AUTOMATION, ROBOTICS, TECHNOLOGY, DRONES -

CHALLENGES OF THE FUTURE

THE PLAN

- Energy
- Wind
- Solar
- Biomass
- Drones
- Precision Ag
- Robotics & Automation
- Final considerations

NEW TECH ON THE FARM

- Farm/Ag exposures are changing
- Convergence on many levels
- Trends of this nature tend to affect the marketplace

CONVERGENCE OF MULTIPLE ISSUES

- Global warming
- Environment
- Politics
- Resources
- Globalization of economies
- Demographics
- Technologies

RENEWABLE ENERGIES

DEFINED

- Renewable energy is any energy source that is naturally replenished, like that derived from solar, wind, geothermal or hydroelectric action. Energy produced from the refining of biomass is also often classified as renewable. Coal, oil or natural gas, on the other hand, are finite sources.

- www.whatis.com

RENEWABLE ENERGY – COMPRISED OF

- Solar
- Wind
- Biomass
- Geothermal

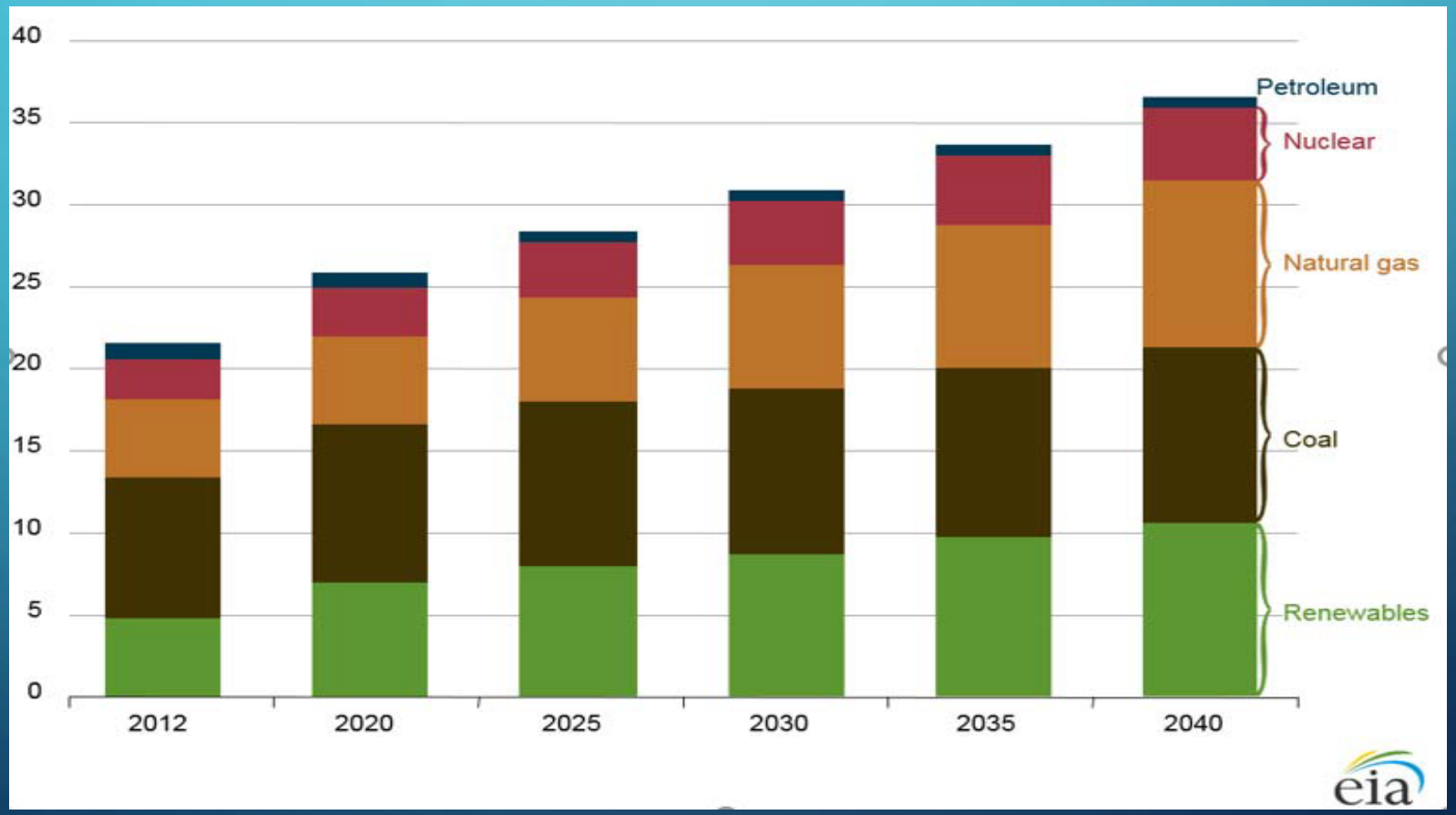
NON-RENEWABLE ENERGIES – COMPRISED OF

