Methane Emissions in the Oil and Gas Sector: Two Recent RFF Projects

Alan Krupnick

Co-Director, Center for Energy and Climate Economics

RFF-Stanford Woods Webinar Series

September 13, 2016

RESOURCES FOR THE FUTURE

The Issue

- Fugitive and vented methane emissions from natural gas lifecycle threaten to erode its climate benefits over coal
- A number of policy initiatives have been put in place and are being considered – including voluntary approaches
- But which are the best?
- A necessary step is an analysis of the stylized facts of methane emissions, monitoring and control matched to available policy options

The projects

- Oil and Gas Methane: Matching Policy to Reality
- Plugging the Gaps in Inactive Well Policy

Oil and Gas Methane Policy Environment

Existing and New/modified Producing Wells

- Voluntary
  - NG Star program in 1993
  - Methane challenge 2016
  - One Future and API
- State Regulatory Efforts
  - CA, CO, PA
- Federal
  - Obama goal: 40-45% reduction by 2025
  - New and modified sources (CAA 111(b))
  - Existing sources (CAA 111(d))
  - Quad O data requirements

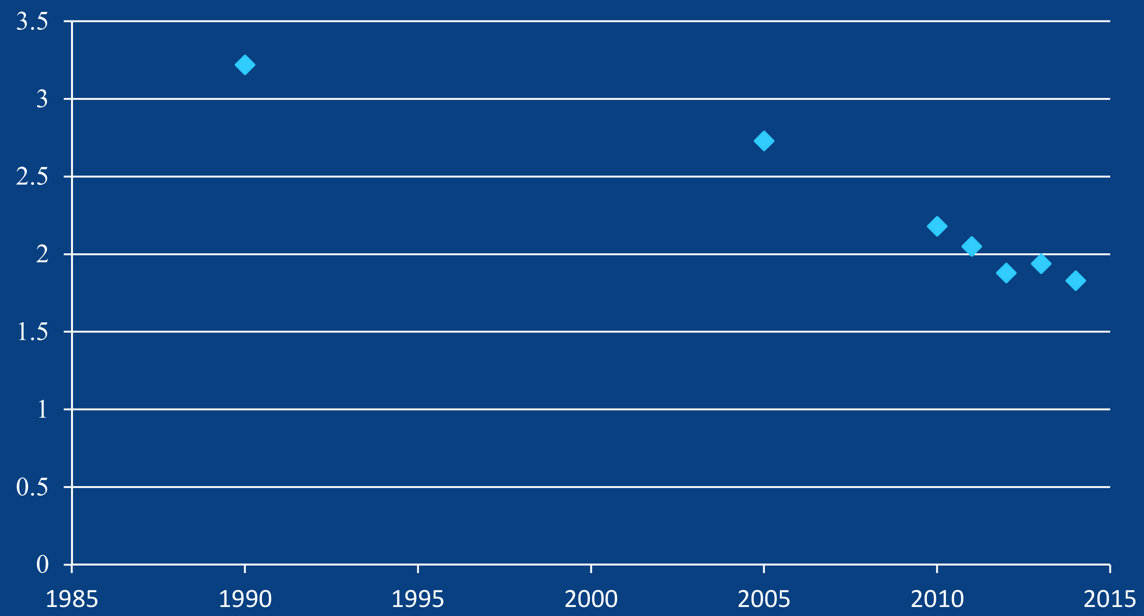
Inactive Wells

- Primarily a state matter except on federal lands
- Regulatory backwater

RESOURCES FOR THE FUTURE

Stylized Facts

- Target is under 2.7% methane loss
- Our calculations from EPA data: 1.8% to 3.2%



RESOURCES FOR THE FUTURE

Stylized Facts (2)

- Recent, credible Top Down (TD) and Bottom Up (BU) studies suggest emissions leakage rates are higher than EPA's and TD>BU
- But new capstone PNAS study (Zavala-Araiza, 2016) **for Barnett only** suggests TD=BU = EPA*1.9.
- If true everywhere, then fugitive methane = 1.8% *1.9 = 3.4% of production

