8 February 2023

House Committee on Climate, Energy and the Environment
Oregon State Capitol
900 Court St. NE
Salem, Oregon 97301

To: Chair Marsh and Members of the committee
Re: Support for HB 2530/Changes to -1 amendment
From: Dr. John Perona

I am Professor of Environmental Biochemistry and Law at Portland State University, and author of the climate and energy book *From Knowledge to Power: The Comprehensive Handbook for Climate Science and Advocacy*.

Thank you for the opportunity to provide written comments on HB 2530. **I write in full support of the bill and in qualified support of the -1 amendment** as described in the written comments from Meredith Connolly on this page.

I strongly support all efforts by the ODOE work group as detailed in sections (4)(a) through (4)(i). Hydrogen produced with low or zero carbon emissions is an essential component of the renewable energy economy - as both a feedstock for essential commodities such as fertilizers and ammonia, and as a fuel for high temperature industrial processes and transportation modes (such as aviation and shipping) that cannot be electrified with today's technology. I am convinced that the working group will make an important contribution towards accelerating development of the state renewable hydrogen industry.

I wish to emphasize two specific issues: (i) the importance of the working group fully considering all low-carbon and zero-carbon hydrogen options, including manufacturing processes that come under the rubrics of "blue", "turqoise" and "green"; (ii) a necessary change to the text of amendment -1 affirming that the definition of "renewable hydrogen" for purposes of the bill is inclusive of both "blue" and "turqoise" hydrogen production. Alternatively, I suggest a different scheme for organizing hydrogen production methods that provides more clarity than the proposed distinction between "green electrolytic hydrogen" and "renewable hydrogen" that is described in the Connolly amendment.

<u>Considering all zero-carbon and low-carbon options for hydrogen manufacturing</u>
Presently, almost all hydrogen in the US is produced from natural gas by the steam reforming reaction, which emits large amounts of carbon dioxide. I strongly concur with many other commenters that green hydrogen, made by electrolysis of water using zero carbon electricity, is the best alternative because it would allow synthesis with zero emissions. However, the green hydrogen industry is presently at a very early stage of development, with no large-scale production facilities in operation now, and with small production streams that incur very high costs. Of course, this is expected for any new technology and we

can certainly anticipate that the industry will develop, especially with the recent federal legislation to create regional hydrogen hubs. The question, though, is how fast it will develop - especially since greening the electricity grid (and not hydrogen production) must be the top usage priority for new zero-emissions electricity as it comes into operation.

We must keep our eyes on the ultimate, highly urgent reason for why we are building a renewable energy economy - to avert a catastrophic breakdown in the Earth's climate system. It is unclear where the tipping points are; for some ecosystems, like tropical coral reefs, the tipping point is already here. Therefore, we are tasked with finding a path from our present high dependence on fossil fuels that minimizes the total quantity of long-lived, legacy carbon dioxide emissions. In this context, I wish to emphasize that abandoning all low-carbon hydrogen production in favor of developing green hydrogen alone would certainly entail a substantial risk. It is very unclear how long it will take for industry-scale green hydrogen development to develop. In contrast, carbon capture technology is available now, and its incorporation into steam methane reformation processes is already a reality. Should we really forego the development of this blue hydrogen option, and thereby allow full emissions to continue until green hydrogen is ready at some unspecified future time?

I also emphasize that HB 2530 is simply a study bill. Fully including all low carbon hydrogen options such as blue and turquoise as part of the study hardly means that Oregon will necessarily go on to actually incorporate them into policy, not to mention dedicate scarce dollars into subsidizing in-state production streams. We must bring the best science to bear to assess what is by far the most important question: *which combination of hydrogen production methods over the next few decades will minimize total carbon dioxide emissions from the industry*?

I emphasize these points because there is a prominent stream of opinion in which fears of locking in subpar technology, and/or unwillingness to accept that a fossil fuel company or fossil fuel-like refinement process has any role at all in helping us achieve climate goals, dominate the thinking. This leads to wholesale rejection of blue hydrogen. But such considerations, not being based in science, do not help us answer the question of how to best minimize greenhouse gas emissions.

At present, blue hydrogen production has seen limited application and still entails significant climate pollution from both incomplete CO_2 capture and upstream fugitive methane emissions. However, there are many promising new developments that offer the potential for substantially reducing the emission of both greenhouse gases. For example, hydrogen plants can be designed that capture carbon dioxide from both the steam reforming furnace and the amine unit. The distinctive and lower-emissions autothermal reforming process could be imported to hydrogen manufacturing facilities, where it would replace steam methane reforming. Both innovations will lower carbon dioxide emissions from blue hydrogen. Upstream fugitive methane emissions can also be controlled far better than they are now. Technologies are available for this and aggressive regulations are in process of development at the federal level to sharply curtail methane emissions from natural gas mining, refinement and transport.

