational models of organization choice. In their critique of the garbage-can research program, Bendor, Moe, and Shotts (2001) suggest the model could be better understood within the theoretical lens of bounded rationality. March and Olsen (1986) however state that the purpose of their garbage-can approach is to "identify and comprehend some features of decision making that are not well treated in other contemporary perspectives and yet are important." Thus, they attempt to "extend, rather than replace, understanding gained from other perspectives" (page 12.) Olsen (2001) points out that the garbage can model presented in the initial paper (Cohen et al., 1972) is one possible form of a garbage can model and that variations on it are possible and have been presented. One such variation could be defined by a different degree of interdependence between the four streams.

Bendor et al. (2001) are probably right in that the garbage can approach to organization choice has not been explained all too clearly and that the metaphoric tone of the presentation elicited imaginative interpretations of the model. On the other hand, Olsen (2001) explains that the garbage can model presented in Cohen et al. (1972) should not be taken as a definite theory and that subsequent explorations (for instance on ways to incorporate intelligent individual behavior, Cohen and March, 1974) should be seen as a natural evolution of the original work. There are clear similarities in the garbage-can and bounded-rationality perspectives on decisionmaking dynamics. To both, decisionmakers lack a-priori knowledge of alternatives of action, they perform limited, often inadequate, searches of these alternatives, they choose satisfactory, not optimal, courses of action, and they have unclear goals and often discover them through the problem-solving

process.[1] True, the garbage can has been questioned for not having a clear model of the individual (Bendor et al., 2001). However the dynamics of decisionmaking it proposes directly implies these characteristics about the involved actors.

4. The Socio-Political Environment Preceding the ZEV Mandate

The definition of the stream of problems entails the understanding of the issues at the center of the policy debate. In particular, it is necessary to understand the perceptions of policymakers and the public opinion regarding air quality as a policy problem. Concern with environmental quality was on an upswing in the late 1980s. The United States of George Herbert Walker Bush (1988-1992) witnessed a shift in the regulatory attitude at the federal and state levels, relative to the Reagan years. Regulatory reform, which had been at the center of the previous Administration's agenda, receded notably, particularly in the areas of health and safety (including the environment.) The public was becoming increasingly concerned with acid rain, air pollution, ozone layer depletion, and climate change. New scientific knowledge on these phenomena[2] was partly responsible for this heightened concern, together with events such as the Exxon Valdez oil spill in Alaska in March 1989[3] and the hot dry summer of 1988 that attracted media attention to global warming. The World Bank called the environment its leading priority for the 1990's (Landsberg, 1989.)

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[1] According to Simon (1985), "[t]he term "rational" denotes behavior that is appropriate to specified goals in the context of a given situation" (page 294). Therefore, the lack of clear goals or the search of goals through problem solving has to be interpreted not as the lack of specific goals but rather as adaptive goal seeking (goals can be defined vaguely and refined through experience.).

[2] For example, data collected over the Antarctica in the mid 1980's showed that the ozone layer was thinning more rapidly than previously thought (Monastersky, 1989.)

[3] In March 24, 1989, the Exxon Valdez, a ship of the Exxon Shipping Company (later the Sea River Shipping Company) ran aground, spilling almost 11 million gallons of oil into Prince William Sound. This spill does not rank today even among the top 50 in terms of oil spilled, but it is considered number one in terms of environmental damage and its impact on the public opinion.[2]

According to Multiple Streams, the streams are mutually independent. However, this tenet of the framework can hardly be justified. For instance, the stream of politics is necessarily related to the stream of problems—policymakers do, at least to some degree, gear the political debate toward issues of concern to their constituencies. One clear example of this interdependence is the conviction with which Congress and the Administration concerned themselves with amending the federal Clean Air Act in 1989.[4] On July 21 of that year, the White House unveiled a sweeping proposal that included a requirement that one million alternative fuel vehicles be sold in the most polluted regions of the country by 1997. This provision was rejected in a 12-10 vote of the House Subcommittee on Health and the Environment of the Energy and Commerce Committee, and replaced with a milder proviso that the automakers simply demonstrate that they were capable of producing and distributing such vehicles. The amendment, introduced by Reps. Jack Fields (R-TX) and Ralph Hall (D-TX), allowed reformulated gasoline to be considered as an alternative fuel.

The courts were making decisions that would influence the debate over air-quality regulation. An important ruling of the U.S. Court of Appeals took place in July 28, 1987. In a case brought by the Natural Resources Defense Council (NRDC), the Court decided, in an 11-to-0 vote, that the Environmental Protection Agency (EPA) should use health considerations, and not the cost to industry, when setting safety levels of toxic pollutants. Judge Robert H. Bork wrote "(toxic pollutant safety levels) must be based solely upon the risk to health. The [EPA] administrator cannot under any circumstances consider the cost and technological feasibility at this stage of the analysis." The Court did not specify any

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[4] Attempts to amend the Clean Air Act over the preceding decade had been unsuccessful.

particular method for determining safety levels, but said they should be based on expert judgment and may take into account scientific uncertainty. (Nancy Lewis, Emission Rules Must Be Health-Based, *The Washington Post*, July 29, 1987.)

Meanwhile, as the result of a lawsuit brought by the Coalition for Clean Air and Sierra Club in 1988, a federal court ordered the US EPA to promulgate a plan to improve air quality in the South Coast Air Quality Management District (which includes Los Angeles) if local officials failed to do so (Reinhold, 1989.) The lawsuit was inspired by the fact that the South Coast Air Quality District had failed to come even close to complying with the December 31, 1987 deadline to attain federal air quality standards. The basin suffered 176 days with ozone levels above standards during 1988—far more than any other metropolitan area in the United States (Reinhold, 1989.) California found itself at risk of losing federal funds for the construction of transportation infrastructure if it didn't show progress toward air-quality attainment. This risk greatly tempered any political resistance to air-quality regulation from elected officials.

Such political climate invited a variety of stakeholders to push for their preferred solutions or policies, thus energizing the stream of policies. Some were in favor of promoting alternative fuels and some (particularly the oil companies) were for reformulated gasoline. Not coincidentally, in those years, the notion of the electric vehicle as a serious means to improve air quality started to enter the policy debate in California. In 1989, Lamont Hempel, with the Center for Politics and Policy of the Claremont Graduate School, led a study partially funded by the Southern California Edison on the potential of electric vehicles to reduce air pollution in the region (Hempel

et al., 1988). The study caught the attention of the media. While arguing that battery electric vehicles were then "becoming attractive" as "new batteries are available on a demonstration basis that offer up to 122 miles on a single charge," the study cautioned that "electric vehicles won't measure up in terms of speed and power" and that they should target the second-vehicle market (Hempel et al., 1989; Koenenn, 1988.) In the same year, Los Angeles councilmember Marvin Braude led the so-called LA Initiative— an international competition looking for companies that would manufacture and deploy 10,000 electric vehicles in the city of Los Angeles by 1995. Part of the program would have been funded by the Los Angeles Department of Water and Power and by Southern California Edison. Clean Transport, a Swedish company, won the competition, but was eventually unable to deliver the required vehicles.

Dr. James Lents, in early January 1988 and in his second year as SCAQMD's Executive Officer, announced a nine-month campaign to recruit public support for a very ambitious plan, known as the Air Quality Management Plan that the district was developing to improve air quality in the region. Lents believed that the district had been excessively concerned with industry interests, to the detriment of air quality. "It's my perception that on the whole our board in the last decade did not do the job they should have done," he said. Lents felt that his agency had to lead the fight for the air quality cause, since elected officials often lack the political incentive to stand for clean air, and environmental groups in the area were "not very strong and disorganized" (Stammer, 1988.) When the AQMD Board set 1996, 1997, and 2007 as targets for attainment of nitrogen oxides, carbon monoxide, and ozone standards respectively, many observers believed that such goals could not be achieved before 2010 to 2020 (Hempel, et al., 1989.)

In March 17, 1989, the South Coast's board of governors approved, with a vote of 10 to 2, a daring three-stage plan to reduce air pollution in the region: the South Coast Air Quality Management Plan (AQMP). Tier I would span the period of 1989 to 1998 and called for important lifestyle changes like reducing the use of automobiles and increase the use of public transportation. Tiers II and III envisioned automobiles progressively transitioning to cleaner fuels like methanol, propane, and electricity, with all automobiles running on fuels other than gasoline by the year 2007. Thus, the AQMP became the first regulatory initiative to include requirements on electric vehicles.

Toward the end of the decade, there was a generalized sense of urgency to clean the air, along with a widespread skepticism that the quality of the air would improve unless drastic steps were taken.

On September 28, 1990, at the end of the two-day public hearing, the California Air Resources Board adopted resolution 90-58 approving the Low Emission Vehicle and Clean Fuels (LEV I) regulation proposed by the staff, with some modifications. Following Section 11346.8 (c) of the Government Code, the Executive Officer made the amended regulatory text available for public review and written comment for a period of 15 days. After new modifications were made on the text, the revised text was submitted for public review again from January 1 through January 31, 1991. After due consideration of further comments, the Executive Officer issued Executive Order G-604, which amended Title 13, Sections 1900, 1904, 1956.8, 1960.1, 1960.1.5, 1960.5, 1965, 2061, 2111, 2112, 2125, and 2139, of the California Code of Regulations. Thus, the new Non-Methane Organic Gas Test Procedures and the California Test Procedures for

Evaluating the Emission Impacts of Substitute Fuels or New Clean Fuels were adopted. Various documents, mostly very technical, were incorporated by reference. Some of these documents incorporated also references to Title 40, Part 86, of the Code of Federal Regulations, which describes federal standards and test procedures. The references to the Federal Code were included for the convenience of manufacturers who have to certify equipment according both federal and state standards. In particular, § 1960.1(g)(2) note (9) indicates that, starting in 1998, in addition to meeting the fleet average NMOG requirement, certain percentages of the passenger cars and light-duty vehicles under 3,750 lbs sold of any major auto manufacturers should be zero-emission. This requirement on zero-emission vehicles (ZEV), became known as the ZEV mandate.

The adoption of the ZEV mandate in September 1990 by the California air Resources Board was not viewed as a particularly dramatic event. In fact, the ZEV mandate was a very small provision within a large complex package of rules formally known as the Low Emission Vehicle and Clean Fuels regulation, and informally known later as LEV I. The specific language used is as follows: "While meeting the fleet average requirement, each manufacturer's sales fleet of passenger cars and light-duty trucks from 0-3750 lbs, LVW shall be composed of at least 2% ZEVs each model year from 1998 through 2000, 5% ZEVs in 2001 and 2002, and 10% ZEVs in 2003 and subsequent model years." (CARB, 1990a, p. 22.) The Mandate included a requirement that the program be reviewed every two years.

The rules allowed automakers to bank emission credits derived from ZEVs for use in later years, and allowed manufacturers to trade excess credits to other automakers. They

also had the option of paying a fine of $5,000 per vehicle in lieu of selling a ZEV. Small volume manufacturers were not required to meet the ZEV requirements, but were permitted to sell ZEV credits. Intermediate volume manufacturers were not required to meet the rules until 2003. Marketers in California with sales of 35,000 vehicles or more were required to meet the full set of rules. They were GM, Ford, Toyota, Honda, Chrysler, Nissan, and Mazda. Mazda was later dropped into the intermediate category.

That the ZEV requirements were embedded in a much broader regulatory piece has two intertwined implications related to this study. First, it affected the strategies adopted by the different policy players (this aspect will be discussed in the course of the paper.) Second, much of the documentation and testimony included in the records is focused on the main parts of the regulation: the stringent—for the time—emission standards for fuel-burning vehicles, and the requirements on production and distribution of cleaner fuels. Indeed, often times the ZEV requirements are either ignored or referred to tangentially.

5. The statutory context

The California Air Resources Board is an agency of the California government. It is headed by a full-time chair and a board of 10 part-time members. Each of the Board members represents a certain constituency. Five members are electives from air quality management districts (South Coast, San Diego, San Francisco Bay Area, San Joaquin Valley, and any other district). Three of the members have expertise in one of the following areas: public health, automotive engineering, and science, agriculture, or law. The two remaining members are regular citizens. All members are appointed by the governor—who has the power to replace them at any time—and ratified by the Senate.

The chair and board oversee a large staff of approximately 1,000, with a technical expertise recognized by most. CARB was and is known for its international leadership on air quality regulation.

Much of the power of CARB comes from the fact that it does not have to formally report to the governor or the legislature on its decisions. This does not mean that the agency is not vulnerable to political influence. The legislature decides on the agency's annual budget and can use (and has used) this power to influence CARB. The governor's power to replace board members gives him the means to influence decisions too. I could not find any incident in which the governor directly tried to influence the board in the context of the ZEV mandate. However, instances in other regulatory processes can be cited.[5] The U.S. Environmental Protection Agency has some supervisory powers over CARB. To exercise its right to adopt its own air quality programs (as given in the federal Clean Air Act), CARB needs to apply for a waiver to U.S. EPA.

As a governmental agency, CARB activities follow statutory guidelines. In its broadest sense, the mission of CARB is to "attain and maintain healthy air quality, conduct research into the causes of and solutions to air pollution, systematically attack the serious problem caused by motor vehicles, which are the major causes of air pollution in the State" (CARB, 2006.) In the particular case of the Low-Emission Vehicle and Clean Fuels regulation, the statutory authority came predominantly from the 1988 California Clean Air Act, also known as the Sher Act, which enacted and amended a number of

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[5] Governor Deukmejian directly objected to the staff's proposal to mandate the sales of alternative fuels in the original language of the LEV I regulation. (Interviewee from CARB.) Chairwoman Sharpless allegedly lost her job when she tried to pass regulation on reformulated diesel, under Governor Wilson. (Interviewee from the environmental community.)

sections in the California Health and Safety Code, relating to air pollution.[6] In particular, Sections 43013(a) and 43018(a),(b), are central to understand the statutory duties and limitations affecting CARB in the LEV process:

> 43013. (a) The state board may adopt and implement motor vehicle emission standards, in-use performance standards, and motor vehicle fuel specifications for the control of air contaminants and sources of air pollution which the state board has found to be necessary, cost-effective, and technologically feasible to carry out the purposes of this division.

> 43018. (a) The state board shall endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of state standards at the earliest practicable data.

> (b) Not later than January 1, 1992, the state board shall take whatever actions are necessary, cost-effective, and technologically feasible in order to achieve, not later than December 31, 2000, a reduction in the actual emissions of reactive organic gases of at least 35 percent, a reduction in emissions of oxides of nitrogen of at least 15 percent from motor vehicles. These reductions in emissions shall be calculated with respect to the 1987 baseline year. The state board also shall take action to achieve the maximum feasible reductions in particulates, carbon monoxide, and toxic air contaminants from vehicular sources.

The Sher Act created the legal foundation for the LEV program, but it was a different legislative initiative that initiated the thrust toward LEV. CARB believed that the

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[6] Approved by the Governor in September 30, 1988.

reductions required by the Sher Act would be achieved even without stringent additional regulation, and that they would be naturally achieved by vehicle turnover and enforcement of the regulations that CARB had already adopted (interviewee from CARB). AB 234, introduced by Assembly Member Bill Leonard on January 12, 1987, had instead a direct influence on the LEV regulation. The main intent was to accelerate the use of alternative fuels as a way of gaining large reductions in emissions. It was widely believed in industry and government that only small incremental reductions were possible with gasoline (interviewees from auto industry and CARB). The perception was that the large reductions needed to meet air quality standards in the Central Valley and the Los Angeles basin could be achieved only with a shift to new fuels.

The fuel receiving much attention at the time, and that was "selected" as the focus of AB 234, was methanol. The initial bill included language directing CARB to adopt regulations requiring that at least 15% of the annual projected new-vehicle sales in the state for the years 1994-1996 to be low-emission motor vehicles, ramping up this requirement to 30% for the years 1997-2000. It also contained language The bill intended to modify the definition of low-emission motor vehicles in the Health and Safety Code to a vehicle which "has been certified by the state board to meet all applicable emission standards and meets one of the following additional requirements: (a) Is capable of operating on methanol meeting the requirements of the sate board adopted pursuant to Section 43115. (b) Is capable of operating on any available fuel other than gasoline or diesel and which, in the determination of the state board, will have an impact on ozone air quality no worse than a vehicle operating on methanol. (c) Operates exclusively on gasoline and is certified to meet a hydrocarbon exhaust emission standard which is twice

as stringent as otherwise applicable to light-duty gasoline vehicles. Most of these regulations would have applied to manufacturers with total project annual sales in the sate of more than 75,000 light-duty vehicles. Language was included also mandating retail outlets with gasoline sales of 600,000 or more gallons in any year to offer methanol fuel for sale at that retail outlet by January, 1994.

The bill faced strong opposition from the oil companies and was eventually passed as a study bill. It created an Advisory Board on Air Quality and Fuels consisting of 17 members. After many meetings and hearings, the AB 234 Advisory Board issued a report. A principal recommendation was a requirement to supply alternative fuels using a complex "fuel-pool"—whereby fuel requirements were to be adopted for fuel suppliers based on the emission levels of the fuels. Completing this report took longer than initially proposed. By the time this report came out, it had become apparent to CARB that new technologies had been developed to reduce emissions from gasoline vehicles, and that achieving tailpipe emission of the order of 50 to 75% was entirely feasible (interviewee from CARB). The idea of the fuel-pool, however, was not perceived as an effective solution in CARB, where it became known to some as the "fool-pool" concept, because they could not really understand how it would be effective (interviewee from CARB).

But the AB 234 report played a crucial role in two other ways as well: 1) it planted the seed of alternative fuels in regulators' minds, setting the stage for ZEVs and 2) it introduced the revolutionary concept of averaging.[7] Partially inspired in the AB 234 report, CARB designed a program to average tailpipe emissions, creating the three

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[7] All California and Federal vehicle emission standards to that time had been single uniform standards that applied to each and every vehicle.

increasingly stringent categories of TLEV, LEV, and ULEV categories, plus ZEV (Interview with CARB representative.)

AB 234 formed part of the argument presented by CARB for the statutory validity of the LEV program. According to Jim Boyd, then CARB's Executive Officer, LEV was "consistent with the requirements of the California CAA, Assembly Bills 1807 and 4392, which are the laws designed to identify and control toxic air contaminants." It also meets "the goals set forth … in the CARB's long-range motor vehicle plan, meets the recommendations of the AB 234 Advisory Board on Air Quality Fuels, and meet the requirements of the CARB's State implementation plan for the South Coast Air Basin, which incorporates both the South Coast Air Quality Management plan and the Air Resources Board's motor vehicle and clean fuels programs." (CARB, 1990.)

The LEV program included mandates not only on ZEVs, but also on the distribution of so-called *clean fuels*. As explained by Susan Huscroft during the 1990 hearing, such fuels included methanol (neat or as blend with gasoline), ethanol, liquefied petroleum gas, compressed natural gas, electricity, and "possibly an ultra-clean gasoline." Gasoline suppliers would have to distribute certain volumes of some of these fuels "based on the needs of the low-emission fleet." Additionally, a given number of retail service stations would have to be equipped to dispense clean fuels, and make these fuels available to customers. CARB believed that these mandates would level the competitive field in the market for vehicle fuels: "[b]ecause the gasoline suppliers are required to distribute certain volumes of fuel into the marketplace, this will ensure fuels are competitively marketed and made attractive to the consumer. (…) Market forces may not be sufficient

by themselves for the transition years when these fuels are new" (Huscroft). Gasoline suppliers were exempted of the responsibility to supply compressed natural gas and electricity though. This exemption was explained by Huscroft: "[w]e believe that these fuels are offered only by utilities, such a requirement could create a monopolistic situation in terms of the prices that the gasoline suppliers might have to pay for the necessary credits." The installation of CNG stations was required by the regulation too, contingent upon approval by the California Public Utilities Commission natural gas sale for resale. No such requirement was imposed on electricity, however, because CARB believed that "it is better for people to use home recharging systems than to have centralized refueling facilities." It is very interesting that two mandates were part of the program proposed by the staff—one on fuels and one on zero-emission vehicles—but that the former could not survive the debate while the latter could. The ARB Legal Office felt that it would have been very difficult to defend that requirement if the case it went to court.

6. How the ZEV mandate was included in the LEV regulation

The inclusion of the ZEV requirements in the language of the LEV regulation is the clearest expression of the raise of electric vehicles to the policymaking agenda, the ultimate event that MS purports to explain. According to MS, this event should be the result of the activity of policy entrepreneurs taking advantage of a window of opportunity created by the crossing of the three streams defined in previous sections. The analysis in the Sections 4 through 6 has shown that the conditions in all areas (problem, politics, and policy) were indeed given for policy entrepreneurs to push for their preferences. The

situation in early 1990 could thus be characterized as a crossroad of the three streams, or a window of opportunity.

According to interviewees from CARB, at about the same time of the AB 234 report, the staff wrote an internal report on battery ZEVs in response to an inquiry from outside the agency (and possibly also from one of the Board members, although this was not confirmed) about battery vehicles. The staff's conclusion was that at that time BEVs did not offer much promise—they were limited by the cost and performance of lead-acid batteries and thus they could not achieve any reasonable driving range per charge. This explains why there were no provisions requiring ZEVs in the early drafts of the LEV I regulation.

In January 3, 1990, at the Los Angeles Auto Show, General Motors unveiled the Impact—a prototype two-seater that was designed from the bottom up as an electric vehicle. The Impact showed important progress in performance relative to previous electric cars. In a speech at this event, Roger Smith, then General Motor's chairman, said that the Impact could go from 0 to 60 miles per hour in eight seconds and that it could go 124 miles before recharging. "There are no yet-to-be-solved secrets," Smith said about the design of vehicles like the Impact, adding that "The thing is its marketability (…) We want an electric car that's producible, that can handle itself on the highway and that can meet the federal standards out there and that is a marketable product. We believe we've accomplished two-thirds of that." John Zwerner, executive director of General Motors's Advanced Product Engineering department said that the Impact "absolutely shattered" the public perception of electric vehicles as slow-moving golf cars (Lee, 1990.)

Smith was explicit about the limitations of the Impact vis-à-vis standard comparable gasoline vehicles. For an auto driven 10,000 miles a year, operating the Impact would cost $70 a month, while a comparable gasoline auto would cost $40 a month. The difference in the cost would come mostly from the need to replace the battery pack every 20,000 miles approximately, at an estimated cost of $1,500. Fuel (electricity) costs would range from $5 to $12 per month. He acknowledged that improvements in batteries technology were expected and that they could extend batteries' life to 50,000 miles, thus making operating costs competitive with those of standard gasoline vehicles. Smith cautioned that production of the Impact would be justified only if a demand on the order of 100,000 cars a year existed (Lee, 1990; Stevenson, 1990.) The Wall Street Journal had a somewhat different version of the latter. According to this source, Smith said that if consumer surveys then underway showed that "GM could one day profitably churn out 100,000 or so Impacts annually, the company would be prepared to put much more funding into it." (Wartzman, 1990.) According to this version, sufficiently large demand would not necessarily lead to the decision to actually produce the Impact. The same source added: "[t]he Impact, which GM says uses a third of the energy of conventional gasoline-powered autos, is part of a broader effort by the company to cope with strict tailpipe-emission regulations being contemplated on Capitol Hill." (Wartzman, 1990.) These media reports show that Smith offered an optimistic though cautious portray of the Impact. This version of the events is slightly different from that given in other published accounts, which tend to focus on Smith's optimism more than in his caution (see, for example, Doyle, 2000.)

Up to this point, the working drafts of the LEV I regulation viewed electric vehicles as a means to comply with the ULEV standard, but contained no provisions mandating sales of ZEVs. The media reported: "[t]he California Air Resources Board is considering a proposal to require that 15% of new vehicles sold by the year 2003 be so-called ultra-low-emission vehicles, which would include electrics." (Lee, 1990)

Roger Smith's speech not only is one of the most famous ones in the history of the air-pollution policy process—it is also a very interesting case study on the role of information on environmental regulatory activity. Many of my interviewees, primarily from government and non-profit organizations, remember that speech as a General Motors' promise to market electric vehicles by 1996. This overly simplified reading of General Motors' statements may be in part explained by the history of limited communication and distrust between regulators and auto manufacturers. Regulators and environmentalists felt that they did not know much about the ability of OEMs to produce cleaner vehicles, while the OEMs felt that as they revealed that cleaner technologies were possible, regulators would demand even cleaner ones. In this context, the information provided by Smith may have been eagerly interpreted by those who wanted electric vehicles on the roads. At the same time, as some interviewees pointed out, General Motors has a particular public relations style. In an effort to portray the company favorably in the eyes of government and the public, it often crafts public statements in ways that may lead to misinterpretations. The careful reader/listener may understand the textual message, but the more casual one may be led to believe that the company is farther along the learning curve than it really is. Such misinterpretations have happened

also with regards to the company's statements about commercialization of fuel-cell vehicles.

Another common misperception is that the idea of the Mandate was seeded in CARB's mind by Roger Smith's public introduction of the Impact. GM's prototype did give CARB the courage to pursue the Mandate, but the CEO's statements had no direct influence (interviewee from CARB). The idea of a sales requirement on zero-emission vehicles was first proposed by Don Drachand, then Chief of the Motor Vehicle Emissions Control Division of ARB. At the time of developing the LEV emission standard, CARB staff realized that testing and measurement were an issue for low-emission vehicles. During a discussion about the LEV regulation with Steve Albu, an emissions engineer, Drachand came up with the idea of going all the way to zero emissions, and add a new category: ZEVs. His major motivation was the potential of electric vehicles to solve the problem of the deterioration of emission-control systems found in conventional vehicles. Drachand, Albu and others in CARB had drive-tested the Impact at an exhibition organized by General Motors in Century City, and were very impressed by it. They knew it wouldn't replace the internal combustion vehicle completely, but it struck them as a great commuting car with good performance. Drachand asked Albu to look at the technical feasibility of a zero-emission category, while he looked at the policy feasibility of such category. California law didn't allow CARB to require a technology—an electric vehicle could not be mandated, but a zero-emission vehicle could. So the strategy was to require zero-emission vehicles, not electric vehicles. Once Drachand and his staff agreed on requiring ZEVs, they moved on to show one technology that could meet such standard—the Impact provided them with the best example of such a technology. Thus,

while Roger Smith's statements did not engender the idea of a sales requirement, the Impact, as a technological achievement, did provide Drachand and his staff with the conviction to proceed with the ZEV idea.

Drachand and his staff then briefed Tom Cackette about their idea and presented some preliminary estimates of emissions reductions and cost effectiveness. Once Cackette approved the idea, the Executive Officer, Jim Boyd, was briefed. Boyd in turn briefed the Board's Chairwoman, Jan Sharpless, who was also supportive. Thus, the ZEV mandate was incorporated in the language of the LEV regulation. (Interviewees from CARB) In view of this description of events, Drachand can clearly be recognized as the policy entrepreneur referred to by MS.