RESOURCES
FOR THE FUTURE

Stylized facts (3)

- Significant heterogeneity in costs across subsectors and technologies → cost-effective trading/averaging opportunities exist

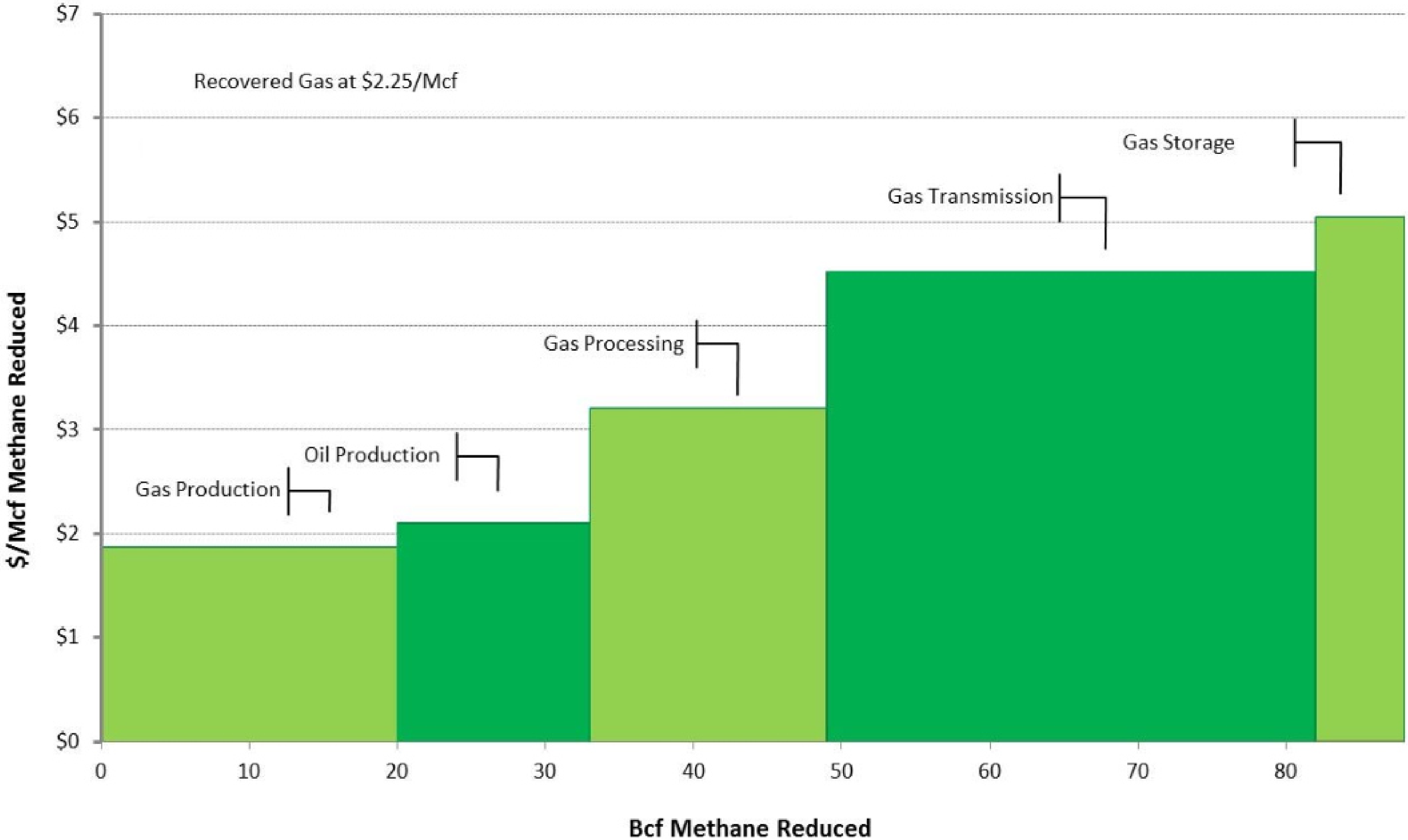
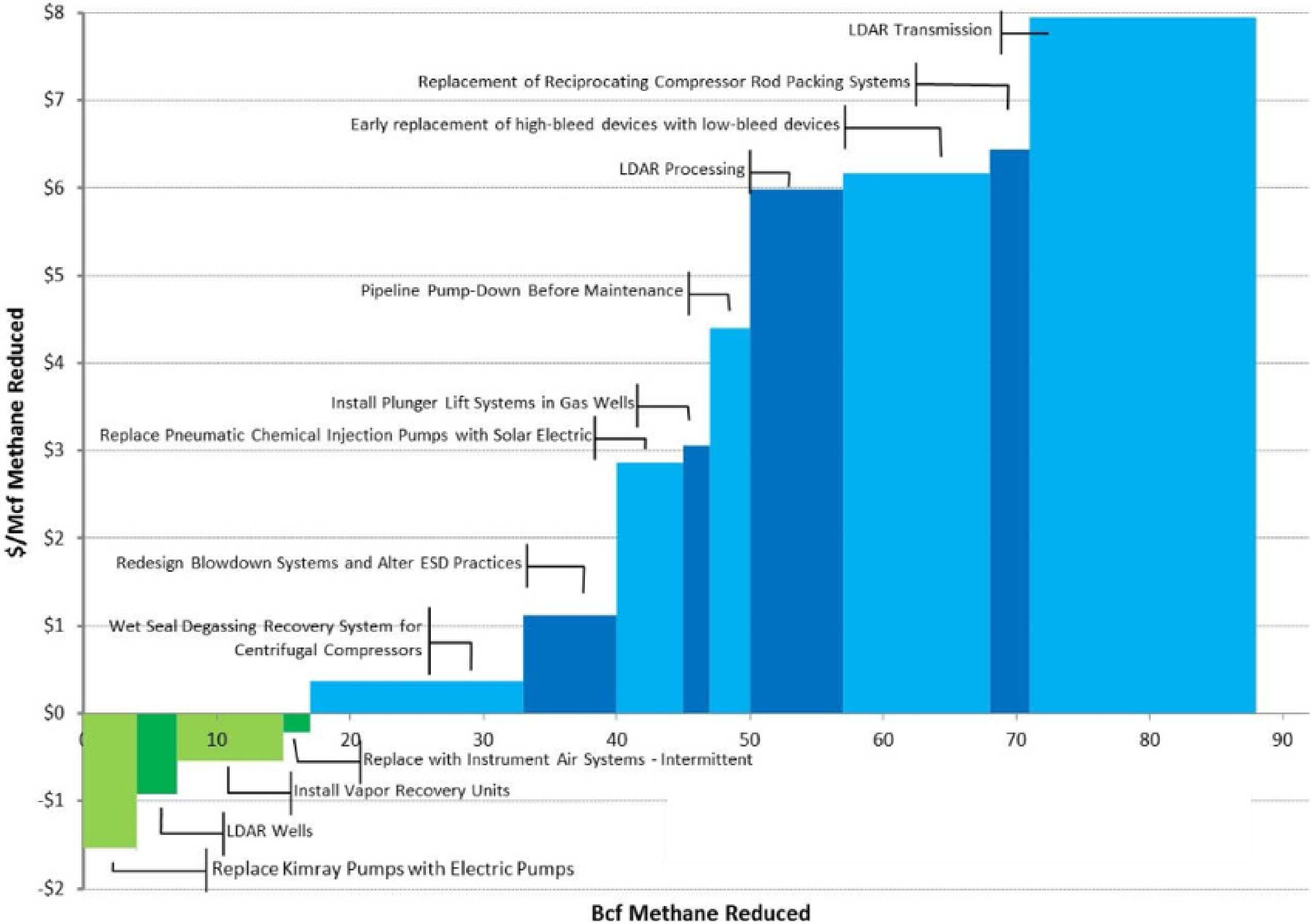


