GFRACK Technologies

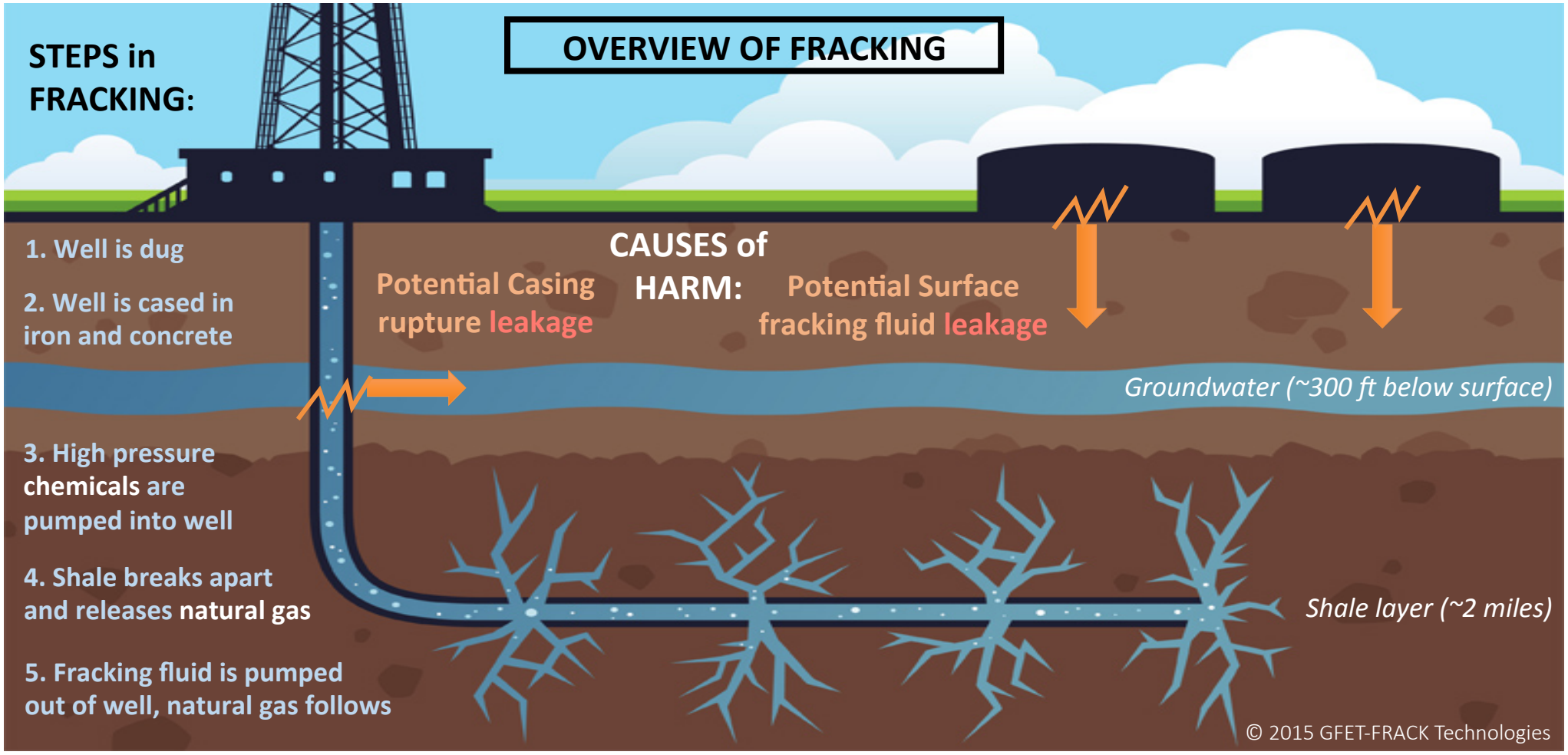
A sensitive graphene-based sensor for detecting fracking fluid components to avoid local water contamination,

Making Fracking Safer.

Ashwin Amurthur and Teddy Guenin

Fracking is lucrative, complicated, and potentially dangerous.

During fracking operations, there is the potential for dangerous leaks of the carcinogens contained in fracking fluid.



Fracking is a **$23.4 Billion** market.

However, in **10%** of operations, leaks can occur.

These leaks cause **economic damage** (they must shut down the well) and cause **health concerns** for local governments controlling the water quality.

Fracking fluid leakage detection is essential to protect the ROI on a natural gas well and to protect citizens from harmful chemicals.

Leaked fracking chemical detection is a large, high-growth market.

Chemicals in fracking fluids include carcinogens, so both the drillers (oilfield service companies) and municipal water suppliers want to detect fluid leakages. Service companies want to keep natural gas wells open, and governments want to stay healthy.

The market for detection is massive.