After the chain of command in CARB agreed to support the mandate, a number of workshops were organized to bring stakeholders together. In these workshops, which were attended by many more people than usual, the most automakers strongly opposed the idea. To get a provision successfully in a regulation, CARB usually prefers to have some kind of support for at least one of the OEMs. If all the affected industry said a required technology is unfeasible, it would be difficult for the staff get it through the Board. According to CARB staff, Ford could live with the idea of a ZEV requirement if they were given enough lead time and if the technology was phased in. Requiring 2% in 1998 seemed feasible to CARB at the time. To show the affected industry that the agency was committed to the Mandate, it was decided to increase requirements at later years, so they picked a 5% in 2001 and a 10% in 2003. By ramping up requirements to a 10% they

intended to provide an opportunity to the technology, believing that once it entered the market to that level it would take care of itself. (Interviewees from CARB)

LEV was a technology-forcing regulation. The level to which technology forcing was taken is where regulator and regulated parted ways most explicitly. To Chrysler, for instance, "the expectation that technology forcing standards will bring forth the innovations needed in the required timeframe" was one of the reasons why the program was likely to fail. ARB, on the other hand, believed that without technology forcing, it would be unlikely that the automakers would develop and deploy the cleanest vehicles possible. "The ARB has historically set the pace for manufacturers to meet progressively more stringent vehicle emission standards", sustained the agency (ARB, Final Statement of Reasons, 1990.) ARB supported this claim with the example of its requirement of catalytic converters: "The success of this strategy indicates that ARB has been reasonable in gauging the stringency of proposed standards." While such reasoning may have been appropriate to support the requirement on NMHC standards, it was not to support the requirement on ZEVs, which constituted a more radical innovation.

A number of stakeholders, including Ford, Mercedes, Chrysler, and Volvo, believed that ZEV should not be mandated, but rather be considered a goal. CARB was however confident that a mandate, and only a mandate, would ensure that developments in battery technology were pursued.

ARB did not have the statutory authority to implement economic incentive programs to stimulate the demand for low-emission vehicles. Only the state legislature had that power. Several stakeholders, including Chrysler, WSPA, and Environmental Defense

Fund, required ARB to consider working with the legislature to develop incentive schemes. ARB was receptive to the notion but did not show a proactive approach: "To the extent that incentive programs are found to be appropriate and beneficial, we are prepared to work with the Legislature in the development of such program." (ARB, Final Statement of Reasons, 1990.)

7. The Role of Scientific and Technical Information

The stream of policies is directly determined by the alternatives to address the policy problem defined in previous sections. The debate was dominated by technological solutions like lower-emission vehicles and cleaner fuels. For the purposes of this study, to understand the implementation of the ZEV mandate, it is pertinent to analyze the zero-emission component of the stream of policies. In this section I describe the technical information on zero-emission technologies as presented in the policy debate and some of the main referents in this area.

The single most important factor determining the commercial viability of ZEVs has always been battery technology and costs. By the time of the implementation of the LEV program, most electric vehicles used lead-acid batteries. While other types of batteries like nickel-iron and zinc-bromine were also available, lead-acid batteries were the most commercially viable alternative. Typically, electric vehicles using lead-acid batteries had a range of only 75 miles (Delucchi, et al., 1989.) Conventional lead-acid batteries had an energy density of about 35 Wh/kg which compared poorly to the 2,000 Wh/kg of gasoline, despite the higher energy efficiency of batteries (about 70%) (Westbrook,

2001.) The cost of lead-acid batteries was estimated at around $95/kWh, in 1985 dollars (Delucchi, et al., 1989.)

According to one interviewee from CARB, the requirements on ZEVs were based on *projected* (or expected) improvements on battery technology. The staff knew that the lead-acid battery would not be sufficient—it demonstrated the technological viability, but it would not be enough for a commercially viable vehicle. The staff members who supported the Mandate were convinced that there would be massive improvements on battery technologies other than the lead-acid. Their confidence came from the great battery demand driven by the electronics industry. Also, some sectors of the battery industry with which CARB consulted were very confident. In particular Ovonics, a Dearborn company that was developing a nickel-metal-hydride battery, told CARB that it could develop a much better battery with the necessary financial support. CARB's Mobile Source Division had an annual research budget of about $7 million and granted some research funds to Ovonics. The staff had also conversations with Sony California, where some work was being done on lithium-ion batteries. At that time they were making battery-powered motorcycles that had great performance and competitive cost. But Sony Japan wouldn't let CARB use their data in official reports. (Interviewees from CARB)

The CARB staff did not present a very detailed analysis of the costs involved in the implementation of the ZEV mandate. During the 1990 public hearing, the cost analysis of the LEV program was presented by Susan Huscroft. CARB's best estimate of the additional cost of a battery electric vehicle, relative to a comparable gasoline internal combustion vehicle, was of $1,350, with a possible ceiling of $3,500. CARB also

assumed that the cost of replacing the battery would be "roughly offset by the reduced maintenance cost associated with electric vehicles." Apparently, these estimates did not include the cost of the home recharging equipment—this would be an inconsistency in CARB's analysis, since a central assumption of the clean-fuel portion of the regulation was that electric-vehicle owners would recharge at home, instead of at centralized facilities. Indeed, one interviewee from CARB admitted that the initial program feasibility analysis was very rudimentary. This interviewee added that the technical report presented by the staff in 1990 included a very short economic analysis, assigning to BEVs an incremental cost of 1,350 dollars due to the battery pack—and that was the main reference of the cost of the ZEV program. In the interviewees' opinion, that shows that there wasn't much invested in the design of this program.

To estimate the cost of maintaining a gasoline vehicle, CARB assumed a projected gasoline of cost $1.35 to $1.45 per gallon, reflecting a $29 projected cost for the barrel of oil by the year 2000. These projections were based on studies by the California Energy Commission, with an adjustment by CARB of 5 to 15 cents, to account for the expected price increases after Phase 2 gasoline standards became effective, in 1991. A significant event took place however, between the time when these estimates were arrived at and the public hearing where they were presented at: the Gulf War. As a consequence, the cost of gasoline spiked to levels well above those assumed in CARB's analysis. The analysis also estimated the cost of electricity at $0.59 per gallon of gasoline equivalent. Based on this, CARB arrived at an estimated $90 to $130 in annual fuel savings for an electric vehicle, relative to a comparable standard gasoline vehicle.

Regarding the marketability of battery electric vehicles in the required timeframe, CARB relied heavily on what they knew about the work done and projected by General Motors. Supporting documentation stated: "Regarding the ZEV mandate, *competitive* electric vehicles such as General Motors' Impact have been developed and may satisfy the ZEV requirement for the 1998 model year once issues regarding battery life are resolved." (CARB, Final Statement of Reasons, 1990; emphasis added.) The same document also read: "General Motors has indicated it plans to introduce its Impact electric vehicle by 1996, and this vehicle is competitive in performance to gasoline-powered vehicles, although battery life is less than desired." (CARB, Final Statement of Reasons, 1990, p. 46.)

Apparently, most of the economic analysis of electric vehicles focused on techno-economic and social cost aspects. Understanding production, maintenance, and running costs of a given technology and the associated social (negative) costs is absolutely essential to the implementation of technology-forcing policies. Feasibility analyses need also include estimates of private non-monetary costs (e.g. consumers' perceptions of the new technology, and the disutility of longer recharging times and shorter range), as well as the cost of achieving the hoped-for technological advances. As explained by one interviewee from CARB, the actual demand for electric vehicles is something that the agency, and even the automakers, learned "only by doing." The understanding of what it would take for electric vehicles to penetrate the market in significant numbers was sketchy at best. Uncertainty is however an inherent characteristic of technology-forcing approaches, as regulators do not know how much innovation industry is capable of achieving, and industry has incentives to withhold such information. In fact, often times

not even industry is well aware of its innovation capabilities. As one interviewee from the environmental community put it: "that has been the key balancing act of ARB—push hard enough to keep investments faster than otherwise would have happened, but not so hard that they lose their credibility or the rule disintegrates."

Life-cycle analyses conducted by Delucchi and collaborators, reported in different sources (e.g. Delucchi, et al., 1989; Hempel, 1989) looked at a variety of scenarios, to arrive at estimates of per-mile costs of electric vehicles. These studies concluded that, under many scenarios, battery electric vehicles had lower life-cycle costs than gasoline vehicles. For example, assuming $0.95/gallon of gasoline and ¢5/kWh of electricity, Delucchi et al. (1989) estimated the life-cycle cost of a gasoline internal combustion engine vehicle at 28.42 cents/mile, and the cost of a comparable electric vehicle ranged from 24.77 to 35.73 cents/mile.

Before the Mandate was conceived of, it was understood that a number of factors could theoretically improve the performance of electric vehicles substantially. Hempel (1989) argued that electric vehicles with low drag coefficients, low rolling resistance, regenerative braking, and efficient battery-to-wheel energy transfer systems, could potentially achieve 8 to 12 miles per kWh.

In summary, ARB concentrated in presenting estimates of the monetary costs of purchasing and operating electric vehicles. It essentially ignored the non-monetary private costs that a potential consumer of this technology would face. Such costs included the lower range between charges and longer fueling time of electric vehicles relative to standard gasoline vehicles. In other words, the original ZEV mandate was based on no

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study of the market possibilities of electric vehicles. During the 1990 public hearing, besides the representatives from the auto companies, one witness—Alec Brooks, from AeroVironment—cautioned about the limited value proposition of electric vehicles if compared to gasoline vehicles. Brooks agreed with CARB's staff on that zero-emission vehicles would be technically viable by 1998. In terms of the value proposition to consumers, Brooks said: "[d]riving range of electric vehicles will not match that of your conventional vehicles, but I believe… my opinion differs in regard to speed and acceleration. I believe they will be adequate, if not better than adequate, in electric vehicles. Lifecycle costs have not yet been demonstrated for a real consumer electric vehicle. It depends primarily on the cost and life of the battery." AeroVironment, a company that strongly supported electric-drive vehicles, was working with General Motors on the development of the Impact.

As the Board was ultimately responsible for upholding and revising the staff's proposal, it is important to understand how the technical information was received by its members. Staff's estimates of battery costs were strongly questioned by Board Member Dr. Wortman during the 1990 hearing. He said: "…while we're all in favor of electricity, one thing that I think should be brought up: We did a study for the Department of Energy with lead-acid batteries, which at present are the most practical probably. Every 15 months, the lucky owner of that car is going to replace his battery set for a cost of between three and four thousand dollars. We're all dedicated to clean air. How many people are going to spend three or four thousand dollars every 15 months for a new set of batteries?" He added: "I've been involved in Navy battery development for about 25 years. And millions, tens of millions every year. And we haven't really progressed." The

Board's chairperson is the contact point for the staff, and she is regularly briefed by staff about the state of relevant technologies. Dr. Jananne Sharpless, Chairwoman at the time of the passage of the LEV I regulation, was perceived by ARB staff as very technically sound. Staff had no trouble conveying technical information to her. Sharpless supported the ZEV elements, but her position was not exclusively based on an assessment of technical information. She understood that there were no warranties about the techno-economic feasibility of the Mandate, but at the same time she believed that battery electric vehicles had sufficient potential for ARB to push for them.

8. The Implementation Process: Stakeholders' Activity

The Multiple Streams framework focuses on understanding how policy issues rise to the agenda. Clearly, that ideas, projects, technological fixes, and such enter the policy agenda does not guarantee their survival of the implementation battles. As one interviewee with CARB put it: "This is not just for ZEVs. For any one of the standards that we enacted… getting the standard on the books is 40% of the fight. 60% is to keep it there, because people come back, send lawyers, they call politicians, they call governors, and say 'no, we can't meet it, this is dumb.' And we have to answer to that." MS remains for the most part oblivious to the implementation process and therefore provides no significant guidance to its study.

An analysis of the implementation process is of particular interest for a policy like the ZEV mandate, because it is a rare example of non-incremental policy innovation. The Mandate proposed a disruption of the status quo, presented the auto industry with a tremendous challenge, and implied a new transportation energy paradigm. How did a

program that would potentially impact so greatly on the two most powerful industries of the United States then survive the implementation process? This section provides an answer to this question.

According to senior people in CARB, the Mandate probably wouldn't have passed hadn't it been such a little part of a big regulation like the LEV program. As a senior person from CARB put it: "The fact that [the ZEV mandate] was part of a larger (policy) package was certainly key to it happening." Overall, there was more debate over the clean-fuels part than over the low-emission vehicle part of the regulation. At the Los Angeles airport, on their way back from the hearing of 1990, Tom Austin (Sacramento-based consultant who often represented the auto companies) said to a group including CARB staff (paraphrasing): "Everybody's thinking about the adoption of these clean-fuel requirements, when actually they have adopted this incredibly stringent regulation on motor vehicles." This focus on the fuel elements took some pressure out of the vehicle ones. On the vehicle side of the debate, most of the attention of the regulated industry was directed to the LEV and ULEV requirements, as it was extremely concerned about their ability to meeting those standards.

Under Section 209b of the Clean Air Act, EPA can grant California a waiver to adopt its own air-quality standards. ARB applied for a "209 waiver" to the EPA on October of 1991. There was a hearing in Ann Arbor on 1992 where the parties presented their respective cases. The automakers were represented by Kirkland & Ellis, a big firm with headquarters in Washington, DC, which would represent them in much of the debate over the ZEV mandate in the future, both in California and in the Northeast. In this instance,

however, none of the automakers' objections focused on the Mandate. During a supplemental comment period reluctantly agreed upon by EPA, ARB presented a compelling, well written document supporting the LEV program. In January, 1993, EPA granted the waiver. The automakers had 60 to file a lawsuit challenging the waiver, but they never did.

8.1 The reaction of the car companies

Indeed, the ZEV requirements were such a minor part of the LEV program that ARB interviewees often referred to the Mandate as "an afterthought," while interviewees from the OEMs often called it "a footnote." The Mandate was by no means among the elements of the LEV regulation that caused the most discussion. The ZEV requirements were far down the road (1998), and the auto industry prioritized fighting over more immediate and important elements of the regulation. At the same time, while no member of the industry thought that the Mandate was a good policy, the internal—not necessarily public—reaction to it varied across and within the companies.

Upper management in General Motors felt that there would be opportunities in the future to negotiate with ARB and try to get the required percentages down. Also, they believed that battery-technology breakthroughs were possible, in which case they would be able to produce electric vehicles profitably initially in the ZEV program. As one interviewee explained: "As part of the compromises made on how the emission standards were put together—the sales-weighted averaging, the lead time, the biennial reviews, all of those things that were included in the regulation—GM's opposition was reduced." While General Motors tolerated the Mandate at the beginning, the company was not happy with

it. Their expectation was to capture about 0.5% of the market with the Impact (later renamed the EV-1) if the program was successful, in a scenario without the Mandate. But now ARB was requiring from them to produce it at a 2%-level, which was more than the market share of its best-selling comparable car in California at the time—the Camaro. General Motors also felt that the Mandate was pushing the other major car companies to compete with them for what already was a very small market niche. (Interviewee from the auto industry.)

Roger Smith's words about the Impact on Earth Day 1990 were not necessarily endorsed by many within General Motors. Some knew that they could be used by regulators against the company. But the publicity of the Impact was part of a larger corporate strategy. As one interviewee described, "This was back in the time when General Motors was trying to reinvent itself, and we wanted to show technology leadership. Building the Impact was a demonstration of technology leadership." The company was trying to "reinvent itself" by changing its image and rethinking the way engineering was done. Through this program, the company hoped to and did learn a lot about project management, creative thinking, integration of other divisions like Hughes, etc. Such learning was much of the idea behind their new electric-vehicle program. At the same time, a few people in the company, supporters of the Impact program, reportedly welcomed the Mandate. They may have seen CARB requirements as a means to justify the program regardless of how strong a business case they could make for it. (Interviewee from the auto industry.)

The internal reaction to the ZEV mandate in the other car companies, particularly Ford and Chrysler, differed from that of GM. Given the general context, defined by generalized environmental concerns and General Motors announcing that the production of electric vehicles was possible, they felt that presenting a strong opposition to the Mandate was not a good strategy. Even though they were convinced that General Motors was overselling the Impact, they realized that ARB staff had taken it very seriously and that it had been the main reason why the Mandate was included in the language of the LEV program. (Interviewee from the auto industry.)

In the view of these companies, the Mandate had a lot of political appeal in the sense that it proposed zero-emissions and zero-emission for the life of the vehicle. CARB had a lot of political cover from the General Motors' press machine, which was talking about producing 40,000 electric vehicles. This gave CARB a lot of confidence that the Mandate set feasible targets and that it was politically defensible. To one interviewee from industry, the Mandate was "kind of a regulator's dream. It got a ton of attention. It fired a lot of people [from government and the press] up." The Impact indeed caught the attention of major newspapers (Collantes, 2005.) The same interviewee's opinion, "you can come up with something very effective [in terms of reducing emissions of criteria pollutants], and nobody will pay any attention if it doesn't photograph well or it doesn't sound real sexy when you describe it."

While it is common knowledge that the car companies did not welcome the Mandate, it is worthwhile to present in detail the reasons that they had to take this position, as described by my interviewees from industry.

a- CARB had traditionally taken a technology-forcing approach, proposing a strong standard-setting regulation, to then work collaboratively with the auto companies to learn about the evolution of technology and modify the regulation accordingly, if necessary. The Mandate was perceived as a unilateral decision that moved away from the spirit of collaboration.

b- While industry was used to facing technology-forcing regulations, the ZEV mandate was perceived, in the words of one interviewee, as "a little bit more extreme," because this time CARB was "mandating a new technology, and volume, and a schedule. You couldn't mandate all three—that's for sure."

c- The question of the commercial viability of electric vehicles was not seriously addressed by ARB when it put together the ZEV mandate. Questions like how much would the vehicles cost, how many people would be willing to pay that cost, who would accept the performance limitations imposed by the battery technology, and others, were not comprehensively studied. As one interviewee from industry put it, the mandate was "trying to push a product down the customers' throat." Another interviewee said "They (CARB) were mandating the way the customers would have to behave."

d- The Mandate was not cohesive part of a regulation with clear policy goals. Essentially, the car companies did not believe that requiring ZEVs was necessary to attain the desired air quality. As a consequence, the Mandate was not cost-effective. It made the car companies spend substantial resources (reportedly several billions of dollars) that could have been spent more effectively on more realistic cleaner technologies.

e- CARB didn't look at the big picture. It concentrated on tailpipe emissions, but didn't do a lifecycle analysis to rigorously consider power-plant emissions, electricity transmission economics, battery disposal environmental impacts, etc.

8.2 CARB's defense of the Mandate

While interviewees from industry described California's air-quality regulatory processes preceding LEV I as collaborative, interviewees from CARB viewed them somewhat differently. To regulators, the auto companies had always displayed a propensity to oppose new emission standards on the argument that they were too challenging technologically or too costly. CARB believed, however, that industry needed to be challenged. Interviewees often referred to instances during the two decades preceding LEV I when car companies managed to meet emission standards claimed by industry to be unfeasible. ARB had then learned to distrust the car companies in terms of what they could deliver technologically. At the same time, during early discussions on the LEV program, there was skepticism, both in industry as well as within ARB, regarding the technical feasibility of the ULEV standard. This shared skepticism infused in regulators the belief that moving beyond the conventional gasoline vehicle. These factors, along with the promise showed by General Motors' Impact, significantly softened in ARB's ears any voice of opposition to the Mandate.

The Mandate enjoyed support across the board in ARB. Some in the staff were lukewarm about it, but nobody opposed it. Dr. Andrew Wortman—the Board member with industry background—was opposed to the idea though. During the 1990 public hearing, Wortman, who had a background on battery research, showed great skepticism about the progress in

battery technology and the suitability of batteries as vehicle power sources. "When was the last time you lifted a battery?" he asked one pro-electric vehicles witness, trying to caution about the impacts that the weight of standard batteries could have on vehicle performance. But Wortman was the only ARB voice against the Mandate—he put forth a motion to eliminate it, but no Board member seconded it.

The policy argument that ARB used to publicly defend the need for zero-emission vehicles was centered on projections available to the agency, indicating that significant growths were expected for population, vehicle ownership, and per-capita vehicle miles driven in the state, and particularly in the South Coast. ARB argued that, given this perspective and if the state was going to comply with air-quality standards, a part of the vehicle fleet would have to be zero-emission.

Once the need for zero-emission vehicles was defended, the question remained of why to set a sales requirement on ZEVs separate from the requirement on the fleet average standard. Ms. Liwen Kao, ARB staff person, presented the agency's argument during her presentation at the 1990 hearing: "ZEVs are different from other types of vehicles because they have the lowest emissions at certification time and in-use. Emissions increase with age for combustion engine vehicles, but ZEVs, by definition, maintain zero exhaust and evaporative emissions throughout their entire lifetimes. Wide scale penetration of ZEVs could ultimately be needed to achieve and maintain healthful air quality in non-attainment areas of the state. The 1989 air quality management plan of the South Coast Air Quality Management District calls for complete penetration of extremely low-emitting vehicles in order to meet ambient ozone standards. Without a mandate, it is

uncertain whether manufacturers would be willing to commit the resources needed to accelerate the commercialization of ZEVs."

Key to neutralizing a challenge on legal grounds was to demonstrate that the Mandate was not technology-specific. Addressing this issue, Kao recognized that in 1990 only BEVs were expected to meet ZEV requirements, but emphasized that fuel-cell vehicles and solar-powered vehicles were expected to "become available in the more distant future." ARB cleverly exploited a statutory loophole arguing that electrochemical batteries were not the only possible technology capable of powering zero-emission vehicles. To defend the technological feasibility of the ZEV elements in the regulation—another statutory requirement—ARB made reference to General Motors's statements about Impact. In Kao's words: "commercially viable electric vehicles with good performance, like that demonstrated by General Motors's prototype, the Impact, should be available by the 1998 year. General Motors has announced its intention to proceed as rapidly as possible with developing an electric vehicle for commercial production."

As described in Section 7, CARB did not address rigorously the cost effectiveness of the ZEV elements of the regulation—at least not publicly. ARB presented techno-economic data on the costs of producing and operating electric vehicles relative to those of a conventional gasoline vehicle. ARB focused instead on defending the cost effectiveness of the entire LEV program. ARB's Final Statement of Reasons stated that "The Board has further determined that no alternative considered by the agency would be more effective in carrying out the purpose for which the regulatory action was proposed or

would be as effective and less burdensome to affected private persons than the action taken by the Board (p. 3.)"

One important difference between a regulatory Board and a government department is that the Board's decisionmaking takes place in public. Therefore, there is much less opportunity to hide political influences in the decisions. The ARB has strict rules about the public process, and if the Board is approached, say by a lobbyist, this contact has to be disclosed. This characteristic of the process deters stakeholders (including politicians) from trying to put pressure on the Board on ways that go against the public opinion. There may be instances however, when the process is not abided by and behind-the-scene political interest affects the course of a regulation. According to one interviewee from ARB, one such instance took place at the implementation of the LEV regulation. Right before the 1990 hearing, ARB's Executive Officer, called the senior staff and told them that the Governor's office had decided that it did not want the Board to adopt the fuels mandate in the LEV program. It was clear to the staff that the Board was going to decide not to include the fuel availability requirement—and that is how it eventually played out. To ARB staff, Governor Deukmejian had always taken a more hands-off approach to ARB than other Administrations, and gave the agency the greatest latitude to work. This was the one instance when his office directly attempted to affect a Board's decision. Deukmejian, however, never expressed to the Board any discomfort with the ZEV mandate.

8.3 The role of the oil industry

A number of authors have portrayed the oil industry as a fierce opponent of the ZEV mandate. The oil companies were linked to the creation of tactical pseudo-grassroots groups to hinder the progress of electric vehicles, to intense political lobbying against the ZEV mandate, and to running expensive campaigns to turn the public opinion against electric vehicles. For example, Doyle (2000) and Mattei (2005) argued that the Western States Petroleum Association (WSPA) supported a group named Californians Against Utility Company Abuse, apparently run by Woodward and McDowell, a public relations firm. According to Mattei (2005), this group "was set up by oil companies in order to promote senate bill SB 1819 and assembly bill AB 3239 which would have prevented the legislature from using utility revenues to develop an infrastructure for natural gas and electric vehicles" (p. 11.) WSPA was also involved in the creation and support of the group Californians Against Hidden Taxes, that openly opposed the Mandate.

To support the argument that oil interests were actively trying to debunk the ZEV mandate, Mattei (2005) also refers to the monetary contributions of oil companies to legislative candidates and Governor Pete Wilson. The same source submits that the Mobil Oil Corporation intended to discredit electric vehicles through ad campaigns, particularly one ad titled "Who pays for plugging in?" To describe that ad, Mattei (2005) quotes the following excerpt: "We have no problem with electric cars competing in the marketplace. We do have a problem, though, with mandates, particularly mandates at this time that would lock in our current electric technology. That technology simply is not good enough" (pp. 10-11.)

I subscribe to the view that the oil industry opposed the ZEV mandate—a position as unsurprising as the electric utilities' support of it—but I purport to analyze this activity objectively, getting rid of implicit subjective allegations and looking at the actual evidence.

The late 1980's witnessed the rise of alternative fuels, particularly methanol, as serious potential challengers to gasoline in the market of personal transportation fuels. An increasing public awareness of environmental problems motivated key lawmakers and regulatory bodies at the federal and state levels to pursue, among other actions, the promotion of methanol-fueled vehicles. Improvements in automobile emissions have been slow and policymakers had little or no indication that regulating fuels could help significantly in this respect (Collantes, 2005). This move faced relatively low resistance from the automobile companies because manufacturing flex-fuel vehicles did not pose significant risks or costs to them (Sperling, 1995.) The stakes of the oil industry however, were much higher: essentially, any significant encroaching of alternative fuels in the market would take place at the expense of an accordingly significant market loss for gasoline.

The reaction of the oil industry was expeditious and timely. In August, 1989, Atlantic Richfield Corporation (ARCO), a medium-sized oil company with a strong presence in Southern California announced that it had developed EC-1, a new gasoline—also known as reformulated gasoline—that contained less butane, making it less prone to evaporation, less olefins and aromatics to reduce ozone formation, and included an additive to enhance the oxygen content and thus promote cleaner burning: methyl tertiary butyl ether

(MTBE). This announcement came in the midst of the debates over two cornerstone air-quality regulations that were gearing toward the promotion of methanol: the Amendments to the Federal Clean Air Act and the California Low-Emission Vehicle program. For a more detailed description of this episode, see Collantes (2005).

Thus, the oil industry responded with innovation to a competitive threat. Probably, the political landscape at the time helped prodding this type of response: the environment ranked high in the agenda of the majority of policymakers both in Washington, D.C. and California (as well as other states, like Massachusetts). President George Herbert Walker Bush put environmental protection at the center of his campaign. His first State of the Union address, in February 9, 1989, he went on the record about his commitment to environmental regulation, promising "a new, more effective Clean Air Act. It will include a plan to reduce, by date certain, the emissions which cause acid rain, because the time for study alone has passed and the time for action is now" (Bureau of National Affairs, 1991). In California, the passage of the California Clean Air Act of 1988, signed into law by Governor George Deukmejian, set the stage for stringent air-quality regulatory action.