Figure 4: National Aggregate Marginal Abatement Cost Curve for Oil and Natural Gas Subsectors

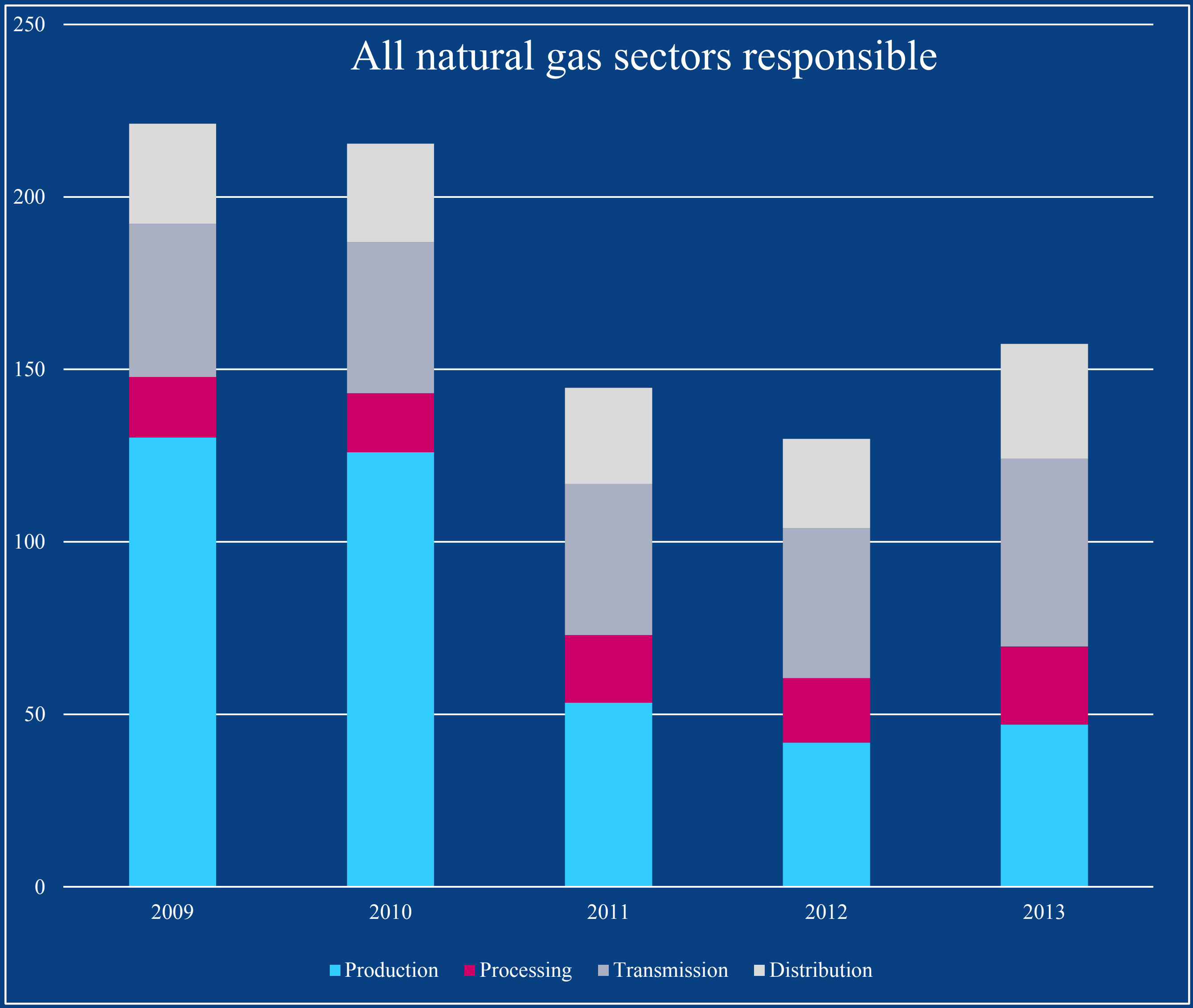
RESOURCES FOR THE FUTURE

Source: ICF 2016b.