Turquoise hydrogen production has also seen very limited application so far. In this approach, a hydrocarbon feedstock such as natural gas (methane) is subjected to a "cracking" reaction at very high temperature, with the products being hydrogen and pure carbon, but no carbon dioxide. Does turquoise hydrogen have a role in Oregon's future low emissions economy? Perhaps the working group envisioned in HB 2530 will offer some insight.

Finally, I want to emphasize that, in the very long term, stabilization of Earth's climate is likely to require not just attainment of "net zero" emissions but the sustained application of "net negative" technologies to vacuum carbon dioxide from the atmosphere, so that the carbon dioxide concentration is rapidly lowered from whatever peak concentration it reaches in the next few decades. Presently, the best prospect for the technology to accomplish this is direct air capture (DAC). DAC uses many of the same elements as carbon capture and sequestration, including from hydrogen manufacturing - the amine reaction to remove the carbon dioxide from the smokestack gas, the regional network of carbon dioxide pipelines, and the development of safe, EPA-regulated geologic sequestration sites in saline aquifers. Thus, carbon capture as envisioned in "blue" hydrogen approaches not only removes the immediate emissions but also, because of economies of scale over time, may help bring the DAC technology into being faster.

<u>Recommended changes to amendment -1</u>

As of this writing, amendment -1 is not posted on Olis; therefore, I am commenting on the text included in the written comments from Meredith Connolly. On page 2 of those comments, it is stated that "...The -1 defines renewable hydrogen to be broader than just green electrolytic hydrogen and also include the production that is commonly called "blue hydrogen."" However, in Attachment A (page 4) of the comments, section (3) defining "Renewable hydrogen" does not allow for the possibility of blue hydrogen; that is, it does not include hydrogen steam reforming from natural gas with carbon capture as a possible option for producing hydrogen. Instead, sections (3)(b) and (3)(c) refer to producing hydrogen directly from electricity, while section (3)(a) refers to producing hydrogen from a renewable energy source "as defined in ORS 469A.005;" ORS 469A.005 references ORS 469A.025 for its definition of "renewable energy source", and ORS 469A.025 makes no mention of natural gas with carbon capture in its list of energy sources that qualify as renewable. That list can also be found in ODOE's 2022 Renewable Hydrogen study, at page 9.

I wish to emphasize that I support the goal of the amendment in bringing as much clarity as possible to the understanding and future policy development for hydrogen manufacture in Oregon. Making distinctions among the ways that hydrogen can be produced is absolutely crucial as we move forward.

I therefore recommend that section (3) of the anticipated -1 amendment be amended to add the following:

(3)(d) A steam methane reforming process using natural gas as a feedstock, in which the carbon dioxide byproduct is captured and removed from the effluent gas

(3)(e) An autothermal reforming process in which hydrogen is produced from synthesis gas, and in which the carbon dioxide byproduct is captured and removed from the effluent gas
(3)(f) A thermal cracking process in which hydrogen is produced by heating a hydrocarbon feedstock to very high temperature, generating pure carbon as a byproduct.

<u>An alternative way to distinguish types of hydrogen according to how they are made</u>
The changes suggested above to amendment -1 would emphasize the importance of considering both low and zero-carbon hydrogen manufacturing options at this early stage of development. However, it is unclear that the distinction between "green electrolytic hydrogen" and "renewable hydrogen" really offers the most clarity going forward. This is because "renewable hydrogen" includes "green" along with "blue". This blurs the distinction - since "green" fits into both categories.

I suggest it would be better to create a scheme in which "green hydrogen" is restricted to the category of "green electrolytic hydrogen". Since "renewable hydrogen" is often taken to mean "green" in popular usage, the other category should be named "low-carbon hydrogen" to make it clear that some smaller amounts of greenhouse gases are still emitted when hydrogen is made in these ways ("blue" and "turqoise"). This category would then be inclusive of all the potential low-carbon manufacturing innovations that may be possible in hydrogen production from hydrocarbon feedstocks, such as those described in the proposed clauses (3)(d), (3)(e) and (3)(f) above, but also others that may be developed in the future.

Thank you for the opportunity to comment on the bill. I hope that these ideas will receive careful attention as the bill proceeds through the legislature.