Public documents show, and interviewees from ARB, SCAQMD, and environmental groups confirm that, at the initial stages of the LEV I program, the oil industry focused its efforts on opposing the Clean Fuels elements of the program, and paid no attention to the ZEV mandate. The oil industry did not believe perceive the Mandate as a serious threat to their interests. In fact, their major concern and main target of their opposition was the language that mandated oil companies to sell—as opposed to make available—certain amounts of clean fuels (electricity was not included in the definition of clean fuel, and

there was no requirement on electricity availability in the regulation.) In this effort, the industry lobbied a number of members of the State Assembly and Senate to pressure the Air Resources Board. The Speaker of the Assembly, Willie Lewis Brown, Jr., the Assembly Republican Leader, Ross Johnson, the Republican Floor Leader of the Senate, Kenneth L. Maddy, and Senator David Roberti sent letters to Chairwoman Sharpless, using language that closely resembled that of a letter sent to the Chairwoman by ARCO Products Company on September 14, 1990. One of the points that these letters addressed was the question of whether fuel sales mandates were within ARB's statutory authority, suggesting that such mandates should be deferred to the Legislature. At the same time, Chevron U.S.A. Inc. sent a letter to Governor Deukmejian expressing similar concerns: "We strongly object to this sales mandate because it is impractical, of questionable legality and could be counterproductive in achieving our state's air quality goals. We believe the alternative offered by WSPA described in the attached letter is a workable way to introduce alternative fuels." Interestingly, in the East-Coast front, the oil companies supported the efforts of the Massachusetts Attorney General's Office to adopt LEV I, because both Massachusetts and New York were trying to implement the low-emission vehicle part of the program, without the clean-fuel provisions.

At the same time, environmental lawmakers lent their support to the course of action defined by ARB. Bill Leonard, then chairman of the Senate Republican Caucus, in a letter to Chairwoman Sharpless, said:"The second issue regards whether the ARB possesses the authority to require a fuel sales mandate. Those who would argue that the ARB is not bound by a stature, which authorizes actions such as those proposed, must review the description of the Board's authority contained in the staff proposal. (…) It is

very obvious the ARB not only has the authority, but the responsibility, to adopt the regulations before it." (Leonard, 1990.) Congressman Waxman, a champion of tightening mobile emission standards during the debate over the 1990 Clean Air Act Amendments, wrote to the Chairwoman: "In our effort to amend the Clean Air Act to establish a sound national clean fuels policy, it has constantly been necessary to resist pressures from oil companies that oppose any movement away from today's gasoline toward loer polluting fuels. I urge you to continue to resist such self serving lobbying efforts and to move rapidly forward with the aggressive program you have proposed in California to protect the public health." (Waxman, 1990.)

The Western States Petroleum Association (WSPA) presented four witnesses at the September 1990 hearing in El Monte, while one witness—George Babikian—represented ARCO. None of these five testimonies directly addressed the ZEV mandate. The only document submitted by the oil industry that relates in some way to the ZEV mandate is paper submitted by ARCO arguing "that the fuel/vehicle system life cycle costs, at the SAME AIR QUALITY EFFECT, are lower for reformulated gasoline than for any of the other commonly discussed clean fuels: CNG, Methanol (as M85), or electricity." (ARCO, 1990, p. 1.) The same document acknowledged that "[T]he potential air quality benefits for electric vehicles are substantial." Making reference to a study, it added: "using stringently controlled, natural gas fired power plants in the LA Basin to supply the vehicular electricity results in the following reductions in emissions per mile: 99% less NMOG and CO than conventional gasoline; and 89-93% less NO_x." (ARCO, 1990, p. 16.)

The documentary evidence shows that the oil industry's investment in the policy process ramped up toward the 1996 biennial review. WSPA presented a common front with the American Petroleum Institute (API) opposing the Mandate. Both groups supported ARB's proposal to eliminate the requirements on ZEVs through 2003, and urged ARB to repeal the Mandate altogether. API and WSPA opposed not only the Mandate, but also any initiative to seek state economic incentives for the development of markets for zero-emission vehicles: "Both mandates and incentives are economically inefficient. When electric vehicle technologies are adequately developed, they will be competitive in the market without such mandates and incentives" (API, 1996); "We strongly oppose, however, the terms of the proposed Master Memorandum of Agreement which would obligate ARB to promote and seek subsidies for one product or industry (electric vehicles) to the exclusion of others. This is inappropriate interference in the marketplace." (WSPA, 1996, p. i.)

WSPA argued against the ZEV mandate from about every possible angle. It questioned ARB's statutory authority, it objected to the use of sales mandates instead of setting emission standards, it argued that the Mandate was not technologically feasible, it pointed out that the Mandate was extremely cost-inefficient, it objected the state's subsidization of cleaner technologies like battery electric vehicles, it warned about negative effects on the state's economy, it questioned the need of mandating ZEVs for ARB to meet its goals, and it directed attention to the emissions reductions that had been achieved through the introduction of cleaner-burning gasoline since 1990. (WSPA, 1996.) Much of WSPA's position was summarized in a nutshell in the following paragraph: "WSPA does not oppose the manufacture and sale of electric cars which are developed in a free

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market, are demonstrated to be technologically feasible, and can be marketed to the motoring public without the necessity of regulatory mandates and subsidies. There is no justification for ARB to mandate technologically unproven EVs which are neither competitive nor cost-effective, and which rely on subsidies to be marketable. There are far more cost-effective alternatives available which will achieve the emission reductions attributed to the ZEV mandate without requiring California citizens to bear the burden of costly subsidies and government disruption of the free market." (WSPA, 1996, p.3.) To support its position, WSPA submitted detailed technical analyses, including 75 documents, reports, and papers from diverse sources.

The documentary evidence therefore shows clearly that the oil industry presented a unified, strong, and vocal opposition to the ZEV mandate in 1996. This, in and of itself, does not elicit a judgment, negative or positive, of the oil industry activity in the policy process. It was a secret to no one that the oil industry had a vested interest in the debate, as a success of electric vehicles would have a potentially major negative impact on them. From this standpoint, their opposition to the Mandate was a natural response given the way the policymaking system works in the United States. Every economic interest seeks to some extent to benefit from these X-inefficiencies. Arguably, what differentiates the oil interest group the most from almost all the other players is the amount of resources they can direct to influencing the policy process.

8.4 The environmental community

Environmental non-profit organizations supported the requirement on zero-emission vehicles in the initial stages, and have maintained such position throughout the process.

The actual involvement of these groups was not significant at the beginning, neither was their influence in the implementation of the Mandate.

The only environmental NGOs giving testimony at the Board meeting of September, 1990, were Sierra Club and the Coalition for Clean Air (CCA), although only the latter addressed directly the ZEV mandate. The Environmental Defense Fund (EDF) and the Natural Resources Council (NRDC) submitted written comments. EDF and CCA, while supporting the ZEV requirements, argued that the classification of vehicles as zero-emission was fictitious because the emissions involved in the generation of the electricity that fueled battery electric vehicles were not accounted for.

During the early stages of the ZEV debate, the environmental community did not present a coordinated front on the issue. The level of coordination had increased significantly toward the mid 1990's, and it became more formal in 1998 with the creation of the ZEV Alliance. This coalition was unified by the common goal of bringing zero-emission vehicles to the market, and it is composed of the American Lung Association, the California League of Conservation Voters, the California Public Interest Research Group, the Coalition for Clean Air, the Natural Resources Defense Council, the Union of Concerned Scientists, the Planning and Conservation League, the Kirsch Foundation, and the California Electric Transportation Coalition (a business group.)

9. Discussion

I have presented an analysis of the process that resulted in the implementation of the California Zero-Emission Vehicle mandate. My analysis looked at the

statutory/regulatory environment and public opinion at the time, the exogenous factors and events related to the process, the origins of the policy idea itself, and the implementation process. Theoretically, I used Multiple Streams as a theoretical lens to study the birth of the ZEV mandate. I found that MS succeeds in describing some of the aspects of the policy process, while it failed to describe others.

Summarizing what was exposed in this study in terms of MS, in 1990, the three "steams" could have been defined as follows:

The problem stream: California, and particularly the South Coast basin, had severe air-quality problems. The Environmental Protection Agency was exerting strong pressure for the state to demonstrate reasonable progress toward attainment of air-quality standards. Simultaneously, there was a generalized perception that a solution to the problem would take a long time and extreme measures. It was widely believed, within government as well as within industry, that the gasoline-burning internal combustion engine could not be made much cleaner, and that alternative fuels and/or new drivetrain technologies would be needed to achieve California's air-quality goals. It was expected that vehicles meeting ULEV emission standards would use fuels like methanol or natural gas. While methanol had widespread support in governmental spheres both in California and in Washington, DC, there were also many who were skeptical about this fuel as a long-term solution. The automakers were not sure about the market acceptability of alternative-fuel vehicles, and ensuring that these fuels would be available to the public was posing serious statutory problems to ARB.

The policy stream: The policy debate over air quality in California began to take note of electric vehicles in the late 1980s. The City of Los Angeles issued a request for proposals in 1988 for 10,000 electric vehicles. The regional air quality agency for Los Angeles issued a plan in 1987 that identified EVs as a possible solution to the region's air quality problems. But EVs were peripheral to the thinking and policy initiatives of virtually all leaders through 1989. This perception was transformed when the largest car company in the world, General Motors, introduced a state-of-the-art prototype sport electric vehicle in January 1990, and announced that it intended to commercialize it within a few years. I found no evidence that General Motors advocated for policies to promote this commercialization, so the company cannot be thought of as an advocate of EVs in a policy sense—this role was played by the regulatory agency instead. The electric vehicle was first perceived by a very small group people within ARB as a possible solution (or policy) to the problem of air quality.

The politics stream: At the time, the public opinion in California was very concerned with the environment in general and with air quality in particular. Several districts in the State were being sued to comply with federal standards, and failure to do so could result in EPA blocking federal funds for transportation infrastructure projects in the state. These factors put pressure on the Governor and State Legislature to support—or at least not to strongly oppose—regulatory activity on air quality. Travel demand management attempts (e.g. Regulation XV) had yielded very limited results, and policymakers were traditionally averse to policies to internalize the externalities of personal travel (e.g. increases in fuel taxes, congestion pricing, deterrence of dispersed land-use patterns, etc). The political clout of the car companies in the State was low relative to that of other

stakeholders because of several reasons, including the perception that regulation of vehicle emissions would have a low impact on the State's economy, the perception that road vehicles were the main single source category of criteria pollutants, and the perception that the car companies had consistently "dragged their feet" on trying to improve emission-control systems.

Contrary to one of the fundamental tenets of MS, my analysis shows that these streams were relatively interdependent. The politics stream just described was shaped to a large degree by the problem stream, namely the severe air-quality problems and the threat on the federal transportation funds contingent on showing reasonable progress. General Motors's electric vehicle program was part of an effort to change the company's image, which affected the politics stream. Finally, the magnitude of the challenge facing CARB in 1990 probably prodded them to turn to extremely innovative technologies. It is hard to imagine a requirement on electric vehicles had the State's air-quality situation been less pressing.

On the other hand, later stages of the ZEV policy debate witnessed a growth in the independence of the stream of policy from the other streams. It is important to notice that Drachand did not advocate for electric vehicles for other reason than he saw in them a means to solve a policy problem (deteriorated air quality.) With the Mandate, ZEVs became the "policy" supported by interest groups related to the electric vehicle (electric utilities, battery developers, and electric-drive components industry). To this constituency, air quality was not the main motivation to push for electric vehicles—their advocacy for electric vehicles was largely independent of the policy problem, and

arguments based on air quality, energy independence, or climate change would be equally viable to them. This is probably a closer manifestation of the notion of stream independence that Kingdon had in mind. Based on my analysis, however, I believe it is erroneous to generalize stream independence as a fundamental guiding principle of a policy process.

Thus, in early 1990 a window of opportunity, as defined by MS, opened for supporters of electric vehicles to push for their agenda: the three "streams" were aligned and no significant constraints were present. According to the Multiple Streams' lens, the conditions were given for a policy entrepreneur to push for electric vehicles as a policy solution. Indeed it was the initiative of one person—Don Drachand—that brought electric vehicles to the agenda at this critical point in time. Drachand was a credible, senior CARB staff person, who strongly believed in the potential of electric vehicles to be an important part of California's long-term air-quality strategy. MS does not elaborate on the necessary conditions for a policy entrepreneur to be successful in her/his quest to raise an item to the agenda. In my case study, it certainly helped that the policy idea originated within the regulatory agency. Credibility was not an issue, and the idea had to survive only a few formal check points on its way to the regulatory language (senior management and the Board's chair person.)

Multiple Streams is concerned with the factors that help an issue rise to the policy agenda. The framework is, however, silent on the policy process beyond that point. Therefore, MS says nothing about the format in which an issue enters regulatory language (e.g. policy mechanisms, related timelines, etc.) or whether a given regulatory

proposal is likely to survive the implementation process. The study of the origins of the ZEV mandate (and comparable policies) demands moving beyond frameworks restricted to the process of agenda setting, because such focus inhibits the study of the following two central questions:

a- Why did the regulatory agency choose a mandate as a policy instrument?

b- How did such a radically innovative policy idea survive the implementation debate?

Regarding the first of these questions, my analysis shows that the central factor that determined the choice of a mandate—as opposed to an incentive-based instrument—was distrust. ARB felt that no other policy mechanism could extract the best effort out of the car companies to develop and commercialize electric vehicles. Other factors were also central. As one interviewee described, mandates were a more common part of the policy/political language before Newton Gingrich and the Republican Revolution. Under current circumstances, a policy like the ZEV mandate would have little chance to enter the language of any regulatory proposal, let alone survive the implementation process. To understand the Mandate, it is thus important to first understand the policy attitudes at that time. Another important factor was ARB's improper generalization of previous regulatory experiences. Technology-forcing, command-and-control regulations had been effective in bringing to the market innovations like catalytic converters. The same regulatory philosophy was adopted with the ZEV mandate, without fully comprehending the magnitude and implications of the requirements. ARB also failed to anticipate the fact that the Mandate would be infused a political life of its own. This facet can only be

appreciated with a study of the evolution of the Mandate's policy process over time, which is beyond the scope of in this paper.

The answer to the second question resides in the complex convergence of a set of factors and events at the "right" time. My analysis shows that the structure of the regulatory piece was essential for the Mandate to survive the implementation debate. The requirements on zero-emission vehicles constituted a very small fragment of a much larger and complex regulatory piece like the Low Emission Vehicles and Clean Fuels program. The LEV program included challenging emission requirements with earlier compliance deadlines. The program also allowed for biennial reviews. This regulatory structure directed the efforts of the regulated industry to more immediate elements like the ULEV emission standards. Industry felt that the requirements on ZEVs were not as serious as the ones on internal combustion vehicles, and that they could safely present a tougher opposition at a later point in time.

Another very important factor that buttressed the ZEV mandate through the implementation process was the overall posture adopted by General Motors. The company's alleged intention to produce a zero-emission vehicle was publicly announced by its CEO at a critical moment, when the LEV regulation was still being drafted. The company was spending significant resources in developing the Impact, had high expectations on the possibilities of this model, and though the ZEV requirements were perceived as overly excessive, they didn't have the urge to present a strong opposition to it. As one interviewee from ARB explained, to successfully defend a regulatory idea, it is usually necessary for at least one stakeholder from the regulated industry to show some

kind of support. GM's overt positive attitude toward electric vehicles precluded the rest of the OEMs from presenting as strong an opposition to the ZEV requirements as they would have liked.

To correctly analyze the ZEV mandate and extract the right policy lessons, the entire lifespan of the program should be looked at. The extraordinarily dynamic evolution of the program over time provides clear evidence in this respect. The study of the program's initiation presented in this chapter yields however a number of highlights worth taking into account in policy practice. In the first place, this chapter presents the first rigorous account of how an emblematic policy piece like the ZEV mandate was born. Further, I present a detailed discussion of the factors that helped it survive the implementation debate.

Appendix 1A: Interview Schedule

1. Personal background

a- Could you please describe your involvement in the policy process related to the Zero-Emission Vehicle program?

2. Institutional structure and behavior

a- How would you characterize the goals of the organizations you were a member of during the ZEV policy process?

b- How has your organization arrived at decisions related to the ZEV program? Have there been internal disagreements? If so, how has your organization resolved them?

   i. *Follow-up question:* What has been the interplay between the lobbying/political group of your organization and the people with direct expertise in this area and the management of the organization?

   ii. *Follow-up question:* In your organization, whose opinions (related to the ZEV mandate) have had the most weight?

c- Who in your organization have had the most expertise and knowledge (political, economic/financial, or technical) and what role have those persons had?

d- In your opinion, how have the California Air Resources Board (CARB) Chair and Board arrived at decisions related to the ZEV mandate over time?

   i. *Follow-up question:* Have individual members of CARB's Board represented a particular interest or political entity? If so, how sensitive have they been to their "constituency"?

   ii. *Follow-up question:* Have there been political pressures at the federal and state level influencing CARB's Board and Chair? How sensitive have CARB's Board and Chair been to them? Please elaborate.

3. Policy dynamics and strategy

a- Why did the ZEV regulation happen, and why did it happen in California? Please consider discussing the importance of the following factors:

    i.   Low industry initial opposition

        1)   Industry thought it would be just an experiment;

        2)   Industry more concerned with main sections of LEV I;

        3)   Industry distracted with the Clean Air Act Amendments;

        4)   Biennial reviews allowed industry to postpone opposition.

    ii.   Adopted ideas from other pieces of regulation (e.g. the South Coast Air Quality Management Plan);

    iii. External factors (Gulf War, Roger Smith's declarations about the Impact, etc);

    iv. Statutory requirement;

    v.   State Agency really believed it was essential to meet air-quality goals

b- What have your/your organization position, goals and general strategy been in the initial (1990) ZEV policy debate? How have your/your organization position, goals and strategy shifted over time?

    i.   *Follow-up question:* Under what circumstances have your organization considered/pursued litigation?

c- Have you and your organization coordinated activities with other organizations or individuals to pursue your goals during the ZEV policy process?

d- Have this coordination been stable over long periods of time or was it rather a short-term tactical coordination? What motivated and sustained this coordination?

e- How have you and your allies decided on the policy strategy to pursue? How has this strategy changed over time?

f- How successful have you/your organization been in achieving your policy goals? Why?

g- How have strategies related to the ZEV mandate differed across automakers?

h- Have the existence of biennial reviews influenced your overall strategy?

i- In your opinion, what have been the reasons for the revisions to the program? (e.g. inclusion of hybrid electric vehicles, neighborhood electric vehicles, fuel-cell vehicles, transportation systems.)

    i. *Follow-up question:* Why did CARB turn to fuel-cell vehicles and away from battery electric vehicles (BEVs) as a focus of the program?

j- Who have you perceived as the most influential players in the policy debate? Why were they so influential?

k- How did the program diffuse to other states? How did this diffusion affect the dynamics of the policy process?

5. Science and technology

a- What role have your organization and CARB's Board assigned to scientific information in taking positions regarding the ZEV mandate?

b- What have been the main sources of the information you and your organization used during the policy debate?

    i. *Follow-up question:* How knowledgeable were your organization and CARB's staff and Board about ZEVs?

c- In your opinion, has scientific information been misused during the policy debate? If so, how, and by whom?

d- How would you characterize the effects of the ZEV program on technology development and innovation?

e- How would you characterize your organization's efforts to promote the development of technologies related to zero-emission vehicles?

6. Economic factors

a- What has your position regarding the costs and benefits of the program been over time?

b- What have been and will be the economic impacts of the ZEV mandate on your organization?

c- What do you think was, is, and will be the demand for BEVs and FCVs?

      i. *Follow-up question:* On what do you base your opinion?

7. Information flows and perceptions

a- How would you characterize the role of the media during the policy process? Was the media manipulated?

b- Are there any documents relevant to the ZEV policy process that you could share with us, or that you think we should search for?

8. Wrap-up questions

a- What important policy lessons have the ZEV debate taught us?

b- Have we missed anything important about the history of the ZEV program? What do you think are the major lessons from the experience so far? Where do you think the ZEV program is going in the future?

CHAPTER 2: A STUDY OF POLICY CHANGE OVER TIME

1. Introduction

It is widely recognized that California has traditionally been the leading state in the Union when it comes to air-quality regulatory action, particularly that pertaining mobile sources. This panorama is likely to persist over the years. Thus, California has been, is, and will most probably be a vibrant policy stage in the area of air quality. What happens in California in terms of air-quality policy, and in most other policy areas for that matter, does not only affect the state itself, but it often impacts on other states (Walker, 1969.)

There is a substantial body of literature on the policy process/politics of transportation-related air pollution in the United States. Much of it, however, can be characterized as either anecdotal (Shnayerson, 1996; Doyle, 2000), mostly descriptive-interpretive (Grant, 1995; Kemp, 2002), centered on the federal level (Ringquist, 1993; Bryner, 1995; Cook, 1988), focused on earlier periods (Krier and Ursin, 1977; Zafonte and Sabatier, 2003), and combinations thereof.

This paper concerns itself with the dynamics of policy change as they relate to a state-level air-quality regulatory program: the California Zero-Emission Vehicle (ZEV) mandate (the Mandate). This program, implemented in 1990, requiring from major auto companies the manufacturing and commercialization of vehicles with no criteria-pollutant tailpipe emissions, is probably the most daring air-quality policy initiative directed to the transportation sector in the United States. Some of the elements and

factors that made the program so unique also made it very controversial, with sectors of the air-quality policy arena vehemently supporting it and others strongly opposing it. The technology-forcing nature of the program, designed to accelerate the rate of technological innovation on clean-vehicle technologies, was particularly divisive. While the program spurred developments in zero-emission technologies and promoted related economic activity (e.g. Burke *et al*., 2000; Shnayerson, 1996)—a result consistent with the predictions of economic theory on regulation and innovation (e.g. Parry *et al.*, 2003)— questions have been raised regarding the efficiency of the Mandate as a means to achieve these goals (e.g. Dixon *et al.*, 2002.)

The debate over the ZEV mandate constitutes a good case study on the dynamics of policy change. Most previous studies on the subject used data on events (e.g. Congressional hearings) at different points in time related to a broad policy arena, like air pollution (Zafonte and Sabatier, 2004) and nuclear policy (Nohrstedt, forthcoming). The ZEV mandate is a regulatory program with a narrower focus that has been active for 15 years, and that has undergone several revisions. Having been continuously run by the same regulatory agency, and having involved consistently major stakeholders like the auto industry, energy companies, and environmental groups, the program offers a particularly-suitable opportunity to study issues like coalition stability over time and policy-oriented learning.

The specific research objectives of this paper are to investigate the issues that characterized the policy debate over the ZEV program over time, to identify the policy beliefs and preferences of the different stakeholders over time, to investigate the patterns

of agreement and disagreement across stakeholders, and to study the stability of stakeholders' policy beliefs and preferences over time. Answers to these questions are expected to improve our understanding of the dynamics of air-quality policy in California and to shed light on the role and causes of policy learning in regulatory processes that involve technological innovation.

As a theoretical lens to guide my study, I adopt the Advocacy Coalition Framework (ACF) (Sabatier, 1987, 1988; Sabatier and Jenkins-Smith, 1993.) This theoretical framework is the only one that meets the following criteria, which are desirable for the present study: 1) ACF has been used to test coalition stability in air-quality policy problems in the past (Zafonte and Sabatier, 2003); 2) air-quality policy researchers have identified the premises of ACF in air-quality policy processes they studied (e.g. Grant, 1995; Kemp, 2002); and 3) ACF explicitly accounts for empirically measured behavioral determinants of the individual actors[8], which I believe is a desirable feature where policy entrepreneurship may be a factor; 4) it is a falsifiable theory, which is a sine qua non condition for the advancement of science. Distinct principles of ACF are:

a- The adoption of the policy-subsystem as the most appropriate unit of analysis;

b- An inclusive conceptualization of the policy subsystems that includes industry, interest groups, journalists, researchers, policy analysts, and all the actors in every sector of government involved with policy formulation and implementation;

c- The premise that understanding the process of policy change is an undertaking that spans over 10 years or more;

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[8] To ACF, actors behave according to their sets of beliefs. Since these are measured directly, behavioral rules are obtained for each stakeholder. In contrast, other theories assume behavioral rules (usually utility maximization) and impute them onto the actors.

d- The premise that actors in the subsystem behave in accordance with their system of beliefs.

To ACF, stakeholders tend to cluster into coalitions in order to influence policy outputs. Coalitions are comprised of stakeholders who share a system of beliefs[9], and that engage in non-trivial levels of coordinated action. Central to ACF's perspective on policy change are the questions of stability of coalitions over time and of coalitions' policy-oriented learning—questions that I intend to investigate for the case of the ZEV program. A detailed discussion of the Advocacy Coalition Framework can be found in Sabatier and Jenkins-Smith (1999.)

I structure this paper in the following way. In Section 2, put this study of coalition stability in the ZEV program into context by presenting the empirical evidence on the coalition stability over time and discussing related issues. Section 3 is devoted to a discussion of the methodology, including data gathering. Sections 4 through 7 present my stakeholder analyses for the public meetings of 1990, 1996, 2001, and 2003, respectively. I dedicate Section 8 analyze the dynamics of policy change.

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[9] ACF sees beliefs systems as having a tripartite structure made of deep core beliefs (ontological and normative beliefs, that are extremely resistant to change, and extend beyond the limits of the subsystem in question), policy core beliefs (comprising policy-related values, commitments, causal perceptions, related to the subsystem in question, and constitute the "glue" that ties coalitions together), and secondary beliefs (including all other beliefs of scope narrower than the subsystem).

2. Coalition stability: Empirical evidence and discussion

The question of time stability of coalitions has been studied in numerous occasions, yielding somewhat contradictory results. Some studies found evidence of coalition stability over long periods of time in different policy arenas (Marmor, 1970; Jenkins-Smith and St. Clair, 1993; Jenkins-Smith, St. Clair, and Woods, 1991; Wildarvsky and Tenenbaum, 1981; Worsham, 1991; Hula, 1999; Sabatier and Brasher, 1993; and Zafonte and Sabatier, 2004.) Conversely, other studies report evidence of coalition fluidity (Browne, 1988; Heinz, Laumann, Nelson, and Salisbury, 1993; Ackerman and Hassler, 1981; and Ripley and Franklin, 1979.).

The issue of political coalitions was theorized upon by Riker (1962) in his classic book on the subject. The author submitted the notion of "minimum winning coalitions" as the driver behind coalition formation. Coalitions satisfying this principle have to be characterized by fluidity, as members would enter whenever they are needed by a coalition seeking to increase its political leverage, and exit whenever the coalition ceases to need them. Heclo (1979) introduced the concept of "issue networks" in his study of short-term fluid coalitions.

The Advocacy Coalition Framework (ACF) maintains that coalitions tend to be stable over long periods of time. Long-term coalitions can be expected on the grounds of at least two concepts: reciprocity and values (Zafonte and Sabatier, 2004). The importance of reciprocity is rooted in the understanding, on the part of coalition members, that the benefits of participating from a coalition may be, in certain policy processes, distributed on the longer term. Reciprocity refers to the phenomenon that resisting the temptation to

defect (when incentives to belong in the coalition are weaker) may result in other members reciprocating with similar behavior at a different point in time. This kind of long-term cooperative behavior would particularly pay off to all coalition members in policy tasks of longer time frames. Actors sharing certain basic values, on the other hand, are more likely to maintain longer-term coalitions (e.g. Merson, 1996; Franklin and Mackie, 1984.)