Figure 5: National Marginal Abatement Cost Curve for Different Methane Abatement Technologies in the Oil and Natural Gas Sector



Source: ICF (2016b).



RESOURCES
FOR THE FUTURE

Stylized facts (4)

- 800,000 wells, million miles of pipes, 7000 operators

Super emitters:

- 2% of emitters responsible for 50% of methane in Barnett (PNAS 2016)
- In three dimensions
  - Sites
  - equipment categories
  - individual equipment
- Chronic emitters, episodic emitters and stochastic super emitters

➔ **Monitoring everything will waste resources**

RESOURCES
FOR THE FUTURE

Monitoring in Infancy

- Typically with handheld or truck-mounted infrared camera to find leaks
- High volume samplers to measure leak rate
- Coupled
- No continuous emissions monitors to get at volume directly

New technologies

- Distributed detectors
- Automated infrared imaging
- Satellites
- Drones
- EDF prize

RESOURCES FOR THE FUTURE

Policy Options

Categories

- Voluntary
- Direct regulation
- Market-based

Specific prototypical policies

- Technology standards
- Performance standards on equipment
- Performance standards at site or firm level
- Leak Detection and Repair (LDAR)
- Carbon tax with default leak rates
- Deposit-refund systems
- Tradable performance standard

RESOURCES FOR THE FUTURE

Comparing Policies: Criteria

- Administrative Costs
- Economic efficiency
- Environmental effectiveness
- Practicality

Conclusions

- Need to analyze success of state LDAR programs
- Heterogeneity in abatement options favors market based/trading and performance standards
- Many sources to regulate favors tax
- Experience and lack of CEMs does not favor economic incentive approaches
- Poor/uncertain inventories favor approaches that result in their improvement, e.g., default rates as basis for regulation
- Stochastic super emitters present huge challenges
- What will the CAA preclude?
- Improvements need to come on monitoring

TABLE 1. TOTAL NUMBER OF INACTIVE WELLS IN EACH STATE[10]

State	Total inactive wells	Inactive non-P&A*	Inactive P&A	Active wells	Inactive non-P&A wells as % of total inactive wells
MO	9,098	5,111	3,987	1,193	56
KY	29,546	12,338	17,208	41,371	42
MT	12,358	4,652	7,706	28,947	38
WV	36,941	14,018	22,923	18,919	38
NY	12,702	1,730	10,972	11,406	14
PA	52,091	6,895	45,196	121,011	13
ND	11,210	1,341	9,869	14,373	12
NM	46,105	4,773	37,076	52,903	10
WY	45,913	3,981	41,932	32,841	9
KS	210,868	15,465	195,403	91,472	7
CO	37,662	1,881	35,781	50,861	5
AR	24,660	948	23,712	17,680	4
OH	106,188	1,178	105,010	61,189	1
Total	**635,342**	**74,311**	**556,775**	**544,166**	**12**

Note: We use P&A—"plugged and abandoned"—here as a synonym for "decommissioned."

Figure 1. Costs of Plugging and Restoring Orphaned Wells Compared with States' Bonding Requirements