Municipal water protection agencies

Spent **$8.4 Billion** *on municipal water treatment, chemical detection, and sensors in 2014[1], with 6-8% growth rate in PA, ND, and WV: heavy fracking states.*

Oilfield service companies

Spent **$615 Million** *on water treatment and detection in 2014[1].*

But current detection methods purchased by these companies and agencies are awful.

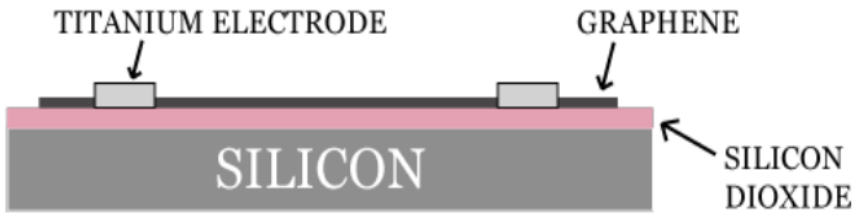
Current Detection Methods	*Reason for Ineffectiveness*
Radioisotopic tracing	✖ Gets diluted in the fracking fluid and only lasts up to 3 weeks in groundwater – so leaks go unrecorded
Traditional chemical sensing	✖ Can't rule out natural factors, because chemicals tested (Mg, Cl) are naturally occuring

1: EPA Executive Summary and Budget Report, 2014

No current methods can perform unambiguous leakage testing, leaving a wide opportunity for a viable detection platform.

Our solution for detecting polluted groundwater: a graphene sensor.

We use **graphene as a field effect transistor** (GFET) and functionalize it with specific compounds to bind the desired chemicals to the graphene surface. Most binding will be achieved via Pi-Pi interactions on the surface of the graphene.



GFETs are:

- Cheap to produce
- Rapid and scalable
- Can sense unique aromatic compounds in solution
- HIGHLY sensitive: can detect **Parts Per Trillion specificity**

Graphene quantum dots on the surface of the graphene will enable fluorescence when different binding events occur.

Example chemicals in fracking fluid:	*Max contaminant Level:*
Benzene	0.05 ppm
Monochlorobenzene	0.10 ppm
1,2,4 - Trichlorobenzene	0.07 ppm

Comparison

Detection Method	*Cost/Test*	*Can detect example chemicals?*	*Reasons:*
Graphene FETs	$25-30	Yes	Highly specific
Radiotracing	$60-70	No	Not able to detect at those low concentrations
Trad. Chemical Sensing	$45-60	No	Unable to test for complex compounds

Our GFET sensors are poised to make a substantial impact on groundwater fracking leakage testing.

We will sell sensors through two channels over the next months.

Our graphene FET sensor can be sold to both oilfield service companies and municipalities.

Oilfield Service Companies

- Would purchase as "preventative care" for natural gas wells to avoid lawsuits (~$40-50 Million each) and well shutdowns
- Will test in local groundwater wells near fracking locations.

Municipalities

- Would purchase to test their water supply along with other chemicals currently tested
- **Will demand oilfield service companies to purchase sensors, or the municipality will deny drilling permits**

In the early stages, GFRACK Technologies will have a centralized facility where sensor testing will occur.

- Both segments of customers will purchase sensors a few months prior to fracking operations until several months after fracking operations have occurred.

Timeline

R&D	Sales & Marketing	IP & Product
Progressively construct and test representative water samples; develop specification standards	Build on current GFRACK Technologies awareness (NPR, Upenn Press, etc.) and continue discussions with interested oilfield service companies	In process to file provisional patent and secure graphene licensing
Feb – April 2015	Feb – June 2015	March – June 2015

Ashwin and Teddy are ideally suited to bring this venture to life.

Strong understanding of Graphene & FETs, biosensor and fabrication background	Biotechnology business & **entrepreneurship background**	**Fracking market expertise** through interviews	Dedicated to **scientific and business pursuits**

Ashwin Amurthur

Penn Senior Undergraduate: BSE Bioengineering & BS Finance 2015

Graphene Experience

- Worked in Johnson Lab 2013
- **Projects in non-covalent functionalization of GFETs**

Biotechnology

- Worked with 1DocWay
- Developed **sales, revenue, regulatory analyses**
- Assessed commercialization opportunities

Teddy Guenin

Penn Senior Undergraduate: BSE Bioengineering & BS Management (M&T) 2015
Graduate: MSE Mechanical Engineering 2016

Graphene & Entrepreneurship

- Worked with Graphene Frontiers Biosensors
- **Developed 80-page bus. commercialization plan**

Biotechnology

- Worked with Oxitec Ltd., a synthetic biology company developing modified mosquitoes for pest control

We are excited to finish prototyping the device, begin sales, and make a positive impact on the fracking industry.