ACF's argument for long-term policy change and related coalitions' activity stems from the *enlightenment function* of policy-relevant research (Weiss, 1977.) According to this notion, policy research develops over time and has the primary goal of influencing policymakers' belief systems. Weiss (1979) explained that the enlightenment function of social research is just one of the *hypothesized* models to describe the role of information in decisionmaking. The authors of ACF, when arguing for policy-processes duration of a decade or more, considered also the evidence showing that such time scales are necessary to complete a cycle of policy formulation-implementation-reformulation (Sabatier and Jenkins-Smith, 1999.) Finally, the assumption of long-term coalitions is consistent, to a large degree, with ACF's adoption of prospect theory to model individual behavior. Because policy actors process information through preexistent beliefs or lenses, individuals in opposite coalitions can perceive the same piece of information in different ways. This would lead to coalition cohesion and thus stability over time (Sabatier and Jenkins-Smith, 1999.)

To Hula (1999), both long- and short-term coalitions may exist. He proposes that interest group leaders decide whether "to engage in political action independently, in unique

temporary coalitions, in recurring temporary coalitions, or under the umbrella of permanent, institutionalized interest group coalitions (Hula, 1999, p. 7.)

There are several possible explanations to this apparent inconsistency in the answers to the question of time stability:

a- Duality of types of coalitions: The simplest possible reason for the divergence in findings can be found in Hula's argument of the existence of both short- and long-term coalitions (Hula, 1999).

b- Policy arena effects: Zafonte and Sabatier (2004) (see also Hinckley, 1982, and Hula, 1999) suggest that factors like differences in the number of actors involved and in density of network ties across policy arenas may help explain the variation in findings. Whether the characteristics of these factors are inherent to the policy arena may remain to be determined. In other words, there is no evidence, to my knowledge, that the number of actors is necessarily different for any pair of policy arenas. Further, different studies have found conflicting evidence for the same policy arena. For example, Jenkins-Smith et al. (1993) supports the stability notion, while Heinz et al. (1993) supports the fluidity view, in the energy policy arena.

c- Methodological limitations: Zafonte and Sabatier (2004) also suggest that most of the work on this area has suffered from the limitations in methodological choices. Quantitative systematic work has been predominantly cross-sectional, while longitudinal studies have used mostly qualitative methods of analysis.

d- Incompatible definitions of the concept of coalition across studies: For example, Zafonte and Sabatier (2004) submit that studies have failed to distinguish between "fundamental beliefs/interests" and "more secondary and instrumental beliefs," as the bonding glue of coalitions. Zafonte and Sabatier inadvertently point to another unresolved question in the definition of the concept of coalition: whether beliefs or interests are what bring together actors in the same coalition. Sabatier and Jenkins-Smith (1999) have preferred to use the notion of beliefs over that of interests, because beliefs lend themselves better to empirical measurement. Zafonte and Sabatier (2004), referring to Hula (1999), define coalition as "a group of actors coordinating their behavior to some extent in order to achieve a common, or complementary, political objective" (p. 75.) This is probably a more general definition, since it focuses on actors acting as a group to pursue a common goal, without regards to whether this strategy requires certain commonalities in belief systems or interests.

e- Internal inconsistencies in the measurement of coalition drivers. The measurement strategy may fail to capture the hypothesized drivers of an actor to join a coalition. For example, if stakeholders are hypothesized to join forces based on shared belief systems, and the measurement scheme captures *revealed* belief systems, there might be a dissonance between the expected longevity of a coalition (based on actual beliefs) and the observed longevity of the coalition (based only to some extent on those beliefs.)

f- Incompatible operationalizations of the concept of coalition across studies.

The question of coalition stability in time is linked to the question of what makes policy actors decide to participate from coalitional behavior in the first place. In this specific aspect, ACF has offered little operational insight. The sharing of a set of beliefs may be a necessary condition, but it is not necessarily a *sufficient* condition for a given actor to join a coalition. Empirical studies have usually investigated the structure of coalitions given that the set of active actors decided to participate in the policy process—empirical measures of the strategic decision to participate have usually not been sought. There is a natural incentive to join a coalition because of the basic principle that group advocacy is more effective than individual advocacy. However, certain stakeholders may have an incentive to free ride on the advocacy efforts of others.

According to the free rider principle of collective action, outlined in Olson (1965), rational self-interested actors would not join a coalition unless doing so would offer them selective benefits as well. This principle rules out the possibility of actors unified solely under a common strategic policy goal. This is so because every actor would have an incentive to free ride, benefiting from others' expenditure of resources pushing for common policy goals. Thus, a necessary and sufficient condition for a policy actor to belong in a coalition, particularly in the mature stages of the policy process, would be that it advocates for a mixture of collective/group and private goods or benefits. An actor advocating only for private goods will not find allies to form a coalition, and pursuing only group/collective goods may provide an incentive to free ride. An actor sharing a set of policy goals with other stakeholders will be more likely to join a coalition if that provides her with an opportunity to push for her preferences and influence the coalition's

agenda. The balance between collective and individual goals is expected to be an important determinant of coalition stability or fluidity.

According to ACF, "the policy core attributes of a governmental action program are unlikely to be changed in the absence of significant perturbations external to the subsystem, i.e., changes in socio-economic conditions, public opinion, system-wide governing coalitions, or policy outputs from other subsystems." (Sabatier and Jenkins-Smith, 1999, p. 124.) Major policy changes may occur when stakeholders experience changes in their policy core beliefs. However, to ACF, such changes may take place only as a consequence of shocks generated outside the policy subsystem. Policy-oriented learning across coalitions cannot result in policy change because learning between coalitions may affect only stakeholders' secondary-aspect beliefs. New evidence, however, suggests that policy change can happen as a result of internally-generated policy learning. (Weible and Sabatier, 2005).

3. Methodology

In this section, I describe my data collection process, my coding scheme including belief measures, the methodology employed to analyze the data, and discuss related issues.

3.1 Database creation

When the ZEV mandate was adopted in 1990, it was agreed that the program would undergo biennial reviews, mainly to monitor the evolution of pertinent technologies. This requirement led to a series of public hearings that took place in 1993, 1996, 1998, 2001, and 2003 (being this the last at the time of writing this paper.) The database used for this

paper results from the content analysis of 175 testimonies given by organizations at four of these hearings. For my analysis I sampled the hearings of 1990 and 1996 as representative of the period when battery-electric vehicles were only zero-emission technology seriously considered, and the hearings of 2001 and 2001 as representative of the period when the main focus moves from battery-electric vehicles to fuel-cell vehicles.

Stakeholders and the public in general are allowed to present oral testimonies, written statements, and/or complementary documents at CARB public meetings. I concentrate in the policy positions of stakeholders who chose to present oral testimonies, taking this as a measure of stakeholder engagement. My stakeholder unit of analysis is the organization, and therefore I exclude from the analysis testimonies and documents submitted by individuals on their own behalf. The only exemptions to this rule are members of the scientific community and elected officials. Written documents submitted by organized stakeholders were used, whenever available, as supplemental sources. Appendix B shows a discrimination of the stakeholders presenting testimonies at each public hearing, according to the sectors they represented.

All the content analysis was done by the corresponding author, over a period of approximately two months. Three tests of intersubjective reliability were performed, the first at the beginning of the coding, the second about three weeks later, and the third toward the end of the coding. For each these tests, the author gave the text of one testimony to a person (the tester) and asked her/him to code the text using my coding scheme. The first tester was a person relatively knowledgeable of the ZEV mandate, while the other two were not. To evaluate the correlation of the tester's and author's

codings, I consider two criteria: a) how many times the two coders chose the same point in the coding scale, and b) how many times the two coders chose the same side of the coding scale (for example, codings of "Strongly agree" and "Agree" would be considered equivalent under this criterion.) The first tester agreed with the author 80% of the times under criterion a) and 97% of the times under criterion b). The second and third testers had similar levels of agreement with the coding of the author, with less agreement under criterion a).

3.2 The measurement of policy beliefs

To ACF, coalitions' belief systems have a three-level structure composed of deep core beliefs, policy core beliefs, and secondary aspects. ACF submits that policy core beliefs are "the fundamental glue of coalitions" (Sabatier and Jenkins-Smith, 1999, p. 122.) I am not studying the debate over a broad policy issue like air pollution—I am studying the debate over a particular long-standing dynamic policy program. I believe that making this distinction is important because each time stage of the program and the policy debate directly builds upon the previous one. This direct relationship leads to strong policy learning and adaptation. Issues that are at the center of the debate on earlier stages may not be discussed in later stages, and new issues enter the debate as it evolves over time. Factors that may determine such pattern include: a) The policy subsystem is comprised of a relatively small number of actors, many of who get to know each other well in terms of their policy preferences through private interaction; b) Policy actors learn quickly what strategies and messages serve best their policy goals; and c) New policy issues are brought about to the debate and others are discarded because of the dynamic (changing)

characteristics of the program and because of the changes experienced by the environment (social, political, and economic) over time.

My measurement of policy core beliefs comprises two broad dimensions: normative and empirical beliefs. I measure the following normative beliefs:

1) Preference for cost-effective policies;

2) Preference for standard-based emission regulations;

3) Preference for market-based policy approaches;

4) Support for command-and-control approaches to bring zero-emission technologies to the market;

5) Support for technology-forcing regulations;

6) Support for behavior –altering policies to address the air-pollution problem

7) Importance of leadership role played by California in air-quality regulation.

My measures of empirical beliefs include the following:

1) California needs zero-emission vehicles

2) The ZEV program is cost-effective

3) Perception of the seriousness of the air-quality problem in California

4) Automobiles are a major source of criteria pollutants in the state

5) Sales of new-technology vehicles will be dictated by market demand

6) There exists a causal relationship between air pollution and health effects

7) Regulation can accelerate technology innovation

8) Belief about the economic effect of the ZEV program on own organization

9) Belief about the air-quality benefits of the ZEV program

10) Belief about the effects of the ZEV mandate on environmental justice

11) The potential of fuel-cell and battery technologies to meet ZEV requirements

I present in Appendix 2A the complete list of items that were coded, together with the variables that were constructed from my coding.

While changes in policy-core beliefs, to ACF, are rare and happen only under rather exceptional conditions, changes in policy secondary aspects are relatively easier. Policy learning across coalitions and compromises usually takes place at this level, as policy secondary aspects are not as deeply held as policy-core beliefs. My measurement of policy secondary aspects includes primarily policy instruments and narrow (less then subsystem-wide) policy strategies. While the debate over policy-core beliefs tends to remain over time, the debate over secondary aspects shows more fluidity—new policy instruments and strategies enter and other exit the debate as a consequence of policy learning/adaptation and of changes in the regulation itself. A good example of policy secondary aspect was the 1996 MOA, which was designed as an instrument to deal with policy issues at a particular point in time during the policy process. My measures of policy secondary aspects are also shown in Appendix 2A.

Following methodologies adopted in previous studies of belief coalitions, I use a data reduction technique to identify policy beliefs underlying my set of policy measures. To this end, I perform factor analyses of my policy-core, thus reducing the number of variables. I exclude policy secondary aspects from the analysis to reduce the complexity of the results and because I expect them to be less important in determining the alignment

of stakeholders into coalitions. For consistency, all my factor analyses will be principal-components, retaining factors with eigenvalues bigger than or equal to one. I then perform varimax rotations on the solutions, for which I apply a Horst modification. To give the resulting factors conceptually meaningful labels, I use the Cronbach's alpha reliability measure. The within-factor set of variables used to label the factor will be that with the maximum number of variables that yields a Cronbach's alpha equal or bigger than 0.7.

3.3 The measurement of belief coalitions

Typically, published quantitative analyses of belief coalitions proceeded as follows:

1- Separate factor analyses on policy-core and secondary-aspect items are performed to identify underlying belief dimensions;

2- Separate cluster analyses are carried out on the set of policy-core factors and on the set of secondary-aspect factors, to identify groups of stakeholders with similarities in their policy positions.

Such methodology looks for commonalities across stakeholders in *all* (policy core or secondary) belief dimensions. When the number of belief dimensions is small (usually two to three dimensions have been found in previous studies) the identification of belief coalitions may be fairly simple. The complexity of the analysis can potentially increase with the number of policy dimensions. As described later in the paper, I consistently found between four and six policy dimensions (as represented by conceptually-

interpretable factors.) For the identification of belief coalitions, I will use the factors with proportions of the explained variance of at least 0.10.

According to ACF, a coalition exists when a group of stakeholders who share views on policy issues engage in non-trivial levels of activity coordination. The measurement of these two elements is easier in situations closer to that of controlled experiments (e.g. surveys or interviews). Public hearings are social situations where the behavior of actors is affected by many possible factors. Contrary to typical Congressional hearings, participation of public hearings at the Air Resources Board is open. This fact, coupled with the strong interest that the ZEV policy debate triggered in a broad spectrum of actors, often leads the Board Chairperson to encourage—even prod—brief statements that do not reiterate opinions put forth by previous witnesses. Constraints like this could limit to some extent researchers' ability to quantitatively identify all coherent policy beliefs across coalition members. Activity coordination, the second element in the definition of a coalition—not only is an elusive concept to measure from public testimonies, but it could potentially complicate the measurement of belief sharing. Indeed, coordinated behavior may lead to variance in the issues that the individual members stress in their testimonies. Actual members of the same coalition can thus, because of coordinated behavior, emphasize different policy dimensions, and unintentionally conceal from a coding scheme part of their agreement on issues.

A question central to standard methodologies that use the factor analysis-cluster analysis sequence to analyze belief coalitions is how to determine the appropriate number of clusters of stakeholders. The number of clusters has been typically determined through

visual inspection of clustering dendrograms (e.g. Jenkins-Smith, et al., 1991.) More recently, Zafonte and Sabatier (2004) and Nohrstedt (2006) used goodness-of-fit measures to determine the number of clusters resulting from partitioning cluster analysis approaches. Their rationale was that "the use of a 'goodness-of-fit' criterion allows us to apply a consistent method for determining the numbers of clusters across all … analyses." (Zafonte and Sabatier, 2004, p. 86.) The Silhouette Width—the goodness-of-fit measure used by Zafonte and Sabatier (2004)—is defined as follows:

$$sil = (b_i - a_i)/\max(a_i, b_i) \quad \textbf{Equation 1}$$

where a_i is the average distance from point i to all other points in i's cluster, and b_i is the minimum average distance from point i to all other points in another cluster. Avoiding procedures that require subjective assessments clearly enhance the replicability of results; a feature that is typically preferred over subjective expert judgments in mainstream social research.

I adopt a methodology that independently determines the number of clusters, to foster the replicability of my results. The methodology involves running *k*-means cluster analyses, using squared Euclidean measures of dissimilarity. I use a commercially-available package for statistical analysis: STATA$^©$. Because the results of a cluster analysis depend on the initial cluster centers adopted by the clustering algorithm, I sort my list of stakeholders in alphabetical order, and take the first *k* observations as the initial centers, where *k* is the number of clusters assumed in the *k*-means solution.[10] I then obtain estimates of the Calinski-Harabasz (*CH*) stopping rule for each of the solutions to find the

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[10] In ordering a variable alphabetically, STATA$^©$ gives priority to caps.

best one. I adopt the *CH* stopping rule (Calinski and Harabasz, 1974) because it has been widely used and was found by Milligan and Cooper (1985) to be the most effective method. The *CH* index is basically a ratio of an inter-cluster to an intra-cluster dissimilarity measures, and it is computed as follows:

$$CH = \frac{[trB/k-1]}{[trW/n-k]} \quad \textbf{Equation 2}$$

Here, *B(k)* is the between-cluster sum of squares, *W(k)* is the within-cluster sum of squares, *n* is the total number of items and *k* is the total number of clusters in the solution. As both *B(k)* and *W(k)* are measures of dissimilarity, bigger values of *CH* will indicate better clustering. Following the recommendation in the original paper (Calinski and Harabasz, 1974), I will select the solutions where the *CH* index reaches the first local maximum

4. Stakeholder analysis of the 1990 hearing

4.1 Background

After a two-day public hearing, the California Air Resources Board adopted resolution 90-58 which approved the Low Emission Vehicle and Clean Fuel (LEV) program proposed by ARB staff. The ZEV mandate was a very small provision within the ambitious LEV program, and therefore most of the testimonies given at the public hearing were either partially or completely unrelated to the requirements on zero-emission vehicles. The LEV regulation was grounded on the specification of four

categories of vehicles with different emission standards for nonmethane organic gas[11], oxides of nitrogen, carbon monoxide, formaldehyde: transitional low-emission vehicles (TLEVs), low-emission vehicles (LEVs), ultra low-emission vehicles (ULEVs), and zero-emission vehicles (ZEVs). ZEVs would have no exhaust or evaporative emissions and would be phased in starting in 1998.

While LEV was a very ambitious program, the ZEV mandate was almost a policy experiment. Included in the LEV language late into the drafting process, the ZEV mandate was the most daring regulatory experiment in the quest for cleaner air. It proposed a radical move from the status quo in the transportation sector, particularly as it concerned the auto and oil industries. At the time, the only drivetrain that could conceivably meet the zero-emission standard in the required timeframe was the battery electric vehicle. For this reason, stakeholders opposing the mandate argued that the ZEV mandate was not an emission regulation but a technology mandate, and thus was beyond CARB's statutory authority. In response to such criticism CARB pointed out that "[m]anufacturers are not limited to the development of electric vehicles or refinement of internal combustion systems to meet the ZEV requirement. Other technologies such as fuel cells may be developed to meet the ZEV mandate. As such, the ZEV mandate is not a technology mandate." (CARB, 1991, p. 48.)

Common wisdom has it that the ZEV mandate was a direct consequence of General Motors' introduction, in 1990, of the EV-1—a battery-powered two-seater prototype, later known as the Impact. Some of the impressive performance characteristics of this

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[11] The LEV program set for the first time standards for non-methane organic gases. Previous regulations were concerned with non-methane hydrocarbons. Non-methane organic gases include non-methane hydrocarbons as well as oxygenated hydrocarbons (e.g. aldehydes, alcohols.)

prototype, along with GM's announcement that it would be commercialized by the mid 1990's, did encourage CARB to include the Mandate in the regulatory language. The ZEV mandate was, however, the result of a more complex set of factors. By the end of the 1980's, air quality had risen to the top of political agendas not only in California, but also at the federal level. Several areas in California were in non-attainment of federal air-quality standards. The state was being sued for this reason and the Environmental Protection Agency was pressing the state to review its state implementation plan under the threat of cutting federal highway funds. Technologically, the generalized perception was that emissions from gasoline internal combustion systems could not be reduced much further and that strategies to incorporate alternative fuels to the transportation fuel mix were a necessity. In this context, California's Legislature passed the California Clean Air Act of 1998, which gave CARB ample authority to implement necessary air-quality regulations. A detailed account of the origins of the ZEV mandate and the policy environment at the time can be found in Collantes and Sperling (2006).

The most dominant issue debated in the 1990 hearing was the staff proposal to mandate the sales of specified volumes of alternative fuels—particularly methanol—to help the development of markets for alternative-fuel vehicles. Eventually, Board member Cefalu made—and Board member Wieder seconded—a motion to delete this requirement from the regulation language. On the wake of this motion, Board member Wortman made a motion to change the mandatory sales of ZEVs to a requirement on the availability of such vehicles—this motion was seconded by no Board member.

4.2 Analysis

Following the methodological path described in Section 3, I carry out a principal-components factor analysis of my policy-core items, to identify the policy dimensions that defined the policy debate around 1990 when the ZEV program was adopted. I obtained three factors with eigenvalues bigger than one and proportions of at least 0.10, which as a whole explained 65% of the variance. The varimax-rotated factor loadings I obtained are shown in Table 1.

The PRO_STDBASED and PRO_MKTBASED variables were the only ones with high loadings in their respective factors, so they were excluded from the analysis. I label the first factor Pro ZEV Solution as it captures the belief that the problem of vehicle emissions can and should be solved with a technology-forcing requirement on zero-emission vehicles. This factor has by far the largest eigenvalues of all and, explaining by itself 43% of the variance, clearly defines the dominant policy belief in the 1990 debate. The second factor represents a generally negative attitude toward the ZEV mandate, as it reflects a disagreement with technology-forcing approaches and mandating sales volumes. This factor also represents the belief that the ZEV mandate is not consistent with ARB's statutory authority, presumably on the argument that it is not cost effective or technologically viable. I label this factor Anti ZEV Mandate. The third factor captures the belief that the ZEV mandate makes economic sense and I label it Pro ZEV Economics.

Table 1. Rotated component matrix of 1990 policy core items' factor analysis

Policy item	Component		
	Pro ZEV Solution	Anti ZEV Mandate	Pro ZEV Economics
LAW	0.216	-0.717	0.101
NEEDED	0.650	-0.312	0.390
PRO_COST_EFF	0.191	0.734	-0.099
ZEV_COST_EFF	0.279	-0.342	0.771
AIRQUAPROB	0.066	-0.661	0.201
MOBILE	0.689	0.178	0.052
COMMAND	0.302	-0.718	0.452
SALES	-0.480	0.634	0.137
CA_ECONOMY	0.065	-0.038	0.841
HEALTH_LINK	0.475	-0.075	0.501
INNOVATION	0.635	-0.505	-0.165
TECH_READY_NEW	0.801	-0.107	0.397
ZEV_MKT_NEW	0.711	-0.143	0.400
TECH_FORCE	0.735	-0.416	0.144
Cronbach's alpha	0.863	-0.772	0.712
Eigenvalues	5.96	1.83	1.40
Proportion	0.43	0.13	0.10

I carry out a cluster analysis of these policy-core scales to identify the groups of stakeholders that had similar policy beliefs. I perform partitioning (*k*-means) cluster analyses with the number of clusters, *k*, set to two through nine, and use the Calinski-Harabasz (*CH*) test to find the solutions that provide the best fit. Table 2 shows the values of the *CH* index for each number of clusters. I select the solution where the *CH* index reaches the first local maximum: the four-cluster solution.

Table 2. Values of the *CH* measure for different numbers of clusters

Number of clusters	Calinski-Harabasz pseudo-F
2	9.25
3	11.91
4	19.25
5	16.94

ANOVA tests show that the means of the three policy-core scales vary significantly across clusters, indicating that all scales are used to define the clustering of stakeholders. This result is summarized in Table 3.

Table 3. Means of policy-core beliefs across clusters and significance of differences, and cluster members, 1990 hearing

Policy-core scale	Cluster				Prob > F
	Anti ZEV Viability	Pro ZEV Mandate Cost Effectiveness	Anti Mandates	Pro ZEV Mandating	
Pro ZEV Solution	-0.97	0.65	0.32	1.02	0.000
Anti ZEV Mandate	-0.27	-0.20	1.27	-0.90	0.000
Pro ZEV Economics	-0.07	2.38	-0.32	-0.54	0.000
Cluster members	AIAM	ARB staff	ARCO	AeroVironment	
	CANGVC	CEC	CAPCOA	CCA	
	CPUC	SMUD	Chevron	LACTC	
	Chrysler		Ford	SCAQMD	
	EMA		GM	Sacramento County Board	
	Honda		SCE	Sierra Club	
	MVMA		Texaco	US EPA	
	Mercedes Benz		WSPA		
	Nissan				
	Senator Rosenthal				
	Toyota				
	Volkswagen				

The first cluster found for the 1990 hearing is characterized predominantly by the belief that technology-forcing approaches are not effective in inducing technological innovation, particularly in zero-emission technologies. This Anti ZEV Viability belief coalition comprised six auto manufacturers, four business associations with links to the auto industry, one state regulatory agency, and one state senator. The second, and smallest cluster, has three members: a state agency, an electric public utility, and ARB staff. This belief coalition is characterized by a strong belief that the ZEV mandate was cost effective—that is, that the benefits the program would bring about were worth the cost. This group, which I name Pro ZEV Mandate Cost Effectiveness, is also characterized by a positive attitude toward technology-forcing instruments and their effectiveness in inducing technological innovation. The third cluster—the Anti Mandates belief coalition—opposed the Mandate as a regulatory instrument, questioning its cost effectiveness and legal legitimacy. This group was dominated by the oil industry and two

domestic car companies. The fourth cluster is characterized by a support of the Mandate as a regulatory instrument and the belief that the technology-forcing approach would induce the necessary technological developments. This Pro ZEV Mandating belief coalition was formed by two environmental groups, two environmental agencies, and AeroVironment (a California company that was involved in the development of the Impact, General Motors' electric-vehicle prototype) among others. The membership of each of these four clusters or belief coalitions is shown in Table 3, where I show stakeholders' denominations as used in STATA$^©$ to order them alphabetically before carrying out the cluster analyses. A list of the stakeholders that were coded, with their complete names and participation at each public hearing can be found in Appendix B.

An external event that found its way into the policy debate was the situation in the Middle East. Iraq had invaded Kuwait in August 2, 1990, less than two months prior to the public hearing. The unstable situation in that region was referred to in the statement of several stakeholders, suggesting that it could have impacted their policy beliefs. To explore this question, I run t-tests of the three policy-core factors on a dichotomous variable that measured whether the situation in the Middle East was mentioned by a given stakeholder. I found that the group of stakeholders who mentioned the Middle East situation had a significantly (at the 0.1 level) lower mean on the Anti ZEV Mandate policy-core belief scale, and had a significantly (at the 0.05 level) bigger mean on the Pro ZEV Economics belief scale. I cannot infer any direction of causality from these significant associations though. Whether stakeholders' belief system was affected by the external event or whether they used the external event to strengthen their policy argument is difficult to discern.

5. Stakeholder analysis of the 1996 hearing

5.1 Background

The biennial review of 1996 was the last before the phasing in of ZEVs was enforced. Starting in 1998, 2% of the sales of each of the seven major automakers would have to have no tailpipe emissions. The requirement will ramp up to 5% and 10% in the years 2001 and 2003, respectively. The main question that the Board needed to answer in 1996 was whether the Mandate could realistically be enforced, given the state of technology at that point in time. To this end, CARB commissioned a study to assess the state of battery technology. The study, conducted by an independent panel—the Battery Technical Advisory Panel (BTAP)—was completed in December, 1995. The BTAP reported that while better lead-acid and nickel-cadmium batteries had been developed since the implementation of the ZEV program, the vehicle manufacturers did not believe that the driving range such batteries could provide was enough to meet the requirements of at least 2% of the consumers. The BTAP "did not study the market for electric vehicles or the dependence of market potential on EV range and performance; indeed I question the validity of existing, very divergent EV market potential estimates. EVs with advanced lead-acid batteries may well be able to gain applications in limited niche markets, but it seems clear that only batteries with substantially higher specific energy will give EVs the real-world driving range (or, for limited-range work vehicles, the amount of payload) required and/or perceived to be required by the majority of vehicle buyers and users." (BTAP, 1995, p. III-8.)

The Panel also reported that results from laboratory tests of advanced batteries like nickel-metal hydride and lithium ion, were good enough to induce investments in pilot-scale cells. In the Panel's assessment, if a program of pilot-scale production, fleet testing, and production planning and implementation was put in place, "electric vehicles with commercial-production advanced batteries could become available in 2000 or 2001." (BTAP, 1995, p. IV-5.) At the same time, the BTAP reported that, according to developers of advanced batteries, the ZEV program had been instrumental in their ability to recruit the investments they needed. A weakening of the ZEV requirements could then jeopardize their efforts to develop advanced batteries over the following years.

As a direct consequence of the results presented in the BTAP report, the ARB staff acknowledged that electric vehicles powered by electrochemical batteries—the only realistic zero-emission drivetrain at the time—would not be ready to meet the sales requirements scheduled for 1998. ARB was however deeply committed to the ZEV program, first and foremost because it had become part of the state implementation plan to bring many areas of the state back into compliance with ozone standards. At the same time, just like the northeastern states that had adopted the program, California was not politically ready to give up on the Mandate. A gubernatorial office backing down from the program would have been perceived as weak on environmental protection (interviews former government officials). At this point, ARB felt that the options were to revise the program to keep it alive or to face an absolute failure in 1998 which would likely be devastating to the survival of the program (interviewee from CARB.)