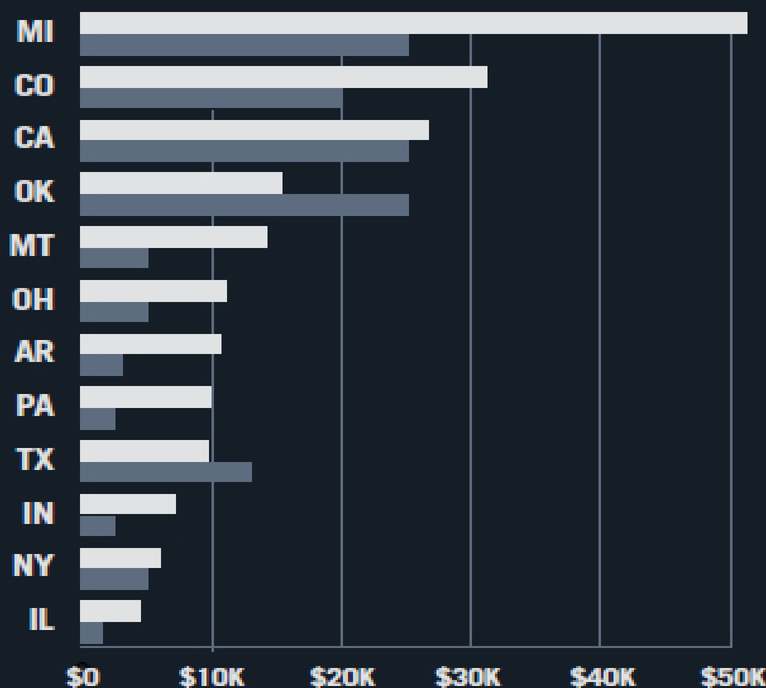


Figure 2. Percent of Orphaned Well Decommissioning Projects with Project Costs That Exceeded Average Bond Amounts

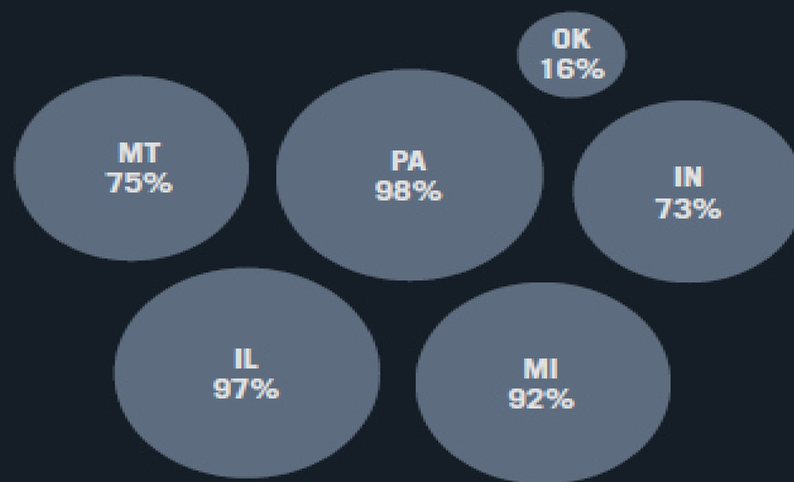
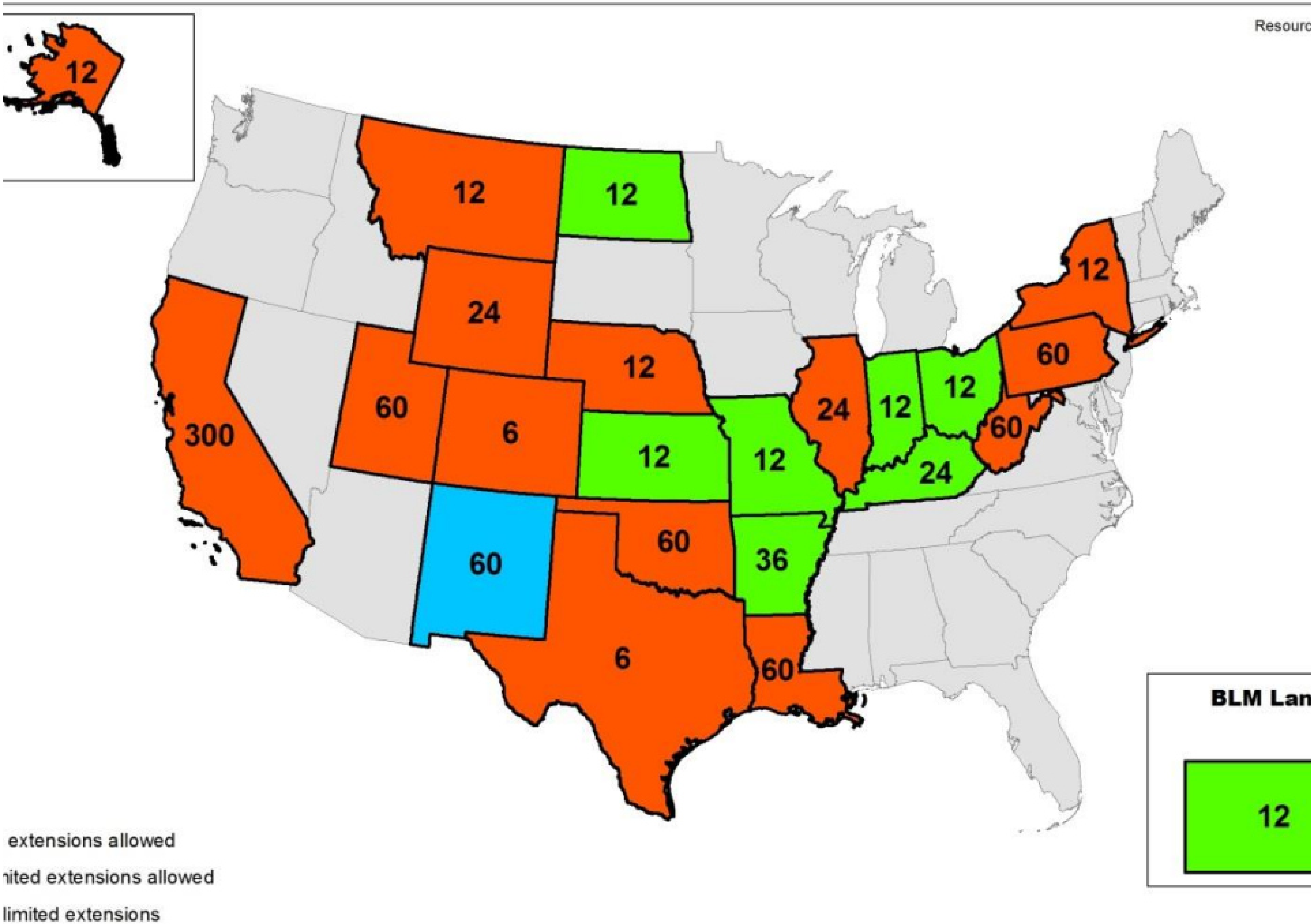


