CONTENTS

Supporting information is listed under the titles and subheadings of the original article and comprises 22 pages, 5 tables, 14 figures, and 28 references:

S1 METHODOLOGY – COMPARING CONVENTIONAL AND SHALE GAS

S1.1 Global warming potential

GHG emissions were calculated using2007 IPCC AR4 factors for 100-year global warming potential: 1, 25 and 298 for CO2, CH4 and N2O respectively. Some authors (notably Howarth[1]) have used 20-year global warming potential in addition to 100-year factors. The case that life cycles should be compared on the basis of their -year warming potential has not been widely accepted and use of 100-year potentials are mandated in U.S., Canadian and European legislation.

In this article, the fraction of total GHGs originating from methane is given at every stage, making it possible to derive GHGs using 20-year GWPs if desired.

S1.2 Allocation of emissions to gas and co-products

A gas production project may have multiple products: not only gas but also condensate, ethane and LPG. In order to calculate the WtW emissions intensity of a gas pathway, it is necessary to divide the total emissions between the sales gas and other co-products. A guiding principle is that products ought not to be burdened with emissions from processes that they did not undergo.

For example, in upstream gas production:

- Some processes affect only gas, for example, export gas compression. Other co-products should not carry this burden.
- Some processes only affect the co-products, for example, stabilization of condensate or fractionation of LPG. The sales gas should not carry this burden.
- Some processes directly affect both gas and co-products. Gas and condensate emerge from the same well and therefore the emissions of well drilling, water pumping, gathering compressors, etc. must be shared between gas and condensate.
- Some processes indirectly affect both gas and co-products - overheads to the whole project such as waste water treatment, for example.

Emissions were allocated to co-products in proportion to their energy content. Dry sales gas accounted for 89.7% of the total energy produced (after allowing for fuel gas consumption) and was allocated 87.6% of emissions.

S2 CONSTRUCTING THE MODEL

Figure 1: Simplified well-to-wire (WtW) pathway

S2.1 Model gas composition

Data from the 2011 EPA Inventory Report[2] show that there is no systematic variation in the CO_2 content of conventional and unconventional gas wells. The data show an almost complete overlap, with both types of gas ranging from nearly zero to more than 7% as shown in Table S1. A single gas composition was therefore used to model both conventional and unconventional production.

Table S1: U.S. Production Sector CO_2 Content in Natural Gas by NEMS Region and Natural Gas Well type

NEMS region	1 NE	2 MC	3 GC	4 SW	5 RM	6 WC	Lower 48
Co vention l	0.92	0.79%	2.1 %	3.81%	7.95%	0.16%	3.41%
Unconventional	7.42%	0.31%	0.23%	none	0.64%	none	4.83%
All types	3.04%	0.79%	2.17%	3.81%	7.58%	0.16%	3.45%
% U.S. production	5%	21%	14%	32%	28%	1%	100%