In a clear example of policy learning as contemplated by ACF, ARB understood that requirements on high production volumes were not necessarily sufficient to induce the technological innovation and cost reduction necessary to bring radically innovative technologies to the commercialization stage. These goals would be now pursued through a demonstration program—a strategy that Toyota had already recommended in 1990 (CARB, 1991). The terms of such program, as presented in the staff proposal, were laid out in enforceable memoranda of agreement (MOA) that ARB negotiated with each of the major auto companies.

According to the MOA, each of the car manufacturers would commit to place specified numbers of ZEVs in service in urban areas of the state, between the years 1996 and 2000. An important clause of the agreements was the *market-based ZEV launch*, by which each manufacturer would commit to "have the capacity to produce specified numbers of ZEVs that could be sold in California if warranted by customer demand." (page 3 of the memorandum of agreement.) This clause, often overlooked by students of the ZEV program, would have entitled ARB to enforce the deployment of ZEVs in numbers larger than baseline numbers specified in the agreements, if a market demand was in place., Whether a true market for ZEVs existed, however, proved to be one of the most controversial aspects of the policy process and on which many stakeholders had dissonant opinions.

To secure the air-quality benefits that would have otherwise lost with release of the original ZEV requirements, ARB negotiated, as part of the MOA, a *49-state program*. Under this program, the manufacturers would commit to produce and deliver for sale

light-duty vehicles certified to standards equivalent to those of California, in the other 49 states with the exemption of those states that had adopted the LEV program. The rationale for this requirement was based on the fact that a significant number of the vehicles registered each year in the state of California came from other states. Thus, cleaner vehicles in other states would translate in air-quality benefits in California as well.

Since the inception of the Mandate, the states of Massachusetts, New York, and Vermont had adopted it too, under Section 177 of the Clean Air Act. This diffusion of the Mandate to these states had significantly increased the costs of compliance to the automakers, for two reasons. First, the absolute number of zero-emission vehicles that the companies had to deploy increased proportionately with the number of states adopting the Mandate (because of the quotas). Second, the cold weather in the northeastern states posed significantly higher challenges to the performance of battery electric systems. Therefore, the regulated car companies were understandably interested in negotiating alternatives that would restrict the ZEV requirements to California. At the same time, ARB was now interested in implementing a demonstration program to foster technological development, and believed that similar requirements from other states would be redundant and would impose unnecessary costs on industry. The decision to frame the ZEV program as a MOA—effectively taking it out of the statute—was a direct outcome of negotiations between the companies and ARB over this issue, as other states would be not impeded from adopting ZEV requirements under Section 177 of the Clean Air Act. This move was resented among supporters of the program in the Northeast. (Interviews with officials in the Northeast.)

The 1996 ARB staff proposal represented a significant philosophical change in the agency's approach to bringing zero-emission vehicles to the roads. The proposal was more reflective of the processes involved in radical (as opposed to incremental) technological innovation. It also showed a predisposition of the agency to work more collaboratively with industry, to better understand the technological challenges and the evolution of the actual market demand for ZEVs. Not everyone in the environmental community welcomed this change in approach, as they were still skeptical of seeing any good-faith efforts on the part of the industry.

5.2 Analysis

A principal components factor analysis of my policy core items explained 79% of the variance with five factors with eigenvalues of at least one and three factors with proportions of at least 0.10. Carrying out a varimax rotation, I obtained the factor loadings shown in Table 4. Shaded cells indicate the policy items used to estimate the Cronbach's alpha reliability parameter.

Table 4. Rotated component matrix of 1996 policy core items' factor analysis

Policy item	Component				
	Pro ZEV Mandate	Pollution Health Effects	Pro Tech Forcing	Pro Staff Proposal	Pro Extant Program
NEEDED	0.730	0.166	0.317	-0.015	0.425
PRO_COST_EFF	-0.931	-0.104	0.013	-0.060	-0.148
PRO_STDBASED	-0.840	-0.030	-0.095	-0.181	0.098
PRO_MKTBASED	-0.701	-0.103	0.260	0.040	-0.302
ZEV_COST_EFF	0.935	0.004	0.030	0.071	0.149
AIRQUAPROB	-0.114	0.510	0.184	0.295	0.382
MOBILE	0.081	0.895	0.085	-0.036	0.225
COMMAND	0.659	0.258	0.382	-0.127	0.466
SALES	-0.544	-0.202	-0.136	0.253	-0.453
CA_ECONOMY	0.815	-0.061	0.153	0.236	-0.081
HEALTH_LINK	0.179	0.890	-0.090	0.176	0.042
INNOVATION	0.093	0.164	0.777	0.085	-0.223
TECH_READY_OLD	0.051	0.213	-0.212	0.137	0.816
TECH_READY_NEW	0.057	0.157	-0.092	0.912	0.098
ZEV_MKT_OLD	0.290	0.116	0.088	0.116	0.865
ZEV_MKT_NEW	0.540	0.093	0.146	0.676	0.132
TECH_FORCE	0.081	-0.098	0.853	-0.084	0.170
Cronbach's alpha	0.908	0.765	0.609	0.760	0.826
Eigenvalues	6.61	2.41	1.72	1.57	1.08
Proportion	0.39	0.14	0.10	0.09	0.06

The Cronbach's scale reliability parameters are bigger than 0.7, with the exemption of one, indicating that the factors reliably represent an underlying concept or belief. The Pro ZEV Mandate factor includes eight policy items and clearly relates to a supportive attitude toward a command-and-control strategy to introduce ZEVs, with a belief that the Mandate is cost-effective and beneficial to the state's economy. As in the 1990 debate, the first factor has a significantly bigger eigenvalues than the rest of the factors. This factor explains 39% of the variance—25% more than the second factor—suggesting that it dominated the policy debate in 1996. The Pollution Health Effects factor, comprising three policy items, captures the belief that air quality in the state is a public health problem and that mobile sources are a major contributor to the problem. The Pro Tech Forcing factor captures the belief that technology-forcing regulatory approaches are

effective means to drive technological innovation. As suggested by the non-trivial loadings on other items, this support is tied both to a support for command-and-control approaches to require ZEVs. The Pro Staff Proposal factor captures the belief that the new staff proposal offers an effective path to obtaining mature ZEV technologies and to create a market for ZEVs. The Pro Extant Program factor reflects the belief that the state of zero-emission technologies was, at the time of the hearing, sufficiently mature for commercialization and that a market already existed. This belief is directly tied with a belief that ZEVs are needed, and with skepticism about the adequacy of market forces to drive the commercialization of ZEVs without command-and-control regulatory measures.

I see that, even though the variables that are factored are essentially the same for the 1990 and 1996 steps, they tend to group into factors differently. For example, in 1990, the positive attitude toward technology forcing instruments was directly related to the belief that zero-emission technologies and markets would be ready in the time frame of the proposed regulation. Such relationship was not found in 1996. I also found an alignment of the variables related to air quality at the 1996 step. While these three variables— AIRQUAPROB, MOBILE, and HEALTH_LINK—were scattered over different factors in 1990, they form a coherent belief scale in 1996. There are multiple potential reasons for such evolution in the pattern of policy-core composition. These reasons would include the fluidity in stakeholder participation and heterogeneous policy learning across stakeholders, reflected in their varying reactions to revisions of the ZEV program.

To investigate the patterns of agreement between stakeholders in the set of policy-core beliefs, I carry out partitioning cluster analyses, increasing the number of clusters and

performing the *CH* test for each solution. I stop when I find the first *CH* maximum. The CH indexes for each cluster run are shown in Table 5. The progression of *CH* values suggests a four-cluster solution.

Table 5. Values of the *CH* measure for different numbers of clusters

Number of clusters	Calinski-Harabasz pseudo-F
2	16.09
3	28.03
4	41.00
5	36.43

Table 6 shows the distribution of policy-core belief means across clusters in my solution and the significance of the differences in these means obtained from a one-way analysis of variance. The ANOVA results show that the Pro Tech Forcing belief is not significant in determining the clustering of stakeholders.

Table 6. Means of policy-core beliefs across clusters, significance of differences, and cluster members, 1996 hearing

Policy-core scale	Cluster						Prob > F
	Moderate		Pro Public Health		Anti ZEV Mandate	Pro Tech Forcing	
Pro ZEV Mandate	0.42		0.30		-2.61	0.14	0.000
Pollution Health Effects	-0.72		1.26		-0.10	-0.01	0.000
Pro Tech Forcing	-0.30		-0.51		-0.14	1.84	0.000
Cluster members	Board Vagim	ABTF	ALA	GM	Assemblyman Baldwin	ARB staff	
	CAMCDA	ALABC	Board Silva	NRDC	Assemblyman Bordonaro	BAT Int'l	
	CalETC	Ballard	CCA	PCL	CAHT	Board Boston	
	EDF	Board Calhoun	CalPIRG	PEM	Senator Haynes	Board Dunlap	
	Honda	Board Edgerton	Chrysler	Toyota	WSPA	Dr. Dixon	
	Integral Design	Board Hilligoss	Ford	UCS		Dr. Frank	
	Mazda	Board Lagarias				Sierra Club	
	NESCAUM	Board Parnell					
	Nissan	Board Riordan					
	SCAAG	Board Roberts					

Table 6 also shows the allocation of stakeholders in the different clusters as given by my cluster analysis. The Moderate cluster defines a diverse belief coalition that most notably

includes the majority of the Board members and three Japanese auto companies. Stakeholders in this cluster share moderate positions in all policy-core dimensions. The Pro Public Health cluster predominantly includes environmental groups and is characterized by its concerns about air quality and a moderate opposition to technology forcing. Regardless of the presence of automakers, on average these two groups presented less opposition to the Mandate than the Anti ZEV Mandate cluster. This cluster represents a belief coalition formed by three members of the state legislature, the Western States Petroleum Association, and Californians Against Hidden Taxes, an organization funded by WSPA among others. This cluster is clearly characterized by its opposition to the ZEV mandate. The Pro Tech Forcing cluster comprises only six actors, among them Board's chairman Dunlap and CARB's staff. This belief coalition expressed above-average support for technology-forcing regulatory approaches. CARB's staff falls in the minority coalition this time, which suggests the majority of the stakeholders were not happy with the proposed revision. Policy learning had led staff to shape the program to account for evidence on the market, technology, and economic obstacles to introduce ZEVs. Much of this learning was the result of intense information flows to and from the auto companies. The closer collaboration of CARB's staff with auto companies even triggered suspicion among some groups, who felt that staff was giving up too soon on BEVs, or that they were giving in to industry interests, or that it was pursuing an agenda supportive of hydrogen that was championed by the Board's chair at the time (interviewee from CARB). Regardless of how closely the staff was working with auto companies, these were not supportive of the ZEV program—they were merely trying to find the least costly alternative that would be acceptable to the staff. The difference

between industry and staff is clearly captured by my results. The staff's position was characterized by great concerns about air quality and a strong conviction that the ZEV program needed to be revised.

6. Stakeholder analysis of the 2001 hearing

6.1 Background

The hearing of January 25th, 2001, was essentially a follow-up of a hearing that took place on September 7th, 2000. In this meeting, the Board had directed staff to "work with the automakers and other interested parties to develop modifications to the program to address some of the implementation challenges facing ZEVs." (Alan Lloyd, CARB, 2001a.) ARB commissioned the Battery Technical Advisory Panel (BTAP) a new study on the prospects of battery technology. The well-respected BTAP—composed of independent experts Dr. Menahem Anderman, Dr. Fritz Kalhammer, and Dr. Donald McArthur—focused on the three battery technologies that appeared to have better performance relative to lead-acid batteries and that had some prospects for meeting electric-vehicle battery cost targets. A summary of their estimates of key characteristics of each of these battery technologies is shown in Table 7.

Table 7. Summary of findings of the Battery Technical Advisory Panel (BTAP, 2000)

Battery technology	Estimated range [miles/charge]	Specific energy [Wh/kg]	Energy density [Wh/liter]	Specific cost [US$/kWh]	Battery pack cost [US$]	Operating life [years]
Nickel-metal hydride	75-100	65-70	140-170	350*	9,500-13,000*	10
Lithium-ion	n.a.	93-138	114-210	600*	18,000-21,000*	2 to 4
Lithium-metal polymer	n.a.	110-130	130-150	n.a.	n.a.	n.a.
* Estimate based on production levels required to meet 2003 ZEV requirements						

The only battery technology sufficiently mature to realistically equip 2003 BEVs was the nickel-metal hydride (NiMH). The BTAP concluded that the 26 to 33 kWh NiMH batteries installed in the BEVs deployed by automakers in California delivered acceptable acceleration, speed and durability. The range between charges that this battery could deliver remained limited to 75 to 100 miles, though. Additionally, cost was still an issue: even under mass production conditions, a NiMH battery pack would cost between $7,000 and $9,000.

The market acceptance that ARB hoped for when it entered into Memoranda of Agreement (MOA) with each of the major automakers had not materialized. Incorporating the findings of the BTAP, ARB staff presented to the Board its assessment on the prospects of current technology to generate a sustainable market for ZEVs at the 2000 biennial review of the program. While acknowledging the progress in battery technology, the staff indicated that "the cost of these batteries will likely be high, even in volume production. This finding, when incorporated into per vehicle cost analysis and lifecycle cost analysis, shows electric vehicles to be significantly more costly than conventional vehicles in the 2003 timeframe." ARB staff estimated the near-term incremental cost for full-function ZEVs in the range of $13,000 to $24,000. (CARB, 2001b) As reflected in the Battery Panel study, energy density was still unsatisfactory and

no major improvements were expected for the available battery types. Energy density is a direct determinant of vehicle range, which was in turn argued to be a direct determinant of the large-scale market viability of a new vehicle technology. Despite the technical evidence, on September 8, 2000, the Board adopted, after a public hearing process, a resolution resolving that the basic ZEV requirements be retained and implemented. This decision was surprising not only to stakeholders but even to ARB staff.[12]

While the automakers had strictly supplied the numbers of vehicles agreed upon in the MOA, ARB staff felt that that the experiment had been unsuccessful. The Executive Officer explained that the automakers had not complied with the MOA "because the MOA also anticipated that we would have essentially the response to market demand. We do not have that. We do not have a market—we do not have the vehicles being offered into the market today, and so that is a problem." (Mike Kenny, CARB, 2001a.)

After the MOA experiment (referred to as a demonstration program by many in ARB), the questions of whether the volume of ZEVs required should be increased, by how much, and how volumes should be ramped up, entered the debate. These questions were tied to that of how much flexibility should be added to the program. The program, as proposed by the staff, had evolved from a very simple schedule for the introduction of ZEVs to a very complicated scheme allowing for credits for non-ZEVs, like partial zero-emission vehicles (PZEVs) and advanced-technology PZEVs. A strong group of stakeholders supported the assignment of certain plug-in hybrid electric vehicles (PHEVs) to the ZEV category.

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[12] From personal interviews with stakeholders and ARB staff members.

Environmental justice aspects of the ZEV program were introduced in the public debate. A number of Assembly Members expressed their concern with the Board spending resources in a program that they felt would inefficiently address the air-quality problems of low-income areas of the state. Similar concerns were raised by citizens and a couple of grassroots organizations, and backed by Board members like Dr. William Burke and Mark DeSaulnier.

California electricity generation system was in the middle of a deep crisis, where the installed capacity was unable to meet demand, and programmed blackouts were common. This situation was used by some opponents to the program to warn against the potential negative effects of adding electric vehicles to the demand of electricity. The weakness of such argument did nothing but discomforting proponents of the program, who were quick to show that the electricity system would be back to normal well before electric vehicles reach any significant number in the marketplace: "I can only wish that we would have the 250,000 electric vehicles, but even then it would require the tiny fraction of one percent of our electricity. Folks, if we don't get this electric power problem solved in the State by 2003 and before, we won't have enough money to buy any kind of car." (David Freeman, CARB, 2001a, p.98.)

Hydrogen-powered fuel-cell vehicles had arisen as a viable zero-emission technology, and they were starting to get strong attention at the federal level as well, though for reasons more related to energy security than air quality. CARB, DaimlerChrysler, and Ford had started a unique collaborative initiative that would soon include a wide group of stakeholders: the California Fuel Cell Partnership.

The central question of whether ZEVs were actually needed to achieve air quality goals was by now less clear. Many believed that faster benefits could be brought about by requiring larger numbers of PZEVs. (Interviewees from industry and ARB.) Proponents of a mandate on zero-emission vehicles based their position on either economic or societal considerations. The mandate had encouraged the development of an industry that relied, to a certain extent, on a baseline demand for electric vehicles sustained by the regulation. This sector, of course, opposed attempts to reduce the numbers of ZEV required. (CARB, 2001a.) Most of those who supported the mandate on societal-benefits grounds centered their arguments on the need to improve air quality, but many pointed out the benefits in terms of energy security and reduction of greenhouse gas emissions. Letters to the Board supporting the requirements on ZEVs because of air-quality concerns did not include or refer to scientific evidence to show that ZEVs were indeed necessary to achieve air-quality standards. Undeniably, the introduction of ZEVs in large numbers would have a significant impact on air quality—there were some doubts, however, on whether they were the more cost-effective way to achieve such impact.

6.2 Analysis

A principal components factor analysis of my policy core items yielded five factors with eigenvalues bigger than one and three factors with proportions bigger than 0.10. The five factors cumulatively explained 73% of the variance. The varimax-rotated factor loadings I obtained are shown in Table 8, where I shaded the cells of the items used to estimate the Cronbach's alphas.

Table 8. Rotated component matrix of 2001 policy core items' factor analysis

Policy item	Component				
	ZEV Program Support	Pro tech forcing	Pollution health effects	Pro Market Ready	Pro Staff Proposal
NEEDED	0.808	0.210	-0.075	0.317	0.141
PRO_COST_EFF	-0.751	0.202	-0.159	0.163	-0.239
ZEV_COST_EFF	0.844	0.003	-0.275	0.081	0.125
AIRQUALPRO	-0.078	-0.140	0.827	-0.103	0.144
MOBILE	-0.120	0.159	0.678	0.040	-0.224
COMMAND	0.440	0.106	-0.116	0.559	0.238
SALES	0.057	0.122	-0.116	-0.827	0.124
HEALTH_LINK	0.013	0.047	0.874	0.020	-0.106
INNOVATION	0.114	0.905	0.063	-0.085	-0.004
TECH_READY_OLD	0.148	-0.220	-0.059	0.456	0.584
TECH_READY_NEW	0.220	0.051	0.000	-0.002	0.870
ZEV_MKT_OLD	0.132	-0.104	-0.130	0.766	0.416
ZEV_MKT_NEW	0.216	0.102	-0.148	0.112	0.824
TECH_FORCE	0.057	0.941	-0.002	-0.085	0.039
SIP	0.841	0.215	-0.040	0.063	0.157
Cronbach's alpha	0.817	0.908	0.719	0.656	0.744
Eigenvalues	4.42	2.28	1.91	1.40	1.26
Proportion	0.29	0.15	0.13	0.09	0.08

The ZEV Program Support factor has a significantly bigger eigenvalues than the rest of the factors and explains 29% of the variance—about double of that explained by the following factor. This first factor captures a general support for the program as necessary, cost effective, and positive in terms of air-quality benefits. This scale is related to the Pro ZEV Mandate scale found for 1996, which included high loadings on COMMAND and SALES. While these two items moved to a different belief scale in the present analysis, COMMAND still has a relatively high loading on the ZEV Program Support factor. The Pro Tech Forcing belief scale, already found in the analysis of the 1996 hearing, captures the support for technology-forcing regulatory approaches as means to induce technological innovation. The Pollution Health Effects belief scale, also found in the 1996 hearing, captures the belief that mobile sources are a significant contributor to public health problems related to poor air quality. The Pro Market Ready factor captures

the belief that a significant market demand for zero-emission vehicles exists and therefore the sales of such vehicles should be enforced. The Pro Staff Proposal belief scale is consistent with that found for 1996. It captures the belief that ARB staff's proposal constituted a viable strategy toward zero-emission technology innovation and market development. Interestingly, stakeholders with high loading on this factor seem to believe that the ZEV technology, as required in the extant program, was ready, but were less confident that a significant market for this technology was in place. It should be noted that while the items defining the Pro Staff Proposal in 1996 and 2001 are compatible, the actual meaning of this belief scale should be studied in the light of the proposals at each of these biennial reviews. The 1996 proposal was geared toward developing a market for battery electric vehicles, while the 2001 proposal was more focused on fuel-cell vehicles than on battery electric vehicles.

I perform partitioning cluster analyses on the three belief dimensions with proportions bigger than 0.10, increasing the number of clusters until I reach a maximum in the CH index. Table 9 shows that the *CH* index reaches the first local maxima for $k = 5$, which I adopt as a solution, following the guidelines provided in the original paper (Calinski and Harabasz, 1974). ANOVA tests of the policy-core factors show that only two of them are significant in determining the clusters in the 3-cluster solution.

Table 9. Values of the *CH* measure for different numbers of clusters

Number of clusters	Calinski-Harabasz pseudo-F
2	14.97
3	23.13
4	25.52
5	40.73
6	40.40

As shown in Table 10, under a 5-cluster solution, all the policy-core dimensions are significant in determining the clustering of stakeholders.

Table 10. Distribution of policy-core factor means across clusters, and cluster members, 2001 hearing

Policy-core scale	Cluster					Prob > F
	Moderate Anti Tech Forcing		**Pro Public Health**	**Pro Tech Forcing**	**Anti ZEV Air Quality Benefits**	**Anti ZEV Mandate**	
ZEV Program Support	0.18		0.86	0.23	-1.56	-3.40	0.000
Pro Tech Forcing	-0.58		0.20	1.69	-0.71	0.91	0.000
Pollution Health Effects	-0.48		1.42	-0.21	2.17	-0.72	0.000
Cluster members	AAM	CalETC	ALA	ARB staff	Assembly Cardenas	GM	
	Assembly Firebaugh	Dr. Frank	Board Lloyd	Ballard	BHMP	Sierra Research	
	Avestor	Dynasty Motorcar	CBE	Board C. H. Friedman	MELASI		
	BAAQMD	EPRI	CCA	Board Calhoun			
	Board Burke	EVDC	Daimler Chrysler	Energy Conversion Devices			
	Board D'Adamo	Ford	LADWP	Honda			
	Board DeSaulnier	NRDC		Int'l Fuel Cells			
	Board McKinnon	Northern Sonoma CAPCD		NYDEP			
	Board Patrick	PCL					
	Board Riordan	SCAQMD					
	Board Roberts	Toyota					
	Board W. Friedman	UCS					
	CFC						

The Moderate Anti Tech Forcing cluster comprised the bigger grouping of stakeholders at the public hearing, including eight Board members, two major car manufacturers, three environmental groups, and two state air quality districts, among others. This is a moderate group with below-average means in the Pro Tech Forcing and Pollution Health

Effects policy-core scales. The Pro Public Health cluster is composed of Board's chair Lloyd, three environmental groups, one major automaker, and the Los Angeles municipal electric entity. This group stood for air quality and in support of the ZEV program. The Pro Tech Forcing cluster, formed by ARB staff, two Board members, a major automaker, two fuel-cell companies, among others, is characterized by its support for technology-forcing regulatory approaches. The Anti ZEV Air Quality Benefits cluster groups an Assembly member and two grass roots organizations, holding the view that the ZEV program was not the appropriate means to address the state's air quality problems. Finally, the Anti ZEV Mandate cluster is composed of one major automaker and a consulting firm usually hired by the auto industry. This group is predominantly characterized by its opposition to the ZEV program.

7. Stakeholder analysis of the 2003 hearing

7.1. Background

The hearing of March 27 and 28, 2003, presented for public debate new modifications to the ZEV program driven, primarily, by a preliminary injunction resulting from a federal preemption lawsuit filed by General Motors and DaimlerChrysler on January, 2002. The plaintiffs asserted that ZEV program's provisions pertaining hybrid electric vehicles (that fell in the category of advanced-technology partial zero emission vehicles or ATPZEV) were related to fuel economy, and were thus preempted by the Energy Policy and Conservation Act of 1975.[13] In response to the court decision, staff modified the

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[13] According to this Act, fuel-economy standards could be established only by the federal government through the Corporate Average Fuel Economy (CAFE) standards.

regulation to avoid any reference, direct or indirect, to fuel efficiency. Additional modifications to the program, and now independently of the legal concerns, included the creation of an alternative compliance path that provided industry with greater flexibility, and the establishment of an independent review panel that would assess the state of ZEV technologies.

By then, the interest in hydrogen and fuel cells—which together allow for zero tailpipe emissions—had clearly spread in the federal government. At the federal level, however, the main driver was greater independence from foreign oil. President Bush had announced, in his 2003 State of the Union Address, a hydrogen initiative that would commit 2.3 billion dollars over a five-year period to research on hydrogen technologies.

Automakers had ceased production of battery electric vehicles and were much more enthusiastic about fuel-cell vehicles as a means to comply with the Mandate. The ARB staff shared the view that no significant market demand existed for battery electric vehicles, while substantial progress was still needed before fuel-cell vehicles were ready for commercialization. Thus, staff felt that no ZEV technology was readily available to meet the Mandate's requirements. Dr. Menahem Anderman, a member of the BTAP gave testimony presenting the results of a study to assess the evolution of battery technology since the Panel's last report. Dr. Anderman's main conclusions were:

1- Efforts to develop electric-vehicle batteries had generally declined over the three previous years;
2- Efforts to develop batteries for hybrid electric vehicles continued to increase;
3- No breakthrough in battery technology was predicted;

4- The development of better batteries for hybrid electric vehicles would have a significant positive effect on the cost of electric-vehicle batteries.

As federal and state preliminary injunctions prevented ARB from enforcing the program's requirements for the years 2003 and 2004, the new staff proposal moved the initiation of the program to 2005. Staff created two compliance paths, which it named the base path and the alternative compliance path. The former kept the category structure of the 2001 program amendments: out of the 10% ZEV requirement, at least 2% should be gold credit vehicles, up to 2% could be met with silver credit vehicles, and up to 6% could be met with bronze credit vehicles. The latter proposed an alternative compliance scheme that promoted the development of fuel-cell vehicles: manufacturers would produce their market share of 250 Type 3 ZEVs (fuel cell vehicles) between 2001 and 2008. Under this compliance path, manufactures could meet the remaining of their gold requirement with silver credit vehicles.(CARB, 2003)

Staff proposed a new categorization of zero-emission vehicles: Type 0, Type 1, Type 2, and Type 3 ZEVs. Each of these types would earn a different number of credits. Type 2 ZEVs would have a range in excess of 100 miles and would not be fast-refueling capable (e.g. full-function battery electric vehicles). Type 3 ZEVs would also have a range over 100 miles, but would be able to refuel fast (e.g. hydrogen fuel-cell vehicles.)