Table 2. Cost Model Regression Results

	Model (1)		Model (2)	
VARIABLES	**Plugging Cost($)**		**Plugging Cost($)**	
Depth	1.766***	(0.150)	1.526***	(0.145)
I(age>31 yrs)			868.7**	(401.1)
I(age=missing)			2,534.4***	(389.6)
Oil Price			76.3***	(5.91)
Plugging Year			-381.6***	(19.96)
Contract Size			-9.532***	(2.31)
I(District=2)	9,652***	(892.7)	7,805***	(846.7)
I(District=3)	-411.2	(867.3)	-3,464***	(852.7)
I(District=4)	3,720***	(749.5)	3,138***	(715.0)
Type (Oil = 1)			-393.5**	(194.7)
% Urban			11.93	(8.75)
% Water			148.5***	(23.84)
% Agriculture			-18.07***	(4.25)
I(Drilled > 1985)			-1,201**	(561.3)
Constant	3,753***	(924.9)	766,223***	(39,762)
Observations	5,838		5,838	
R-squared	0.269		0.353	

MAP 5. DURATION OF TEMPORARY ABANDONMENT (IN MONTHS)



Methane-Relevant Policy Recommendations

1. Revise bonding requirements: higher, eliminate blanket bonds, adjust for depth and other factors affecting costs. Diversify funding sources
2. Tighten well ownership transfer conditions
3. Tighten requirements for maintaining temporary abandonment status

RESOURCES
FOR THE FUTURE

Thank You

Krupnick@rff.org

Co-authors:

Methane Policy: Clayton Munnings

Inactive Wells: Jacqueline Ho, Jhih-Shyang Shih, Clayton Munnings, Lucija Muehlenbachs, Katrina McLaughlin

RESOURCES FOR THE FUTURE