Staff also proposed modifications to the system of credits to the silver category. In particular, staff eliminated credits based on CO_2 emissions and efficiency, which had motivated earlier industry litigation. Instead, credits would be given only based on attributes of the electric drive system that would help move the learning curve toward

fully zero-emission drivetrains. Such attributes would include system voltage, peak power rating, idle stop-start capability, regenerative breaking, and others. Three categories of hybrid electric vehicles were proposed: low voltage-low power, high voltage, and high voltage-high power. Other vehicles that would earn credit within the silver category are compressed natural gas vehicles, hydrogen internal combustion engine (ICE) vehicle, hydrogen ICE hybrid electric vehicles, methanol fuel-cell vehicles, and plug-in hybrid electric vehicles with at least 20-mile all electric range.

As in the 1996 review, Section 177 of the Clean Air Act influenced the staff proposal. Staff believed that fuel-cell vehicles needed to go through a demonstration stage before commercial volumes were required. Under this argument, staff proposed that any fuel-cell vehicle deployed by automakers in *any* state that had adopted the ZEV program would count toward their required share of the 250 fuel-cell vehicles contemplated under the alternative compliance path.

At that point, ARB found itself in a curious situation where only few supporters of the program were left. Industry had always been philosophically opposed to mandates, and that would not change. The program had undergone so many and complicated modifications that the environmental community and the supporters of battery electric vehicles had grown frustrated and disappointed, and most opposed the program too.

A few policy issues dominated the Board's deliberations after the testimonies. One was whether plug-in hybrids should be allowed in the gold category, and if so for how long, and what the minimum all-electric range of these vehicles should be. Second, how many zero-emission vehicles should be required until 2008, and how this number should

accommodate battery electric and fuel cell vehicles. On this question it can be clearly seen how CARB departs from the standard-setting approach to a technology development intention. In 1990, CARB responded to criticisms that they were picking a specific technology (the battery electric vehicle) saying that they were actually setting a clear standard: zero emissions. Now, however, CARB is not simply requiring a certain number of vehicles with no tailpipe emissions—they are entering the question of how requirements on specific zero-emission technologies should be set to ensure that the automakers will succeed in developing a commercially viable zero-emission vehicle. While CARB's staff and some Board members are technically savvy, it is very difficult to find efficient answers to such questions without a broader expertise that could proficiently study the behavioral and economic mechanisms that would bring this type of vehicles to the road. On addressing the former policy question, CARB found itself trying to decide whether requiring 250 fuel-cell vehicles made more sense than 500 zero-emission vehicles, whether it should let automakers to focus only on fuel-cell vehicles rather than on battery-electric vehicles if so they preferred, whether the automakers had made a reasonable effort to market battery-electric vehicles, etc. In reality, the question of whether zero-emission vehicles were supplied by the major automakers or by smaller industry players was in itself irrelevant in the short term—if the market viability of ZEVs was proven by a smaller company, the larger manufacturers could not argue otherwise. So was the question of whether any given number of zero-emission vehicles was supplied by the major automakers as a group, or by any individual company. In the longer term, because industry responds to business opportunities and competition, all companies would be enticed to go that way if any one company is very successful. CARB could

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have focused more on creating conditions for the supply of any latent demand for zero-emission vehicles to be feasible, thus moving faster toward its zero-emission goal. To this and similar ends, there may be room for improvement in the level of cooperation and coordination that CARB has with other agencies and sectors of the state government.

7.2 Analysis

Several traditionally important policy-core variables were excluded from the factor analysis because they were not part of the debate in the 2003 hearing. Such variables include the preferences for cost-effective policies, for market-based policies, and for standard-based air-quality regulations, as well as the belief about the impact of the regulation on environmental justice. The fact that these policy dimensions did not enter the public debate during the hearing does not imply that the stakeholders did not have clear, or even strong, positions in these areas—it only means that they chose not to make them part of their explicit policy discourse. On the 13th year of the ZEV policy process, the views of the major stakeholders on these fundamental policy notions were rather well known. Due to this reason and to the evolution of the ZEV program, later stages of the debate tended to focus less fundamental, more specific policy issues. This is one shortcoming of using content analysis of public hearings, as discussed above: Because of many possible reasons, policy actors select a limited number of issues to highlight in their statements, they decide the expression of which beliefs may be counter to attaining their policy objectives, they coordinate what policy areas will be addressed by each member of a coalition, or limit the span of their presentation to meet time constraints. LAW and

BEHAVIOR were also excluded because they had very small variance and were not important components of the policy debate.

Table 11 shows the factor loadings on each variable after a varimax rotation was performed. I indicate with shaded cells the variables that were used to estimate the Cronbach's alpha reliability measure and to define a name for the factor. The first four components have high Cronbach's alphas, indicating that they can reliably be interpreted as coherent underlying policy beliefs. Four factors have at least a 0.10 proportion. However, contrary to the pattern found in the previous hearings, there is no single dominant factor in terms of the variance explained. The eigenvalues of the first two factors are relatively close, which suggests that the debate was dominated by more than one issue.

The Pro Extant Program factor captures the belief that, at the time of the hearing, the state of ZEV technologies—particularly battery-electric vehicles—and market demand for ZEVs are such that the ZEV program did not need to be revised. This factor correlates negatively with the belief that fuel-cell vehicles are a promising means to meet ZEV requirements. The Pro Staff Proposal factor relates to the belief that revisions to the program, as described in the staff's proposal, improved the chances of ZEVs being successfully commercialized. Factors related to the involved technologies and their market viability had been secondary in the last two hearings (in terms of the variance they explained) now are at the center of the debate. This factor correlates with the belief that fuel-cell vehicles can meet the program's requirements. The Pollution Health Effects factor represents the belief that air quality is a problem in the state and that there is a

causal link between air pollution and health impacts. This factor correlates with the belief that mobile sources are major contributors of air pollution and that zero-emission vehicles are needed. The Anti Tech Forcing factor captures the belief that technology-forcing regulation is *not* an effective means to induce technological innovation. The Anti Command-and-Control factor captures the belief that command-and-control policies are *not* necessary to bring zero-emission vehicles to the market and the opposite of the belief that only market demand should determine the number of vehicles sold.

Table 11. Rotated component matrix of 2003 policy core items' factor analysis

Item	Component				
	Pro Extant Program	**Pro Staff Proposal**	**Pollution Health Effects**	**Anti Tech Forcing**	**Anti Command and Control**
NEEDED	0.215	0.592	0.458	-0.082	-0.149
AIR_QUALITY_PROB	0.016	-0.097	0.795	0.055	-0.343
MOBILE	-0.200	-0.111	0.777	0.080	0.231
COMMAND	0.063	0.274	0.134	-0.455	-0.640
SALES	-0.368	-0.003	0.003	0.202	0.618
CA_ECONOMY	-0.148	-0.035	0.056	0.212	-0.798
HEALTH_LINK	-0.027	-0.006	0.760	-0.072	0.022
INNOVATION	-0.125	0.028	-0.151	-0.850	-0.048
TECH_READY_OLD	0.743	-0.090	-0.041	0.077	0.017
TECH_READY_NEW	-0.089	0.847	-0.125	0.079	0.044
ZEV_MKT_OLD	0.878	0.030	0.039	0.063	-0.086
ZEV_MKT_NEW	0.119	0.831	-0.123	-0.095	-0.011
TECH_FORCE	0.130	0.036	0.107	-0.870	0.012
SIP	-0.246	0.166	-0.543	-0.024	0.367
FCV_PROMISE	-0.469	0.602	-0.256	-0.155	-0.054
BEV_PROMISE	0.897	0.139	-0.074	-0.265	-0.092
Cronbach's alpha	0.817	0.723	0.703	0.719	0.534
Eigenvalues	3.14	2.81	2.28	1.60	1.33
Proportion	0.20	0.18	0.14	0.10	0.08

To investigate how stakeholders grouped according to their positions on policy-core issues, I carry out a partitioning cluster analysis of the four policy-core factors with proportions of at least 0.10. The values of the *CH* index, shown in Table 12, suggest that a 4-cluster solution is appropriate. ANOVA tests show that all of the five policy factors

were significantly different across clusters, thus indicating that all factors were significant in defining the clustering of the sample.

Table 12. Values of the *CH* measure for different numbers of clusters

Number of clusters	Calinski-Harabasz pseudo-F
2	9.77
3	12.12
4	13.85
5	11.61

Table 13 shows the mean values and standard deviations of the policy-core factor scores for each of the seven clusters. This table also shows how my cluster analysis allocates stakeholders in the different clusters.

Table 13. Distribution of policy-core factor means across clusters, and cluster members, 2003 hearing

Policy-core scale	Cluster				Prob > F
	Pro Extant Program's Health Benefits	Pro New Proposal	Anti Extant Program	Pro Tech Forcing	
Pro Extant Program	0.75	-0.50	-0.82	0.36	0.000
Pro Staff Proposal	0.04	2.23	-0.35	-0.51	0.000
Pollution Health Effects	0.83	-0.31	-0.40	-0.38	0.001
Anti Tech Forcing	0.58	-0.21	0.40	-1.17	0.000
Cluster members	AC Propulsion	ALA	BAAQMD	Avestor	
	Board C. H. Friedman	ARB staff	Board Burke	Board D'Adamo	
	CCA	EPRI	Board Calhoun	CalStart	
	CalETC	NRDC	Board DeSaulnier	Compact Power	
	City of Fresno	UCS	Board Lloyd	Dr. Frank	
	EV Works		Board McKinnon	Evercel Inc.	
	Electricab Corp		Board Riordan	Hydro Quebec	
	Global Motor		Board Roberts	Kirsch Foundation	
	Green Car Institute		Board W. Friedman	NY DEC	
	Mobility Lab		Dr. Anderman	SCAQMD	
	PCL		Dr. Santini	SMUD	
	PEVDC		Ford	Sierra Club	
	Phoenix Motorcars		Honda		
	SCE		LADPW		
	Stanislaus County		MA DEP		
			Toyota		

The Pro Extant Program's Health Benefits composed of electric drive businesses and environmental groups. This belief coalition supports the extant version of the program

and stood for air quality. The Pro New Proposal essentially defines a belief coalition supporting the staff's revision proposal and moderately opposing the extant program. It is composed of environmental groups and CARB's staff. The Anti Extant Program cluster includes most of the Board members (including chairman Lloyd) and the three auto companies that participated of this hearing. This belief coalition stands essentially for the need to revise the program, mostly because of the belief that battery electric vehicles did not offer a promising path to introducing ZEVs in significant numbers. This group shows however a rather low level of support for the new proposal. The Pro Tech Forcing cluster represents a diverse belief coalition with many historical supporters of the ZEV program, including environmental groups, environmental agencies, pro-electric drive organizations, and one scientist. This group stands mostly in support of command-and-control regulatory strategies, but also shows the lowest level of support to the new proposal.

8. Analysis of policy change and discussion

I have presented separate analyses for four representative ZEV public hearings. In this section I will look at the bigger picture and analyze the two fundamental questions of concern to this study: policy change and coalition stability. I found that in the 1990, 1996, and 2001 meetings there was one policy dimension that prevailed over the others in shaping the policy debate: The level of support for the ZEV program. This policy-core dimension took slightly different forms for each of these meetings, but they could all be characterized in the same general terms. The 2003 meeting was different in that the debate was more dominated by technological issues and compliance pathways.

At the same time, I found that the policy debates were fairly diverse. Five policy-core dimensions (or beliefs) with eigenvalues bigger than one were found for the last three hearings, while three beliefs were found for the 1990 hearing. Such diversity suggests a more complex policy debate than that found in studies of coalition stability and policy change in other contexts. In general, I found associations between the policy dimensions in one hearing with those in the previous hearing. In all of the last three hearings I found a factor representing a concern with the impacts of tailpipe emissions on public health, a factor representing the level of support of technology forcing regulatory approaches, and factors standing for the levels of support for the extant and proposed forms of the ZEV program.

In terms of stakeholder participation, I found both evidence of fluidity and stability. Table 14 shows a detail of the number of hearing participants over time, discriminated by the stakeholders they represented.

Table 14. Composition of stakeholders giving testimony at ZEV public hearings

Stakeholder group	1990	1996	2001	2003	Total
Auto Industry	12	8	7	3	30
Oil Companies	4	1	1	0	6
Governmental Agencies	6	1	1	5	13
Government	3	5	5	2	15
Public Utilities/Energy	2	1	1	4	8
Electric-drive Industry	1	5	4	13	23
Misc. Associations	0	2	3	1	6
Environmental NGOs	4	7	7	7	25
Research/Science	0	2	4	4	10
Total	32	32	33	39	136

Appendix 2B shows the stakeholders that participated of each of the public meeting coded for this study. The presence of participation fluidity is quite apparent, with many stakeholders giving testimony at only one or two of the meetings. I found 15 stakeholders

who participated in at least three out of the four coded hearings: ALA, CalETC, CARB, CCA, DaimlerChrysler, Ford, Dr. Andrew Frank, GM, Honda, NRDC, PCL, SCAQMD, Sierra Club, Toyota, and UCS. This group represents a 44% of the 34 stakeholders who participated on average of each meeting. While such proportion can be interpreted as evidence of fluid policy participation, it is also clear evidence of the engagement of a baseline fraction of the stakeholders. The more consistent participants are air-quality regulatory agencies, car companies, or environmental groups. This fact is a reflection of the predominant issues that have been at stake along the ZEV debate: the environment and a transformation of the auto industry.

To gain better insight into the question of coalition stability over time, I carry out an analysis similar to those in Sections 4 through 7, but on a dataset resulting from the collapsing of the four individual ones. The results of the factor analysis of the policy-core measurements in this dataset are shown in Table 15. For this aggregate analysis, I obtain six factors with eigenvalues over one, though only three with proportions of at least 0.10. The Pro ZEV Viability factor has by far the largest eigenvalues and, explaining 26% of the variance, represents the most dominant issue in the debate over time. This factor captures the belief that zero-emission vehicles are needed, that their production should be mandated, and that ZEVs are ready for commercialization. The second and third factors are the Pro Tech Forcing and Pro Health Effects, that were found several times in the course of the study.

Table 15. Rotated component matrix of all-hearings policy core items' factor analysis

Item	Component					
	Pro ZEV Viability	Pro Tech Forcing	Pro Health Effects	Anti Mandates	Pro New Proposal	Pro ZEV statutory
LAW	-0.070	0.422	0.066	0.013	0.171	0.462
NEEDED	0.400	0.242	0.132	-0.293	0.407	0.382
PRO_COST_EFF	-0.218	-0.028	-0.092	0.436	0.015	-0.619
PRO_STDBASED	-0.007	0.062	-0.042	0.800	-0.032	-0.195
PRO_MKTBASED	-0.156	-0.032	-0.084	0.725	-0.088	-0.241
ZEV_COST_EFF	0.235	0.094	-0.080	-0.113	0.301	0.727
AIRQUALPRO	0.048	-0.072	0.327	0.700	-0.115	0.317
MOBILE	0.026	0.067	0.863	-0.022	-0.015	-0.054
COMMAND	0.444	0.372	0.116	-0.434	0.249	0.311
SALES	-0.568	-0.289	-0.148	0.268	0.040	-0.183
CA_ECONOMY	0.005	0.025	0.023	-0.051	0.022	0.790
HEALTH_LINK	0.001	0.015	0.856	0.022	0.091	0.092
INNOVATION	-0.036	0.852	-0.028	-0.031	0.017	0.096
TECH_READY_OLD	0.827	-0.119	-0.059	-0.023	0.084	-0.009
TECH_READY_NEW	0.000	0.080	0.063	-0.044	0.905	0.076
ZEV_MKT_OLD	0.906	-0.050	-0.009	0.033	0.062	0.098
ZEV_MKT_NEW	0.132	0.112	-0.007	-0.112	0.875	0.145
TECH_FORCE	0.054	0.862	0.078	0.008	0.145	0.001
Cronbach's alpha	0.773	0.778	0.678	0.558	0.705	0.677
Eigenvalues	4.72	1.95	1.72	1.51	1.34	1.28
Proportion	0.26	0.11	0.10	0.08	0.07	0.07

I perform a partitioning cluster analysis on the first three belief dimensions with increasing numbers of clusters, until I reach a maximum in the *CH* index. Table 16 shows that the *CH* index reaches the first local maxima for $k = 4$—thus I choose a four-cluster solution.

Table 16. Values of the *CH* measure for different numbers of clusters

Number of clusters	Calinski-Harabasz pseudo-F
2	48.57
3	56.22
4	76.01
5	72.56

As shown in Table 17, three of the four clusters are characterized by a high (absolute) value in one of the three policy-core beliefs, while the fourth cluster is characterized by rather moderate positions. The stakeholder membership of these four clusters is also

shown in this table, with the name of the stakeholder followed by the year of participation. To analyze belief stability, of course, I take the testimonies given by the same stakeholder at different points in time as independent observations. Because this table is hard to read and interpret, and because I have shown that there existed a fraction of the stakeholders who showed consistent participation, I present in an abridged version of Table 17, with only these consistent participants.

Table 17. Distribution of policy-core factor means across clusters, and cluster members, all hearings

Policy-core scale	Cluster					Prob > F
	Pro Public Health	Anti ZEV Mandate Viability	Moderate (Pro Program, Anti Tech Forcing)		Pro Tech Forcing	
Pro ZEV Viability	0.27	-1.29	0.43		0.16	0.000
Pro Tech Forcing	0.14	-0.42	-0.52		1.55	0.000
Pro Health Effects	1.99	-0.19	-0.37		-0.42	0.000
Cluster members	ALA 01	AAM 01	AC Propulsion 03	EV Works 03	ALA 03	
	ALA 96	ABTF 96	AIAM 90	EVDC 01	ARB staff 01	
	ARB staff 90	ARB staff 03	ALABC 96	Electricab Corp 03	Avestor 03	
	ARB staff 96	Assembly Firebaugh 01	ARCO 90	Evercel Inc. 03	BAT Int'l 96	
	Assembly Cardenas 01	Assemblyman Baldwin 96	AeroVironment 90	Ford 03	Ballard 01	
	BHMP 01	Assemblyman Bordonaro 96	Avestor 01	Ford 90	Board Boston 96	
	Board C. H. Friedman 03	Board Calhoun 96	BAAQMD 01	GM 90	Board C. H. Friedman 01	
	Board Lloyd 01	Board Lagarias 96	BAAQMD 03	Global Motor 03	Board Calhoun 01	
	Board Lloyd 03	Board Parnell 96	Ballard 96	Green Car Institute 03	Board D'Adamo 03	
	Board Silva 96	Board Riordan 96	Board Burke 01	Honda 90	Board Dunlap 96	
	CBE 01	Board Roberts 01	Board Burke 03	Hydro Quebec 03	Board McKinnon 03	
	CCA 01	Board Roberts 03	Board Calhoun 03	Integral Design 96	CalStart 03	
	CCA 03	CAHT 96	Board D'Adamo 01	LADWP 01	Compact Power 03	
	CCA 90	CAMCDA 96	Board DeSaulnier 01	MA DEP 03	Dr. Dixon 96	
	CCA 96	CANGVC 90	Board DeSaulnier 03	MVMA 90	Dr. Frank 03	
	CalPIRG 96	CEC 90	Board Edgerton 96	Mercedes Benz 90	Dr. Frank 96	
	MELASI 01	CalETC 96	Board Hilligoss 96	Mobility Lab 03	EPRI 03	
	NRDC 96	Chrysler 96	Board McKinnon 01	NESCAUM 96	Energy Conversion Devices 01	
	PCL 03	Daimler Chrysler 01	Board Patrick 01	NRDC 01	GM 01	
	PCL 96	Dr. Anderman 03	Board Riordan 01	NRDC 03	Int'l Fuel Cells 01	
	PEM 96	EPRI 01	Board Riordan 03	Nissan 90	Kirsch Foundation 03	

Table 17 (continuation)

Policy-core scale	Cluster					
	Pro Public Health	**Anti ZEV Mandate Viability**	**Moderate (Pro Program, Anti Tech Forcing)**	**Pro Tech Forcing**	**Pro Public Health**	
Cluster members	SCAQMD 90	Ford 01	Board Roberts 96	Northern Sonoma CAPCD 01	LACTC 90	
	Sierra Research 01	Ford 96	Board Vagim 96	PCL 01	LADPW 03	
	Stanislaus County 03	GM 96	Board W. Friedman 01	PEVDC 03	NY DEC 03	
		Honda 01	Board W. Friedman 03	Phoenix Motorcars 03	NYDEP 01	
		Honda 03	CAPCOA 90	SCAAG 96	SCAQMD 03	
		Honda 96	CFC 01	SCAQMD 01	SMUD 03	
		Mazda 96	CPUC 90	SCE 03	Sacramento County Board 90	
		Nissan 96	CalETC 01	SCE 90	Sierra Club 03	
		Senator Haynes 96	CalETC 03	SMUD 90	Sierra Club 90	
		Texaco 90	Chevron 90	Senator Rosenthal 90	Sierra Club 96	
		Toyota 01	Chrysler 90	Toyota 90	US EPA 90	
		Toyota 03	City of Fresno 03	UCS 01		
		Toyota 96	Dr. Frank 01	UCS 03		
			Dr. Santini 03	UCS 96		
			Dynasty Motorcar 01	Volkswagen 90		
			EDF 96	WSPA 90		
			EMA 90			

Table 18. Distribution of policy-core factor means across clusters for more consistent participants, all hearings

Policy-core scale	Cluster				Prob > F
	Pro Public Health	**Anti ZEV Mandate Viability**	**Moderate (Pro Program, Anti Tech Forcing)**	**Pro Tech Forcing**	
Pro ZEV Viability	0.27	-1.29	0.43	0.16	0.000
Pro Tech Forcing	0.14	-0.42	-0.52	1.55	0.000
Pro Health Effects	1.99	-0.19	-0.37	-0.42	0.000
Cluster members	ALA 01	ARB staff 03	CalETC 01	NRDC 01	ALA 03
	ALA 96	CalETC 96	CalETC 03	NRDC 03	ARB staff 01
	ARB staff 90	Chrysler 96	Chrysler 90	PCL 01	Dr. Frank 03
	ARB staff 96	Daimler Chrysler 01	Dr. Frank 01	SCAQMD 01	Dr. Frank 96
	CCA 01	Ford 01	Ford 03	Toyota 90	GM 01
	CCA 03	Ford 96	Ford 90	UCS 01	SCAQMD 03
	CCA 90	GM 96	GM 90	UCS 03	Sierra Club 03
	CCA 96	Honda 01	Honda 90	UCS 96	Sierra Club 90
	NRDC 96	Honda 03			Sierra Club 96
	PCL 03	Honda 96			
	PCL 96	Toyota 01			
	SCAQMD 90	Toyota 03			
		Toyota 96			

Looking at Table 18, I want to find evidence on the stability of stakeholders' policy positions and on the stability in the grouping of stakeholders (belief coalitions.) Three

stakeholders exhibit impeccable consistency according to my analysis: the Coalition for Clean Air, the Union of Concerned Scientists, and Sierra Club. If the significance of moves between the Moderate cluster and any one of the remaining three is discounted, several quasi-consistent stakeholders are found, including Toyota, Honda, Ford, the California Electric Transportation Coalition, (Daimler) Chrysler, the Natural Resources Defense Council, the Planning and Conservation League, and Dr. Andrew Frank (an academician at the University of California at Davis). The remaining stakeholders exhibited more significant moves between clusters. In particular, CARB's staff moved from the Pro Public Health (1990, 1996), to the Pro Tech Forcing (2001), to the Anti ZEV Mandate Viability cluster (2003). General Motors and Chrysler, who did not attend the 2003 hearing because they were challenging some elements of the program in the courts, were part of the moderate cluster in 1990. GM then fell in the Anti ZEV Viability cluster in 1996, to move to the Pro Tech Forcing cluster in 2001. The latter result, while unexpected, is consistent with my analysis of the 2001 hearing, where GM focused on an Anti ZEV message, but publicly offered a rather accepting position regarding technology forcing.

In the aggregate, most of the five largest auto companies were on the same belief coalition. For the 1990 debate, I found all of them in the Moderate cluster, while for the rest of the hearing they fell in the Anti ZEV Viability cluster (the exceptions were GM in 2001 and GM and DaimlerChrysler in 2003.) This result shows a change in the main policy stance taken by the auto industry from an opposition to technology-forcing approaches in the early stages of the debate, to an opposition to the Mandate on the argument that ZEV technologies and markets were not ready.

The environmental groups, while showing consistent belief at the individual level, do not consistently fall in the same clusters as a group over time. They do have in common that they never stand in clear opposition to the program. Evidence from my interviews indicates that the main bond keeping the environmental coalition (the ZEV Alliance) together was their interest in bringing zero-emission vehicles to the roads. Each member of the Alliance, however, may have somewhat different policy foci and contributes a particular expertise. These considerations help us interpret the results in Table 18. The American Lung Association, the Coalition for Clean Air, and the Planning and Conservation League, whose agenda is more exclusively oriented to a healthy environment, fell more consistently in the Pro Public Health cluster. These groups concentrated their messages on directing attention to the effects of tailpipe emissions on public health. The Sierra Club was represented in all hearings by John White, the person in the Alliance with the strongest political skills. Not surprisingly, it was he who articulated in his testimonies the importance of technology forcing as a regulatory approach. The Union of Concerned Scientists and the Natural Resource Defense Council are the coalition members with the best technical expertise. They are the ones who can better understand the standpoints of industry stakeholders and debate them on technical issues. These two groups consistently fall (with the exception of NRDC in 1996) in the Moderate cluster, which has the highest mean on the Pro ZEV Viability policy-core belief.

The staff of the Air Resources Board is the stakeholder with more variation in its policy positions, according to my analysis. It falls in the Pro Public Health cluster for the 1990 and 1996 hearings, focusing its message on air-quality problems. In 2001, CARB's staff

message was more concerned with supporting technology forcing regulatory approaches. The 2003 policy position of the staff falls in the same cluster that best describes the historical positions of the automakers.

My analysis thus finds some evidence of long-term belief-coalition stability for the auto companies and for the environmental groups. The latter group engages in activity coordination under the umbrella of the ZEV Alliance (which includes also the business-oriented CalETC), and therefore can be identified by a coalition. I do not have evidence, however, of significant coordination between the car companies. Interviewees indicated that some communication often existed prior to the public meetings, but not necessarily to coordinate behaviors. Such communications usually took place at the personal level between policy people in the companies, but it was not necessarily to share or decide the official positions of the respective companies. As indicated by interviewees from industry and CARB, coordination between the car companies is difficult because of the highly competitive nature of this industry.

In view of the results of most previous ACF studies, we need to ask ourselves why stronger evidence in support of coalition stability is not found. Part of the answer may be that the hypothesis that stakeholders in the same coalition share a set of policy beliefs is difficult to test. The hypothesis is not explicit about the level of belief agreement necessary for two stakeholders to be considered part of the same coalition. For example, can two stakeholders decide to join in a coalition based on agreement on one policy dimension, even if they disagree in other dimensions? Testing the hypothesis in its present form is easier when only one or two policy dimensions/beliefs are present. When

more policy beliefs are significant, it may be necessary to refine the hypothesis and make it more explicit about the level of belief agreement that should be tested.

A second possible explanation for the relatively weak association between some of my results and empirical evidence lies in the methodology. Regardless of the rule used to defined cluster (coalition) membership, such rule is an artifact of the analysis. Beliefs exist on a continuous scale and determining the cut-off point that decides whether a stakeholder join one coalition or another is a potential source of error. In other words, errors may enter the analysis when coalition membership choices are determined solely by the distance of the stakeholder's data point to the center of the alternative clusters of stakeholders. Again, these methodology-borne errors may not become apparent in simpler policy analyses with one or two belief dimensions.

A third potential explanation can be found in the data acquisition process. The California Air Resources Board allows the public to give testimony on agenda items at public meetings. While individual citizens regularly take these opportunities to express their views to the Board, these public forums are usually dominated by organized stakeholders. Testimonies at public meetings are not the only channel that stakeholders use to communicate with CARB (other channels include technical documentation, personal communications, private briefings, etc.)[14] Public testimonies do provide a good source of data on stakeholders policy positions because at least three reasons: a) All stakeholders present their testimonies at the same point in time and thus the same external conditions apply to all of them; b) All testimonies address issues concerning the same policy piece—

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[14] CARB's public process requires that Board member publicly report on any ex parte communications they had with stakeholders prior to a public meeting.

that is, they refer to the staff proposal as it stand at that point in time; and c) Stakeholders provide the closest approximation to their actual policy beliefs that can be linked to them without infringing in their confidentiality.

The major source of coalition stability is, however, the fluidity that characterized the ZEV policy process. In other words, the changes in the composition of belief coalitions are, to a large degree, the consequence of stakeholders entering and exiting the policy arena (at least as defined by their participation in public hearings). Once I concentrate in stakeholders with more consistent participation, higher levels of coalition stability are observed. The fluidity of the policy arena may be interpreted as a direct consequence of the evolution of the ZEV program itself. As the program was amended and technological uncertainties evolved, participation in the debate became more or less appealing to different stakeholders. The oil industry tempered its opposition to the program as they started believing that it was less of a threat to its economic interests, electric-drive industry stakeholders participated to support requirements for different drivetrain configurations, etc. Thus, interestingly, like stakeholder participation affected the dynamics of the program, the dynamics of the program affected stakeholder participation in turn.

Appendix 2A: Coding Items

Variable name	Variable definition and coding scale
POLICY-CORE ITEMS	
LAW	1- Proposed regulation is consistent with existing laws/regulations/statutory authority 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
NEED	2- It is necessary promote the introduction of ZEVs 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
PRO_COST_EFF	3- Regulations need to be cost-effective 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
PRO_STDBASED	4- Regulations need to be standard-based 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
PRO_MKTBASED	5- Regulations need to use market-based mechanisms 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
ZEV_COST_EFF	6- The ZEV program (as proposed) is cost-effective 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
AIRQUALPRO	7- Seriousness of the air-quality problem in California 1=Not a problem 2=A problem 3=Serious problem 4=Very serious problem
MOBILE	8- Mobile sources are prime contributors to California's air-quality problems 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
COMMAND	9- Command-and-control measures are needed to bring new technologies like ZEVs to the market 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
SALES	10- The sales of cleaner vehicles/fuels should be determined by the market 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
CA_ECONOMY	11- Impact of the proposed regulations on California's economy 1=Very negative 2=Negative 3=No position/no net impact 4=Positive 5=Very positive
HEALTH_LINK	12- There is a causal link between mobile-source emissions and health problems 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
INNOVATION	13- Regulations can induce significant technological innovation 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
TECH_READY_OLD	14- Technology to meet the standard will be ready for commercialization in the current program's required timeline 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
TECH_READY_NEW	15- Technology to meet the standard will be ready for commercialization in the NEW-proposal's required timeline 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
ZEV_MKT_OLD	16- A significant market for ZEVs will exist in the timeline proposed by the current program 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
ZEV_MKT_NEW	17- A significant market for ZEVs will exist in the timeline proposed by the NEW proposal 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
TECH_FORCE	18- Technology-forcing is an appropriate regulatory approach 1=Strongly opposed 2=Opposed 3-Neutral 4=Support 5=Strongly support
BEHAVIOR	19- Behavior-altering regulations are needed to tackle the problem of air quality 1=Strongly opposed 2=Opposed 3-Neutral 4=Support 5=Strongly support
INTERESTS	20- Impact of proposed regulation on economic interests of organization 1=Very negative 2=Negative 3=No position 4=Positive 5=Very positive
SIP	21- Regulatory proposal results in acceptable air quality benefits 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
FCV_PROMISE	22- Fuel cell technology has good potential to meet ZEV requirements 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree

Variable name	Variable definition and coding scale
BEV_PROMISE	23- Battery technology has good potential to meet ZEV requirements 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
LEADERSHIP	26- California leadership in the regulating air-pollution is important 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
COLLABORATION	27- Collaboration between stakeholders' sides is desirable 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
SECONDARY-ASPECT ITEMS	
SUPPORT	Support or oppose CARB staff's new proposal 1=Strongly opposed 2=Opposed 3=Support/oppose 4=Support 5=Strongly support
SCIENCE	Scientific/technical evidence/data was presented or referred to during the testimony 0=No 1=Yes
DEMO_NEED	Demonstration programs are needed before commercialization of ZEVs 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
INCENTIVES	Incentives for the purchase of ZEVs should be provided 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
FLEETS	Government fleets should be adopters of ZEVs 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
MOA	The MOA improves the likelihood of ZEVs entering the market 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
VOLUME_NEEDED	Requiring greater volumes of qualifying vehicles helps the success of the program 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
ENV_JUSTICE	The ZEV program is consistent with environmental justice 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
FAIR_MKT_TEST	The "fair market test" is a reasonable means to determine whether a market demand for ZEVs exists 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
2009_REQUIREMENTS	ZEV requirements for 2009 and beyond should be determined in the 2003 proposal 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
VOLUME_SILVER	Requiring greater volumes of non-ZEV qualifying vehicles helps the success of the program 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
INFRASTR_CREDIT	Automakers should get ZEV credits for the deployment of hydrogen infrastructure 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
SECTION_177	ZEVs deployed in LEV states should count toward California requirements 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
KEEP_BEVS	Automakers should keep supplying battery-electric vehicles to the existing market demand 1=Strongly disagree 2=Disagree 3-No position 4=Agree 5=Strongly agree
	24- Support technology qualifying as ZEV (specify) _____
SUPP_BEV	24a- Support for battery-electric vehicles 0=No 1=Yes
SUPP_FCV	24b- Support for fuel-cell vehicles 0=No 1=Yes
SUPP_PHEV	24c- Support for plug-in hybrid electric vehicles 0=No 1=Yes
	25- Support for technology getting credit within the program (specify) _____
SUPP_HEV	25a- Support for hybrid electric vehicles 0=No 1=Yes
SUPP_PZEV	25b- Support for partial-zero emission vehicles 0=No 1=Yes

Appendix 2B: Stakeholders Index and Participation of Coded Public Hearings

Stakeholder code	Stakeholder name	Public hearing			
		1990	1996	2001	2003
Auto Industry					
AIAM	Ass'n of International Automobile Manufacturers	1			
CANGVC	California Natural Gas Vehicle Coalition	1			
Chrysler	Chrysler	1	1		
DaimlerChrysler	DaimlerChrysler			1	
Ford	Ford	1	1	1	1
GM	General Motors	1	1	1	
Honda	Honda	1	1	1	1
MVMA	Motor Vehicle Manufacturers Association	1			
Mercedes Benz	Mercedes Benz	1			
Nissan	Nissan	1	1		
EMA	Engine Manufacturers Association	1			
Toyota	Toyota	1	1	1	1
Volkswagen	Volkswagen	1			
Mazda	Mazda		1		
CAMCDA	California Motor Car Dealers Association		1		
AAM	Alliance Automobile Manufacturers			1	
	Sub total	**12**	**8**	**6**	**3**
Oil Companies					
ARCO	ARCO	1			
Chevron	Chevron	1			
Texaco	Texaco	1			
WSPA	Western States Petroleum Association	1	1		
	Sub total	**4**	**1**	**0**	**0**
Governmental Agencies					
CEC	California Energy Commission	1			
CPUC	California Public Utilities Commission	1			
ARB staff	California Air Resources Board staff	1	1	1	1
SCAQMD	South Coast Air Quality Management District	1		1	1
US EPA	U.S. Environmental Protection Agency	1			
LACTC	Los Angeles County Transportation Commission	1			
NYDEP	New York State Dept Env. Conservation			1	1
BAAQMD	Bay Area Air Quality Management District				1
MA DEP	Massachusetts Department of Environmental Protection				1
	Sub total	**6**	**1**	**3**	**5**

Stakeholder code	Stakeholder name	Public hearing			
		1990	1996	2001	2003
Government					
CAPCOA	California Air Pollution Control Officers Ass'n	1			
Sacramento County Board	Sacramento County Board	1			
Senator Rosenthal	State Senator Herschel Rosenthal	1			
Assemblyman Baldwin	Assemblyman Baldwin		1		
Assemblyman Bordonaro	Assemblyman Tom Bordonaro		1		
NESCAUM	Norteast States for Coordinated Air Use Management		1		
SCAAG	Southern CA Association of Governments		1		
Senator Haynes	Senator Ray Haynes		1		
Assembly Cardenas	Assemblyman Cardenas			1	
Assembly Firebaugh	Assemblyman Firebaugh			1	
Northern Sonoma CAPCD	Northern Sonoma County Air Pollution Control District			1	
Stanislaus County	Stanislaus County				1
City of Fresno	City of Fresno				1
	Sub total	**3**	**5**	**3**	**2**
Public Utilities/Energy					
SCE	Southern California Edison	1			1
SMUD	Sacramento Municipal Utility District	1			1
CalETC	California Electric Transportation Coalition		1	1	1
LADWP	Los Angeles Department of Water and Power			1	1
	Sub total	2	1	2	4
Electric-drive Industry					
AeroVironment	AeroVironment	1			
Integral Design	Integral Design		1		
BAT Int'l	BAT International		1		
Ballard	Ballard Power Systems		1	1	
CalETC	California Electric Transportation Coalition		1	1	1
ALABC	Advanced Lead-Acid Battery Consortium		1		
Energy Conversion Devices	Energy Conversion Devices			1	
Int'l Fuel Cells	International Fuel Cells			1	
Dynasty Motorcar	Dynasty Motorcar			1	
Avestor	Avestor Corp			1	
CalStart	CalStart				1
Mobility Lab	Mobility Lab				1
Phoenix Motorcars	Phoenix Motorcars				1
Compact Power	Compact Power				1
AC Propulsion	AC Propulsion				1
Avestor	Avestor				1
Hydro Quebec	Hydro Quebec				1
EV Works	EV Works				1
Electricab Corp	Electricab Corp				1
Evercel Inc.	Evercel Inc.				1

Stakeholder code	Stakeholder name	Public hearing			
		1990	1996	2001	2003
Global Motor	Global Motor				1
Green Car Institute	Green Car Institute				1
	Sub total	**1**	**5**	**6**	**13**
Environmental NGO's					
CCA	Coalition for Clean Air	1	1	1	1
Sierra Club	Sierra Club	1	1		1
ALA	American Lung Association		1	1	1
EDF	Environmental Defense Center		1		
NRDC	Natural Resources Defense Council		1	1	1
PCL	Planning and Conservation League		1	1	1
UCS	Union of Concerned Scientists		1	1	1
PEM	Peoples Energy Matters				
CBE	Communities for a Better Environment			1	
CFC	Clean Fuel Connection			1	
Kirsch Foundation	Kirsch Foundation				1
	Sub total	**2**	**7**	**7**	**7**
Research/Science					
Dr. Dixon	Dr. Lloyd Dixon		1		
Dr. Frank	Dr. Andrew Frank		1	1	1
ABTF	Advanced Battery Task Force		1		
Sierra Research	Sierra Research			1	
EPRI	EPRI			1	1
Dr. Anderman	Dr. Anderman				1
Dr. Santini	Dr. Dan Santini				1
	Sub total	**0**	**3**	**3**	**4**
Other					
CAHT	Californians Against Hidden Taxes		1		
CalPIRG	CalPIRG		1		
MELASI	Mothers of East LA Santa Isabel			1	
BHMP	Boil Heights Mejoramiento Project			1	
PEVDC	Production Electric Vehicles Drivers Coa			1	1
	Sub total	**0**	**2**	**3**	**1**

CHAPTER 3: A MODEL OF STRATEGIC BEHAVIOR OF THE POLICY ACTORS

1. Introduction

The California Air Resources Board (CARB) is the governmental body responsible to regulate criteria-pollutant emissions of new automobiles sold in California. With the Low Emission Vehicle (LEV) program, initiated in 1990 and still active after several revisions, the chosen regulatory approach has essentially been to phase in increasingly cleaner vehicles. As a part of the LEV program, CARB enacted the zero-emission vehicle (ZEV) mandate, which originally required that 2% of the new vehicles sold in California by a major auto manufacturer in 1998 would have to have zero tailpipe emissions. The percentage of ZEVs required ramped up to 5% for the year 2001, and to 10% for 2003 (California Air Resources Board, 1991). Biennial reviews would be held to assess technological progress and decide whether to ratify or revise the mandate.

CARB, concerned mainly with air quality, believed that the industry had the capability to successfully introduce zero-emission vehicles in the market within the specified timeline. The automakers, whose main concern was profit maximization, argued that this goal was unrealistic and cost inefficient. Faced with a very costly regulation and eight years to compliance,[15] the automakers had to decide on the strategy they would pursue in the policy debate. At every two-year period between reviews, the automakers had essentially

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[15] The ZEV program provided some flexibility to comply, for example through a system of marketable credits.

two possible strategies: to try to comply with the mandate through the necessary investment in research and development (R&D), or look for means to avoid compliance (for instance, proposing an alternative program or colluding.)

It is important to notice that compliance is not entirely up to the automakers: regardless of their investment in R&D, obtaining a marketable ZEV in the specified time period could in fact be an unattainable goal. The strategy of investing in R&D was unavoidable to them, as the absence of R&D would give the regulator reason to stick to the original provisions. An investment in R&D would give leverage to the automakers to argue against the viability of the regulation (so long as this R&D did not yield the necessary technological breakthroughs.) The latter is intuitively expected, as the automakers' profit-maximization objective would have been better served with only incremental deviations from the status quo. Thus, on logical grounds, the auto industry is expected to try to show that it is pursuing a composite strategy, that is not only seeking profit, but also seeking innovation and attempting compliance. Malik (1991) compares regulations that allow for reviews before implementation with those that do not allow for this flexibility.

In the literature of environmental regulatory games, the regulator plays a leader role in a noncooperative game, which often receives the name of Stackelberg noncooperative game (see for example, Gibbons, 1992; Mas-Colell et al., 1995.) In such a game, the regulator selects an emission standard and/or abatement technology that takes into account the firms' reaction function for technology. Firms then follow by complying with the regulation (Amacher and Malik, 1996.) It is often assumed or contemplated, however, that the regulator is not able to dictate the abatement technology that the firms

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are to adopt (for example, because of political pressures), thereby being left with the only option of setting emission standards. Malik (1991) shows that it is in general not possible for an environmental policy to attain a first-best optimum if the regulator has no control over the abatement technology. He further suggests that, in policy processes with costly enforcement of regulations and characterized by uncertainty, it may be best for the regulator, not the firm, to dictate the abatement technology. Thus, the regulator may have an incentive to try to dictate not only emission standards, but also the technology. In this respect, the original ZEV mandate is .interesting. While CARB dictated an *emission standard* for a fraction of new vehicles, leaving to the automakers the choice of technology, the only technology that could conceivably achieve the zero-emission goal back in the early 1990's was battery electric vehicles (BEV.) Thus, the regulation *technically* aimed at emission levels, but *effectively* targeted a technology as well.

Probably where the ZEV case differs most from the cases studied in previous work on regulatory games is in that the regulator (CARB) had, particularly at the beginning of the process, a poor knowledge of the firms' reaction function for technology. In other words, the regulatory agency did not know for certain whether the automakers could indeed produce marketable zero-emission vehicles. In fact, one important factor that precipitated CARB's decision to include the ZEV mandate in the LEV program was the announcement by General Motors CEO, early in 1990, that his company would produce and market an electric vehicle by the mid 1990's (Shnayerson, 1996; Doyle, 2000.) Therefore, although CARB led a (Stackelberg) game by setting an emission standard, there was no guarantee in its mind that compliance would follow.

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The objective of this paper is to present a game-theoretic model to study the strategic behavior of policy actors when there is one regulator and two regulated firms. The model was conceived as a simplification of the ZEV mandate, but it can certainly be used to other policy scenarios that meet the general configuration of the model. Section 2 briefly describes the main policy players in the actual ZEV debate. Section 3 follows that introduces and discusses the model. Section 4 presents the analysis and results. Finally, in Section 5 I present some conclusions and summary of the results.

2. The Players

The policy debate around the ZEV regulation involves myriad actors from many different sectors of society. The two actors most directly involved are undoubtedly the regulatory agency (CARB), and the automobile industry. The automakers have often been represented by the Automobile Manufacturers' Alliance (AMA). Thus, in its simplest form, the policy process could be modeled as a game between two players, CARB and AMA.

Given the potentially big environmental and economic implications of the ZEV regulation, many actors entered the policy debate as well. From among these, the most influential were oil companies, like Arco and Exxon, utility companies like Southern California Edison and Sacramento Municipal Utility District, health groups like the American Lung Association, and environmental groups like the Natural Resources Defense Council and Sierra Club. These actors usually joined forces into organizations that represented their common interests. Examples of these groups are the Western States

Petroleum Association, in opposition to the regulation, and the California Electric Transportation Coalition and the ZEV Alliance, in support.

In policy processes with potentially substantial impacts on the general public, the mass media can play significant roles. In California, historically, the printed media, particularly the Los Angeles Times and The Sacramento Bee, have been very active in keeping their readers aware of environmental problems, particularly those related to air quality. While this activism has lost intensity with the relative improvement of the quality of the air during the last several years, the coverage given to the issue in the years of the mandate's inception was extensive.

A final important set of actors is constituted by research and development (R&D) centers and experts related to technologies involved in the regulation. These actors are potentially very important, as they may affect the information asymmetry typical in regulatory processes involving technological innovation. They limit the ability of the regulated industry (automakers) to hide their innovation capability.

3. The Model

Having outlined some of the features of the ZEV process that may need special consideration in the model, let us start to formalize the policy process in the form of a game. Originally, the driver behind the regulation was twofold: concerns with poor air quality and the automakers' belief that there were not sufficient (market) incentives to invest in the development of substantially cleaner technologies. The impacts of the new

light-duty vehicles sold by a given firm on air quality (on human health, crops, visibility, and the environment) are represented here by a damage function

$$D(\mathbf{x}, \mathbf{n}) \qquad \textbf{Equation 3}$$

Assuming the fleet of new vehicles sold by a given automaker in the State of California is composed of s segments with different emission levels where, $\mathbf{x} = [x_0, x_1, ..., x_s]$ is the vector of per-mile level of emissions of each of these segments, and $\mathbf{n} = [n_0, n_1 ..., n_s]$ is the vector of quantities of new vehicles within each of the segments. The vector $\mathbf{x}$ is assumed ordered, with x_0 being the lowest emissions level and x_s the highest.

In turn, the emission level achievable at a given point in the future can be expressed as a linear combination of a baseline (or mainstream) level and a function of R&D:

$$x = x_s - f(RD) \qquad \textbf{Equation 4.}$$

That is, the greater the investment on R&D, the cleaner will be the technology available to the firm.[16]

Notice that the presence of $\mathbf{n}$ among the arguments of D suggests, intuitively, that the regulator may have an incentive to tinker with the free market and try to influence the number of cleaner vehicles sold. This may complicate the policy problem, as it may affect market prices of vehicles, which would in turn influence market demand.

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[16] In actuality, this relation represents an *expectation* of the rewards from research and development in terms of technological breakthroughs.

Amacher and Malik (1996) submitted that the objective function that an environmental regulator strives to minimize has to form

$$R(x, \beta; \theta) = \theta C(x, \beta) + D(x) + E(x, \beta) \qquad \textbf{Equation 5,}$$

where E is the expected cost to ensure compliance, and θ is a parameter between 0 and 1 that characterizes the regulator in terms of the weight it gives to the firm compliance costs, relative to the damage and enforcement costs.[17] They call *neutral* a regulator for whom $\theta = 1$ and *biased* a regulator for whom $\theta < 1$. A couple of comments are in order regarding this formulation. From the standpoint of pure game theory, it could be argued that there is no reason why the regulatory agency should include the costs to the firm into its utility function, as its only concern should be air quality. Under this argument, if the emission standards that the agency sets are too stringent, they may impose too high costs on the firm for it to comply, the firm would simply choose a non-compliance strategy, and the environmental goals of the regulator would not be served. Thus, theoretically, the costs to the firm could simply enter the regulator's utility function through the damage function. In real policy settings, however, the costs of a regulation are, in one way or another, taken into account. This reality manifests itself through the (often required) use of cost-benefit analysis in the process of selection from among policy alternatives.

The neutral vs. biased terminology is also unfortunate. The generic portrayal of a regulator as biased just because it does not give the same weight to the costs to society and the costs to the firm is, at best, unfair. Finally, the estimation of such parameter may be very difficult, and probably subjective. The firm's cost is likely to be unknown to the

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[17] To Amacher and Malik, β is a measure of the dirtiness of the technology.

regulator. While the firm may make information on this cost available to the regulator, this may be inclined to be suspicious of the accuracy of such information. Trust here is potentially an important factor. In view of these considerations, all the regulator has available is an *expected* cost to the firm.

One possibility would be to define CARB's objective function as

$$R(x, \beta, n) = \mathcal{E}[C(x, \beta)] + D_R(x, n) + E(\beta) \qquad \textbf{Equation 6,}$$

where $D_R(x, n)$ is the *regulator's* valuation of the damage function. This formulation remains along the lines of that proposed by Malik (1991) and Amacher and Malik (1996), in that the costs to the firm enter the regulator's preference function. Notice that the enforcement cost is assumed to depend solely on the technology, and not on emissions level. Contrary to the typical case studied in the literature, enforcement costs do not depend on the probability of auditing the firm. The regulator will simply check whether the technologies adopted by the firm comply with emission standards.

I submit that, in the context of the ZEV mandate, the regulator's preference function may have the simplified general form

$$R(x, n, RD) = \alpha_1 D(x, n) + \alpha_2 C(x, n) + \alpha_3 x_{MIN}(x, RD(x)) \qquad \textbf{Equation 7,}$$

CARB then sets a single emissions level (as opposed to a vector of emission levels), and requires the same number of new vehicles with this emissions level from all the automakers. This constitutes a simplification of the actual case, where CARB required the same *percentage* of cleaner new vehicles from all the largest automakers. In this form

of the social cost, $x_{MIN}(x, RD)$ is the lowest level of emissions that could be developed in a certain period of time, which is a function of R&D, as described above. This term is included to control for the possibility (as suggested by some pieces of evidence), that part of the mandate's rationale was to encourage innovation in cleaner technologies. Cleaner technologies will be obtained with higher firm investments in R&D, as denoted by the presence of *RD* among the arguments of this function. The dependence of the function on *x* indicates that the regulator contemplates the possibility that the firms will decide not or be unable to obtain the required level of emissions—that is, x_{MIN} does not necessarily equal *x*. In fact, I model R&D as a function of *x* itself, to account for the influence that the standard set by the regulator may have on R&D strategies adopted by the firm. What the regulator is likely to expect, given the gap between market and societal drivers to reduce emissions, is that $x_{MIN} \geq x$ — that is, the automakers will not develop vehicles that are cleaner than required. One possible strategy for the regulator then is to require lower emissions than necessary, in hope to pull x_{MIN} to "ideal" levels.

Although, as mentioned above, normatively, there is no reason why the regulator should consider the costs to the firm, the history of the ZEV policy process suggests that CARB may have chosen a non-normative regulatory path in this respect. The coefficients α_i represent the weights that CARB gives to each of the postulated components of its utility function. As pointed out before, the precise estimation of such coefficients may prove very difficult, but determining at least whether they were equal to or bigger than zero would be an important finding.

The proposed formulation contemplates the possibility that CARB behaved as a benevolent regulator ($\alpha_2 > 0$) and/or an economic-technology broker ($|\alpha_3| > 0$), and not only as a neutral regulator whose motivation is strictly the reduction of air pollution.[18] Nentjes (1988) and Kemp (1997) allow time to enter the utility function of the regulator, thus accounting for the depreciation of reductions in emissions. The regulator would prefer emission reductions to be achieved as soon as possible, but it would also be willing to compromise and grant the firm more time to develop cleaner technologies. That is, the regulator can opt between a certain reduction in emissions earlier and a greater reduction later. The effects of time are not accounted for in the formulation. The costs of enforcement are neglected for reasons discussed above.

Since the zero-emission goal cannot be achieved by merely improving the mainstream technology (internal combustion engine), CARB knows that its piece of regulation implicitly requires from automakers to invest in developing new or improving existing alternative powertrain technologies. Most of the literature on regulatory games considers two players: the regulatory body and the regulated industry. I account for the presence of more than one regulated firm in the actual policy process, and for the sake of tractability I consider only two regulated players.[19] The total cost of compliance to the automobile companies is assumed to have the general form

$$C_i\left(x, n_i, RD\right) = K\left(x, RD\right) + V\left(x, n_i, RD\right) - N\left(x_j - x_i\right), \quad \forall i, j = 1,2 \qquad \textbf{Equation 8.}$$

The costs of non-compliance, on the other hand, are

$$C_i(x, m_i, RD) = K(x, RD) + V(x, m_i, RD) + f(n_i - m_i) - N(x_j - x_i), \quad \forall i, j = 1,2$$

Equation 9.

Here, K and V are the fixed and variable costs associated with the production of the new technology respectively, m is the number of vehicles produced with a certain level of emissions, n is, as before, the number of these vehicles the firm is required to produce. As a variation of the cost function, the fixed costs of production could be affected by the Heaviside function, $H(m)$, which will be equal to one when $m > 0$, and equal to zero otherwise. f is the fine that the firm faces for every unit that the firm fails to produce (assumed to be constant for every type of vehicle). $N(x_j - x_i)$ is the expected impact on competitive advantage that may result from a given strategy. In other words, the firm may see a competitive opportunity in developing and marketing cleaner vehicles, and/or may fear a competitive disadvantage that could result from a decision not to comply if a competitor does comply. The argument of N indicates that the competitive (dis)advantage that may result from (non-)compliance depends on the difference in cleanness of the technologies developed by the different automakers. This term should be understood as an expectation, since at the moment of the strategic decision regarding the regulation (to comply or not to comply), the firms are uncertain about the market potential of a certain cleaner technology. It is important to realize that the actual success or failure of a new cleaner technology that is developed as a result of the regulation is not relevant to the game, as these are outcomes of the strategic decision. Since I deal with expected outcomes and not actual outcomes, the term $N(x_i - x_j)$ is not endogenous to the game. As a final comment on the proposed cost function, notice that the arguments of this function differ from the cost function considered by the regulator. While the firm will

choose *m* to minimize its costs, the regulator bases its cost estimates on the assumption that the firm will comply, and thus takes $m = n$.

This formulation differs from that of Amacher and Malik (1996) in several respects. First, their version of the firm's costs includes only the first two terms of the above expression. Second, their variable costs are a function of the technology and emissions. Third, I allow for firm innovation strategies through the introduction of a research and development variable (*RD*.) Fourth, I take different cost functions for the cases of compliance and non-compliance, to simplify the analysis, and obtain different policy scenarios. Fifth, my formulation does not assume that the fine is such that ensures firm's compliance. Here, the fine enters the firm's cost function, thereby providing the firm with the option of noncompliance as a cost-minimizing strategy. In its original version, the ZEV mandate applied to manufacturers with an annual sales volume in California of 35,000 vehicles or more, and the fine specified by CARB was of 5,000 dollars for each zero-emission vehicle that the firm failed to deliver below the required number. Failing to comply with the regulation altogether would have then resulted in a fine of at least 3.5 million dollars for each year with a requirement of 2% zero-emission vehicles.

In the literature, enforcement is characterized by two variables: a fine for non-compliance, *f*, and an audit probability, *p*. In order to ensure partial compliance by the polluting firm, the product $p \times f$ (the expected fine) has to be greater than the cost of abatement. To ensure complete compliance, the *marginal* expected fine has to be greater than the *marginal* cost of abatement. Malik (1991) and Amacher and Malik (1996) assume that the amount of the fine is beyond the control of the regulator, and it is set by a

legislative body. Building on this assumption, they claim that the regulator can ensure compliance by appropriately setting the value of p, the audit probability, which directly affects the cost of enforcement (see Malik, 1991, p. 130.) This reasoning is not entirely correct however, as even if the regulator sets $p = 1$, compliance might not follow if the fine level is not high enough. In fact it seems a good policy recommendation to let the regulator participate in the determination of the amount of the fine, since it is $p \times f$, not just p, that directly affects the social cost of enforcement.

The decision variables of the regulator, x and n, can be functionally associated to each other. Although CARB was and is very interested in the automakers obtaining viable zero-emission technologies, its most defining objectives are to reduce air pollution and promote technological innovation. For instance, as argued by CARB, the mandate played a major role in the development of hybrid electric vehicles (HEVs), which are not only cleaner than standard vehicles, but also incorporate technologies that, with further R&D, could be used in zero-emission vehicles. Thus, as it actually happened, CARB may be willing to trade level of emissions for number of vehicles. This is because a certain number of ZEVs can yield a reduction in overall emissions equivalent to a certain, bigger number of hybrid electric vehicles, and because internal combustion engines tend to emit more as they age.

If CARB wanted to reduce the total amount of emissions from the current levels to a level X_{new}, it could allow the automakers to achieve that goal by either introducing n_0 ZEVs (with emissions $x_0 = 0$) or n_1 cleaner vehicles with emissions of $x_2 > x_1 > x_0$, where x_2

is the level of emissions of the mainstream technology. It can be shown that, to achieve the new total level of emissions, the relation that the automaker needs to satisfy is

$$n_1 = \frac{x_2 n_{tot} - X_{new}}{x_2 - x_1} \qquad \textbf{Equation 10,}$$

where n_{tot} is the total number of vehicles sold, that is $n_{tot} = n_1 + n_2$. If, through R&D, an automaker attains a marketable zero-emission technology, and chooses this technology to comply with the mandate, then for this automaker $x_1 = x_0 = 0$, and the number of vehicles it will be required to produce is

$$n_1 = \frac{x_2 n_{tot} - X_{new}}{x_2} \qquad \textbf{Equation 11.}$$

This relation can be generalized to the case that CARB requires at least some percentage of new vehicles to be zero-emission.

Defining α_2 and α_3 as the weights relative to α_1, the regulator's problem is then to minimize its social cost function:

$$\min R(x, n, RD) = D(x, n) + \alpha_2 C(x, n) + \alpha_3 x_{MIN}(x, RD) \qquad \textbf{Equation 12.}$$

Here the decision variables are x and n. In words, the regulator will choose the level of emissions that the automakers need to achieve, and the number of vehicles with this level of emissions that the automakers need to sell.

4. Analysis

The firms' problem is to minimize its costs. I consider the case that the automakers have three possible strategies: full compliance (produce the required number of vehicles, n, with the required level of emissions, x_0), non-compliance (produce only vehicles with mainstream emissions level, x_2), and partial compliance (produce vehicles with a certain, higher than required, but lower than mainstream, level of emissions, $x_2 > x_1 > x_0$.) Thus, the firms' problem is

$$\min_{RD} C_i(x_0, n_i, RD) = K(x_0, RD) + V(x_0, n_i, RD) - N(x_j - x_0), \quad \forall i, j = 1,2 \qquad \textbf{Equation 13.}$$

for the case of full compliance with the regulation ($x = x_0$ and $m = n$),

$$\min_{RD} C_i(x_1, n_i, RD) = K(x_1, RD) + V(x_1, n_i, RD) - N(x_j - x_1), \quad \forall i, j = 1,2 \qquad \textbf{Equation 14}$$

for the case of partial compliance, ($x = x_1 > x_0$), and

$$\min_{RD} C_i(x_2, n_i, RD) = f(n_i) - N(x_j - x_2), \quad \forall i, j = 1,2 \quad \textbf{Equation 15}$$

for the case of non-compliance ($m = 0$.) Given the asymmetry of information regarding the industry's innovation capabilities, the regulator is reluctant to charge the fine to automakers that, though not achieving the required level of emissions, do develop cleaner technologies. Thus, the fine term does not enter the cost function of the partially-complying firm.

If the investment in R&D can be unequivocally determined from Eq. 2 for the chosen level of emissions, the optimization problems for the firm would become trivial, and I would obtain

Compliance: $C_i(x_0, n_i) = K(x_0, RD(x_0)) + V(x_0, n_i, RD(x_0)) - N(x_j - x_0), \quad \forall i, j = 1,2$

Equation 16;

Partial compliance: $C_i(x_1, n_i) = K(x_1, RD(x_1)) + V(x_1, n_i, RD(x_1)) - N(x_j - x_1), \quad \forall i, j = 1,2$

Equation 17;

Non-compliance: $C_i(x_2, n_i) = f(n_i) - N(x_j - x_2), \quad \forall i, j = 1,2$

Equation 18.

However, if the same level of emissions could be achieved with different investments in R&D, firms would solve the optimization problem corresponding to their compliance strategy to decide on their optimal investment in R&D.

The first-order condition for x in the regulator's problem is

$$R_x(x,n) = [D_x(x,n) + D_n(x,n)n_x] + \alpha_2[C_x(x,n) + C_n(x,n)n_x] + \alpha_3 \frac{\partial x_{MIN}(x, RD)}{\partial x} = 0,$$

Equation 19.

I have $D_{x_i} > 0$, as the higher the emission levels allowed by the regulator in each vehicle category, the bigger the damage. Also, $D_{n_i} < 0$, as the more cleaner vehicles of any type required by the regulator, the lower the damage; $\partial x_{MIN}/\partial RD \geq 0$, since more R&D will not yield dirtier technologies; $C_{n_i} > 0$, as more cleaner vehicles cost more to the firm; $C_x < 0$, since cleaner technologies are more expensive to develop; $n_x > 0$, as the number of vehicles of a given level of emissions required grows with the level of emissions.

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Determining the sign of $\partial x_{MIN}/\partial x$ may be not so trivial. Intuitively, one may expect this gradient to be positive, which is certainly the likely case for incremental deviations of the required emission levels from the mainstream levels. However, a regulation requiring radical reductions in emissions may trigger unexpected reactions on the automakers, who might, for example, choose to present a tougher opposition and become reluctant to invest in cleaner technologies. The regulator could then face many possible reaction curves, examples of which are shown in Figure 1.
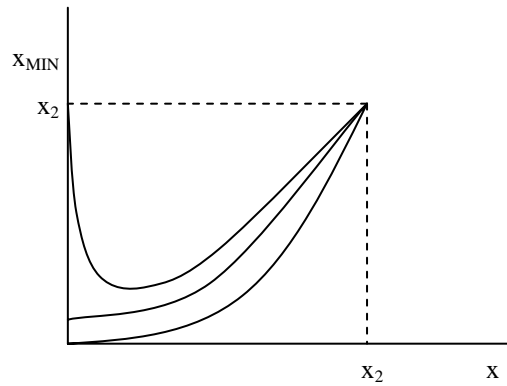

Figure 1. Examples of response curves of cleanest technology developed as a function of required cleanness

Thus, the sign of the derivative of x_{MIN} with respect to x would depend on x. In practice, the regulator would expect the reaction curve to vary from automaker to automaker, which further complicates the problem.

In view of the signs of each of the terms, the first-order condition can be written as

$$D_x(x,n)+\alpha_2 C_n(x,n)n_x+\alpha_3\frac{\partial x_{MIN}(x,RD)}{\partial x}=D_n(x,n)n_x+\alpha_2 C_x(x,n),\qquad \text{Equation 20}$$

for x_{MIN} increasing with x, and

$$D_x(x,n) + \alpha_2 C_n(x,n) n_x = D_n(x,n) n_x + \alpha_2 C_x(x,n) + \alpha_3 \frac{\partial x_{MIN}(x,RD)}{\partial x},$$ **Equation 21**

for x_{MIN} decreasing with x.

The problem described could be basically presented as a leadership (or Stackelberg) game, whereby the regulator makes the first move setting the required level of emissions, and the firms subsequently decide on a strategy based on the regulator's move. This game is presented in the schematic in Figure 2.
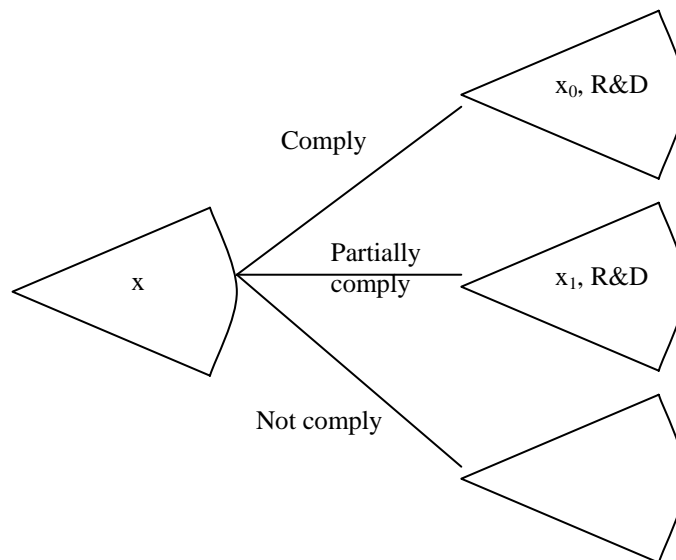

Figure 2. Stackelberg game in the model of the ZEV regulation

The presence of more than one firm makes the problem more complicated. Given the form of the cost function, there may be an incentive for each firm to use the mandate to gain a competitive advantage. If one firm manages to develop complying technologies while the other does not, the former may position itself at a competitive advantage in a potential new market niche of clean vehicles. To do so, however, the firm would need to invest substantially in R&D. The other firm would have the same incentives to invest in

R&D: if it does, it may gain a competitive advantage, and if it does not, it risks placing itself at a considerable disadvantage if its competitor does innovate. Both firms may thus end up innovating, bearing the associated costs of R&D, but without gaining an advantage over their competitor. Therefore, their costs would be higher than if they had opted not to comply. The firms are then potentially playing a prisoner's dilemma game.

Once CARB decides on the required level of emissions, x_0, the automakers would then play the strategic game shown in Figure 3.

	Comply	Partially comply	Not comply
Comply	$-K(x_0)-V(x_0)$, $-K(x_0)-V(x_0)$	$-K(x_0)-V(x_0)+N(\Delta)$, $-K(x_1)-V(x_1)-N(\Delta)$	$-K(x_0)-V(x_0)+N(\Delta)$, $-f-N(\Delta)$
Partially comply	$-K(x_1)-V(x_1)-N(\Delta)$, $-K(x_0)-V(x_0)+N(\Delta)$	$-K(x_1)-V(x_1)$, $-K(x_1)-V(x_1)$	$-K(x_1)-V(x_1)+N(\Delta)$, $-f-N(\Delta)$
Not comply	$-f-N(\Delta)$, $-K(x_0)-V(x_0)+N(\Delta)$	$-f-N(\Delta)$, $-K(x_1)-V(x_1)+N(\Delta)$	$-f$, $-f$

Figure 3. Strategic game played by two industry players after standards have been set

Given the social cost function

$$R(x,n,RD)= D(x,n)+\alpha_2 C(x,n)+\alpha_3 x_{MIN}(x,RD), \quad \textbf{Equation 22}$$

in general, CARB is expected to prefer an equilibrium with the lowest possible emissions; that is

$$D(x_0, n) + \alpha_2 C(x_0, n) + \alpha_3 x_0 < D(x_1, n) + \alpha_2 C(x_1, n) + \alpha_3 x_1$$
$$< D(x_2, n) + \alpha_2 C(x_2, n) + \alpha_3 x_2$$

Equation 23.

If $\alpha_2 > 0$, however, requiring x_0 to be too low might cause the firm costs to be such that the social cost would be better served with emission levels of x_1.

As discussed above (and shown in practice during the ZEV process), because of the uncertainties involved regarding the firms' capabilities to comply fully (due to asymmetric information), the regulator is reluctant to impose a fine to the automakers, unless there is clear evidence that the firm's strategy is of non-compliance. This reality is shown in Figure 3, where the regulator applies no fine whenever the firm is apparently trying to comply by investing in R&D and, at least, developing cleaner technologies (though not as clean as desired by the regulator.)

The situation that the regulator would like to prevent the most is that in which at least one of the firms chooses not to comply (one of the firms does not invest in R&D and therefore develops no cleaner technologies.) The tool that the regulator has to prevent such situation is the fine for non-compliance. To induce the firm to develop cleaner technologies, the fine must be such that

$$f > K(x_1) + V(x_1) \qquad \textbf{Equation 24.}$$

Assuming that CARB is able to accurately identify and set this fine level, none of the cells involving non-compliance is an equilibrium, and the problem reduces to the four cells on the upper left corner—the firms will at least partially comply.

If

$$K(x_1) + V(x_1) > K(x_0) + V(x_0) - N(\Delta)$$
Equation 25

however, each firm would have an incentive to move to compliance both because it could position itself at a competitive advantage and because it would expect its competitor to attempt a similar move, which would position the firm at a competitive disadvantage. Thus, if the condition above holds, the equilibrium would be for both firms to comply. This equilibrium could potentially be changed however if communication between firms exists. If the condition

$$K(x_1) + V(x_1) < K(x_0) + V(x_0)$$
Equation 26

holds, both firms would be better off agreeing to comply only partially, and argue before CARB that no better improvements in emission levels could be achieved despite real efforts in that direction—that is, collusion would be a better strategy to both firms.

What eventually happened in the ZEV policy process is that firms partially complied, investing most of their efforts to developing cleaner technologies, while less—though still significant—resources were directed to developing zero-emission vehicles. The interesting question is whether the automakers chose this strategy because the condition $K(x_1) + V(x_1) > K(x_0) + V(x_0) - N(\Delta)$ did not apply (for example, they believed there was

no substantial competitive advantage to be gained because there was no sizeable market for zero-emission vehicles), or because they formed an organized coalition to avoid the higher costs of joint compliance.

If the former reason applied, CARB could have probably avoided it by setting less stringent emission standards, say $\hat{x}_0 > x_0$, so that $|N(\Delta)|$ would be sufficiently larger to make the condition

$$K(x_1) + V(x_1) > K(\hat{x}_0) + V(\hat{x}_0) - N(\Delta) \qquad \textbf{Equation 27}$$

hold, thus obtaining the comply-comply equilibrium. It has in fact been argued that the zero-emission requirement of CARB was unreasonable and that more cost-efficient outcomes could have been obtained with different, more moderate standards (e.g. Dixon *et al.*, 2002.) If the reason for the equilibrium observed in reality was collusion, there is little the regulator could have done to change this equilibrium, given its uncertainty about the real costs to the firms. However, from a game-theoretic standpoint, collusion is not viable in a situation like that described in my model, where both industry players have a simultaneous, one-shot opportunity to choose their strategy. Even if communication between these parties existed and they had agreed—before choosing their strategy—to collude, they would both have an incentive to cheat and obtain competitive advantage. This result is in fact reflective of reality: evidence from interviews with representatives from industry and CARB confirms that policy cooperation between industry players is extremely difficult, due to the competitive nature of the car industry.

Another important question with policy implications is what would the equilibrium have been had CARB failed to accurately estimate the necessary fine, and had instead set it such that the condition

$$f < K(x_1) + V(x_1) \qquad \textbf{Equation 28}$$

held. In this situation, the fine does not rule out the possibility of joint non-compliance. The automakers, however, would have an incentive to move toward partial compliance by investing at least some resources in developing a cleaner technology. This would be so primarily because of the competitive advantage they would gain in a market niche for cleaner vehicles, but also because their partial compliance would result in a fine on its competitor if this chooses not to comply. Given these incentives to invest in reducing emissions, the equilibrium situation would be for both automakers to at least partially comply.

Utilizing my discussion on the upper left-corner game, I can conclude that, here too, partial compliance is the game's equilibrium. As before, the automakers could have obtained a better common outcome by agreeing not to comply—that is colluding and potentially paying a fine. It is likely that paying the fines would have been less costly to the automakers than developing and producing vehicles with lower emissions.[20] If this was true, the fact that firms partially complied in practice may be additional evidence that the automakers did not engage in collusion and that their strategic choices were determined by competition considerations. Further, if one accepts this as valid evidence of non-collusive behavior, the same argument could be used in the discussions relating to

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[20] This depends however on how much lower emissions were sought. Radical changes in technology for example are much more costly than incremental improvements of the mainstream technology.

the equilibrium when $f > K(x_1) + V(_1)$, to show that the partially-complying equilibrium was arrived at because of reasons unrelated to collusion.

5. Discussion

A game-theoretic model was presented of the strategic behavior of a regulatory agency and two regulated firms in an environmental policy process. I used the model to study the behavior of the main actors in the Zero-Emission Vehicle mandate policy process: the California Air Resource Board and the automobile manufacturers. The model improves in several aspects over previous models of regulatory games, thus capturing key characteristics of the ZEV policy process, as reflected in practice. Two important contributions are:

a- The model presented here does not assume that the regulator can ensure compliance. This approach has the benefit of providing insight into the causes of non-compliance of firms in many real environmental regulatory processes.

b- The model accounts for the participation of more than one regulated firm. It is shown that when two firms participate simultaneously, they may be led to play a prisoners' dilemma game that would lead both firms to comply with the regulation at least partially.

As a counterintuitive result with policy implications, it was shown that, when more than one firm is simultaneously regulated, the regulator does not need to determine accurately the level of the fine that would theoretically enforce (full or partial) compliance. The

regulator can use to its benefit the prisoners' dilemma game played by the firms and induce them to develop cleaner technologies.

Where the regulator needs to be more careful is in the determination of the emission standards. A form of the social cost function was proposed which includes the lowest level of emissions achieved by a technology that a regulated firm may develop. Following common sense, the utility of the regulator will increase the cleaner the technologies developed. However, the cleanness of these technologies was shown to be dependent on the level of emissions standard set by the regulator. Setting too stringent a standard may result in lowering the market incentives for the firms to attempt compliance.

The model shows that colluding behavior is unlikely because competition creates incentive for industry players to cheat and defect any agreement with the competition. This result is consistent with empirical evidence. The regulatory agency should account for this "competition factor" when setting its strategy. By setting standards such that the potential competitive advantage of compliance is appealing, would deter industry from seeking collusion. By the same token, if compliance offers no competitive advantage potential, collusion might become attractive. Empirical evidence from interviews shows that CARB did use the competitiveness of the industry as a means to prevent a unified industry front against the ZEV program.

SUMMARY & CONCLUSIONS

I have presented, in the preceding chapters, an analysis of the policy process of the California Zero-Emission Vehicle mandate. In each of the chapters I looked at different aspects of this policy process and used a variety of theoretical frameworks. The first chapter focused on the process of implementation of the original mandate, the second chapter centered on the policy change and coalition stability over a time span of 14 years, and the third chapter offered an analysis of policy strategic behavior as related to the main policy actors. In this final chapter, I will summarize and integrate the major findings (described in detail in the Discussion section of each of the chapters.)

I found that Multiple Streams (MS) provided a reasonably adequate framework to study the origins of the ZEV mandate as a policy idea, while it provides no help on the study of the implementation process. The metaphorical notion of three streams—problem, policy, and politics—proved useful to describe and categorize the main factors leading to the policy idea. However, I found—consistent with criticism by other scholars—that the three streams cannot be assumed independent of each other.

A finding consistent with the postulates of MS is that the birth of the ZEV mandate as a policy idea can be interpreted as a window of opportunity (defined as simultaneously favorable "streams" of problems, policy, and politics) exploited by a policy entrepreneur. I identified such policy entrepreneur in Don Drachand, a senior member of CARB's staff. One of the more important factors that contributed to the opening of the window of opportunity, was General Motors' decision to introduce the Impact (later called the EV-

1.) This vehicle helped improve the image of electric vehicles and gave CARB's staff the courage to include the ZEV mandate in the LEV language.

My analysis shows that a central factor that determined the choice of a mandate—as opposed to an incentive-based instrument—was distrust. CARB felt that no other policy mechanism could extract the best effort out of the car companies to develop and commercialize electric vehicles. Other factors were also central. Mandates were a more common part of the policy/political language before Newton Gingrich and the Republican Revolution. Under current circumstances, a policy like the ZEV mandate would have little chance to enter the language of any regulatory proposal, let alone survive the implementation process. Because of the importance of understanding the policy attitudes at pertinent points in time to understand particular policy processes, extrapolations of lessons from one process to another ought to be done with caution.

Proper understanding of technological, economic, and market factors is also imperative before extrapolating lessons from previous processes. In this respect, the ZEV mandate offers an illustrative example. On implementing the Mandate, CARB improperly generalized previous regulatory experiences. Technology-forcing, command-and-control regulations had been effective in bringing to the market innovations like catalytic converters. The same regulatory philosophy was adopted with the ZEV mandate, without fully comprehending the implications of the radical innovations that would necessarily be involved in complying with the requirements. CARB, however, showed flexibility to effectively incorporate some of these lessons into the revisions of the program.

My analysis shows that the structure of the regulatory piece was an essential factor for the Mandate to survive the implementation debate. The Mandate was described by some interviewees as "an afterthought." Indeed, the ZEV requirements were almost a last-minute very minor addition to a much larger and complex regulatory piece like the Low Emission Vehicles and Clean Fuels program. The LEV program included challenging emission requirements with earlier compliance deadlines. The program also allowed for biennial reviews. This regulatory structure directed the attention efforts of the regulated industry to more immediate elements like the ULEV emission standards. Industry felt that the requirements on ZEVs were not as serious as the ones on internal combustion vehicles, and that they could safely present a tougher opposition at a later point in time.

Stakeholder engagement in the debate over the ZEV mandate was relatively low initially. As discussed, their attention was more directed to the more dominant elements of the LEV regulation, like the fuel mandates and more immediate clean-vehicle requirements. Over time, as shown by my analysis of policy dynamics, stakeholder engagement increased significantly. Unlike the first public hearing, the Mandate was discussed as a separate policy piece after 1990. Intensely debated public hearings focused on the Mandate were held every two years. Stakeholder participation was found not only to increase but also to show some fluidity. One of the economic impacts of the ZEV program was to encourage an "electric-drive industry" comprising battery developers, electric-drive components, fuel-cell developers, recharging infrastructure developers, and other groups. While these groups' participation sought to strengthen the ZEV program, the oil industry participated to weaken it. During the ZEV debate, the latter was

represented by the Western States Petroleum Association, which in turn sponsored lobbying groups to help in their cause.

There has been a two-way causal relationship between the participation of such groups and the evolution of the ZEV program, which was one important reason for the observed fluidity. For instance, the oil industry showed no specific concern with the ZEV mandate at the beginning as the industry efforts were focused on the fuel provisions of LEV I. The oil industry's attacks on the ZEV mandate increased toward 1996 and essentially stopped afterwards as it became persuaded that electric vehicles were unlikely to represent a significant threat to their share of the market for transportation fuel.

I used multivariate analysis to identify the policy-core dimensions that characterized the policy debate at different points in time. My analysis shows that the level of support for the ZEV program was the policy dimension that dominated the debates in the 1990, 1996, and 2001 meetings. The debate in the 2003 meeting was more dominated by technological issues and compliance pathways. While generally one policy dimension was significantly more important in shaping the policy debate, I found that the policy debates were fairly diverse. Such diversity suggests a more complex policy debate than that found in studies of coalition stability and policy change in other contexts. Policy dimensions that frequently entered the debate over time were the concern with impacts on public health of tailpipe emissions, the degree of support for technology forcing as a regulatory approach, and the levels of support for the extant and proposed forms of the ZEV program.

The stakeholder organizations with more consistent participation at the public hearings analyzed were environmental groups (American Lung Association, Natural Resources Defense Council, Coalition for Clean Air, Planning and Conservation League, Sierra Club, and Union of Concerned Scientists), regulatory agencies (the California Air Resources Board and the South Coast Air Quality Management District), auto companies (DaimlerChrysler, Ford, General Motors, Honda, and Toyota), and one business group (California Electric Transportation Coalition.)

My analysis of coalition stability shows that, while auto companies presented more cohesive policy messages than the environmental groups (as measured by policy beliefs), the latter had higher levels of coordination than the former. One interesting facet of the coordination of the environmental groups—generally gathered under the umbrella of the ZEV Alliance—is a sort of distribution of labor. The members of this coalition have different areas of expertise and capabilities, and use them to the benefit of the coalition as a whole. On the other hand, the car companies did not exercise significant policy coordination, predominantly because of the competitive nature of the industry. This last result is consistent with what I found in my analysis of strategic behavior in Chapter 3.

Indeed, the competitive nature of the auto industry is a key element to understand the policy dynamics of the ZEV program. As revealed by various interviewees, and confirmed by the strategic analysis in Chapter 3, an important strategic tool that the regulatory agency can and did use is to exploit the limited ability of regulated industry stakeholders to trust each other in a common policy front. Simply put, the strategy of the regulator would be to set the most stringent requirements that any one industry player is

willing to accept. The likelihood of such strategic behavior is captured by the game-theoretic model I developed. The ZEV policy process illustrates the inadequacy of previous models that accounted for only one industry player. In such models, collusion is a significantly more appealing strategy to the industry player, who could use to its advantage the information asymmetry between regulator and regulated. The presence of multiple industry players simultaneously regulated completely changes this dynamics and tilts the strategic balance toward the regulator.

The strategic dynamics just described opens the door for regulator and regulated to increase their communication and seek more collaborative pathways. Indeed the strategy of communication and collaboration was embraced by CARB and certain car companies, more and more over time. My analysis does show some evidence of convergence in the policy positions of CARB and some of the automakers over time. Manifestations of such convergence were, for example, CARB's better understanding of the market and tecno-economic realities involved in the introduction of radical innovations, and the proposals of alternative means of compliance made by some of the automakers. In general, the industry players that opted for more collaborative approaches were able to affect more—and be hurt less by—the subsequent revisions of the program.

The ZEV mandate of 1990 has evolved over time into a ZEV *program*, as the result of a very intense and complex policy process. This dissertation has examined various important aspects of this process, while other aspects can be the subject of future research. For instance, the problem of policy diffusion deserves investigation, since the ZEV program (as part of the LEV regulation) can—as it has—be adopted by other states

in the Union under Section 177 of the Clean Air Act. The implications of and lessons learned from this daring policy program are multiple and important. Many have been explored in this study. Some remain to be studied.

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