- Coal
- Oil
- Natural gas
- Fossil fuels
- Nuclear

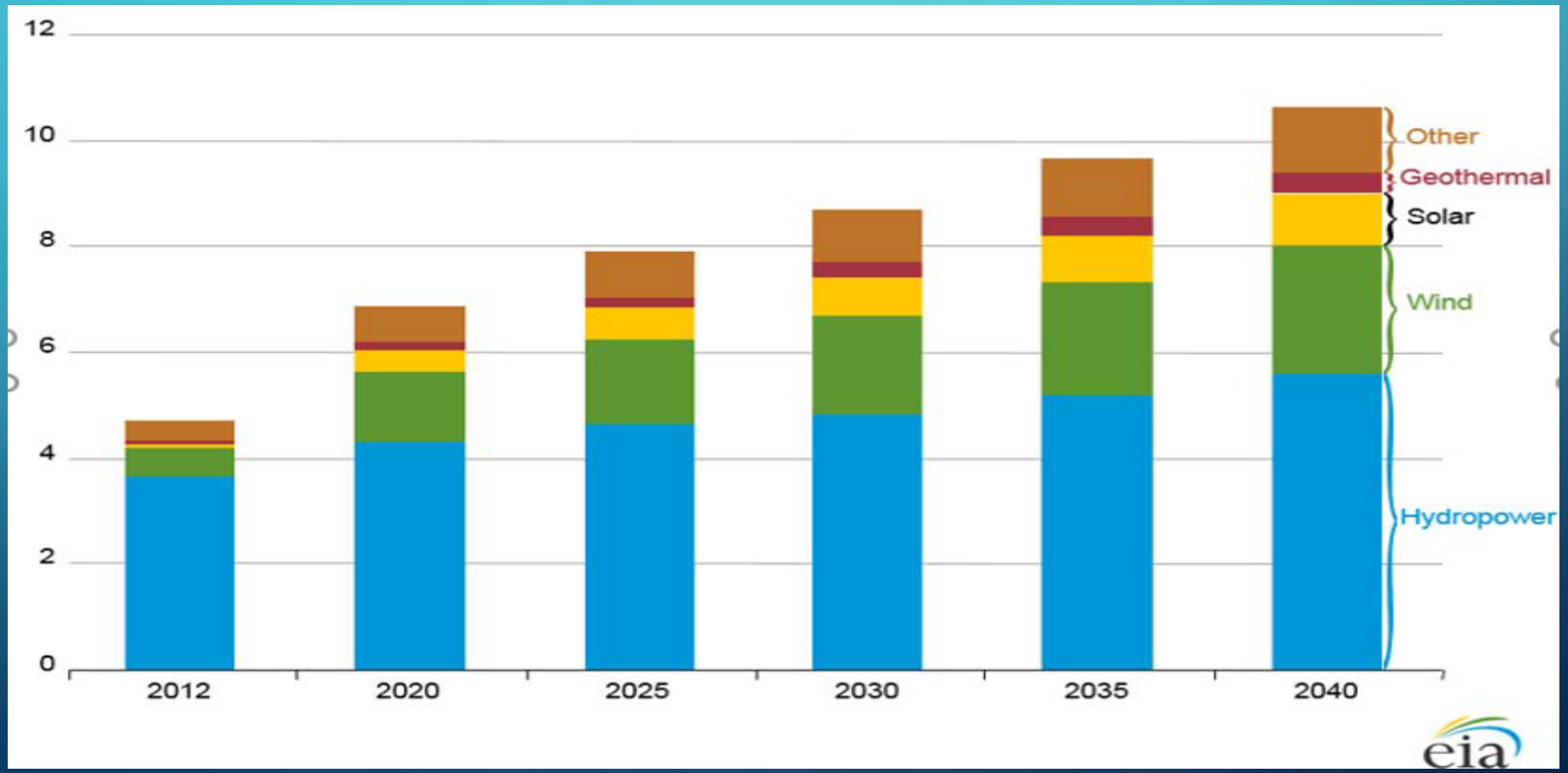
DRIVERS OF RENEWABLE ENERGY

- Improved technology
- Energy security concerns
- Renewable portfolio standards
- Decarbonization pf power generation
- Financial & Tax incentives
- Job creation
- Public perceptions

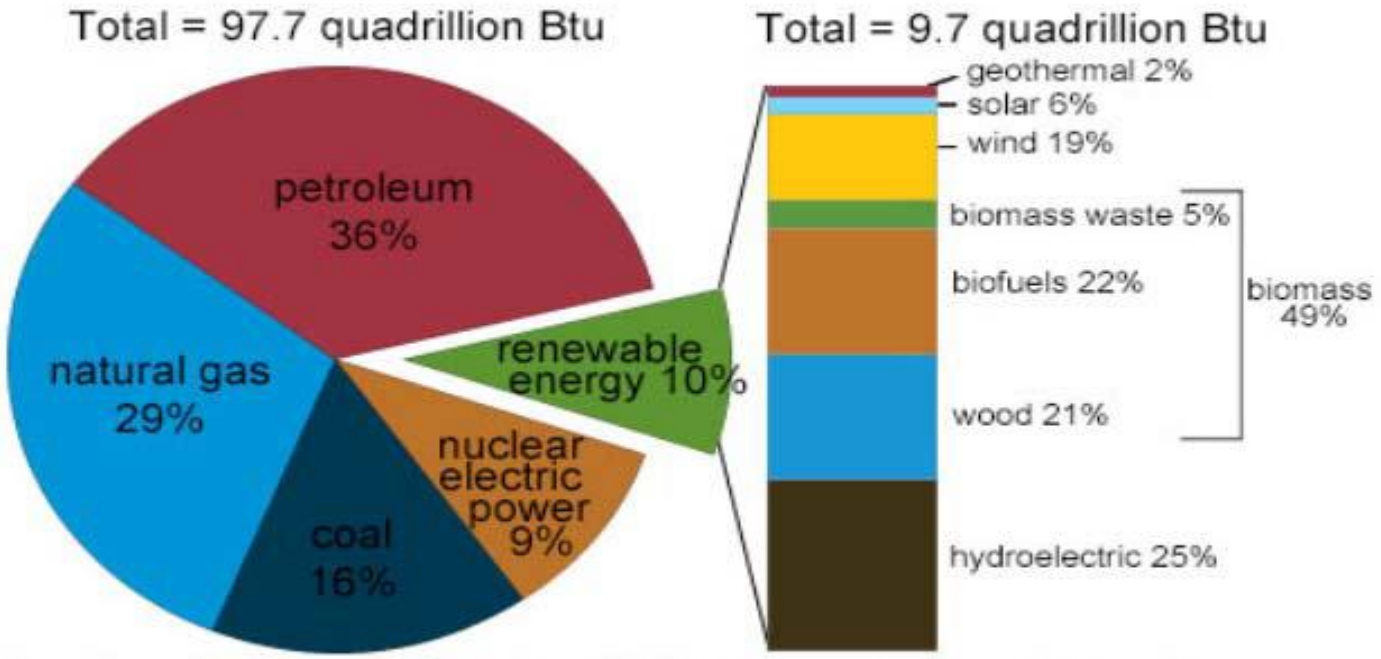
WORLD NET ELECTRICITY GENERATION BY SOURCE 2012 - 2040



WORLD NET ELECTRICITY GENERATION FROM RENEWABLES 2012 – 2040



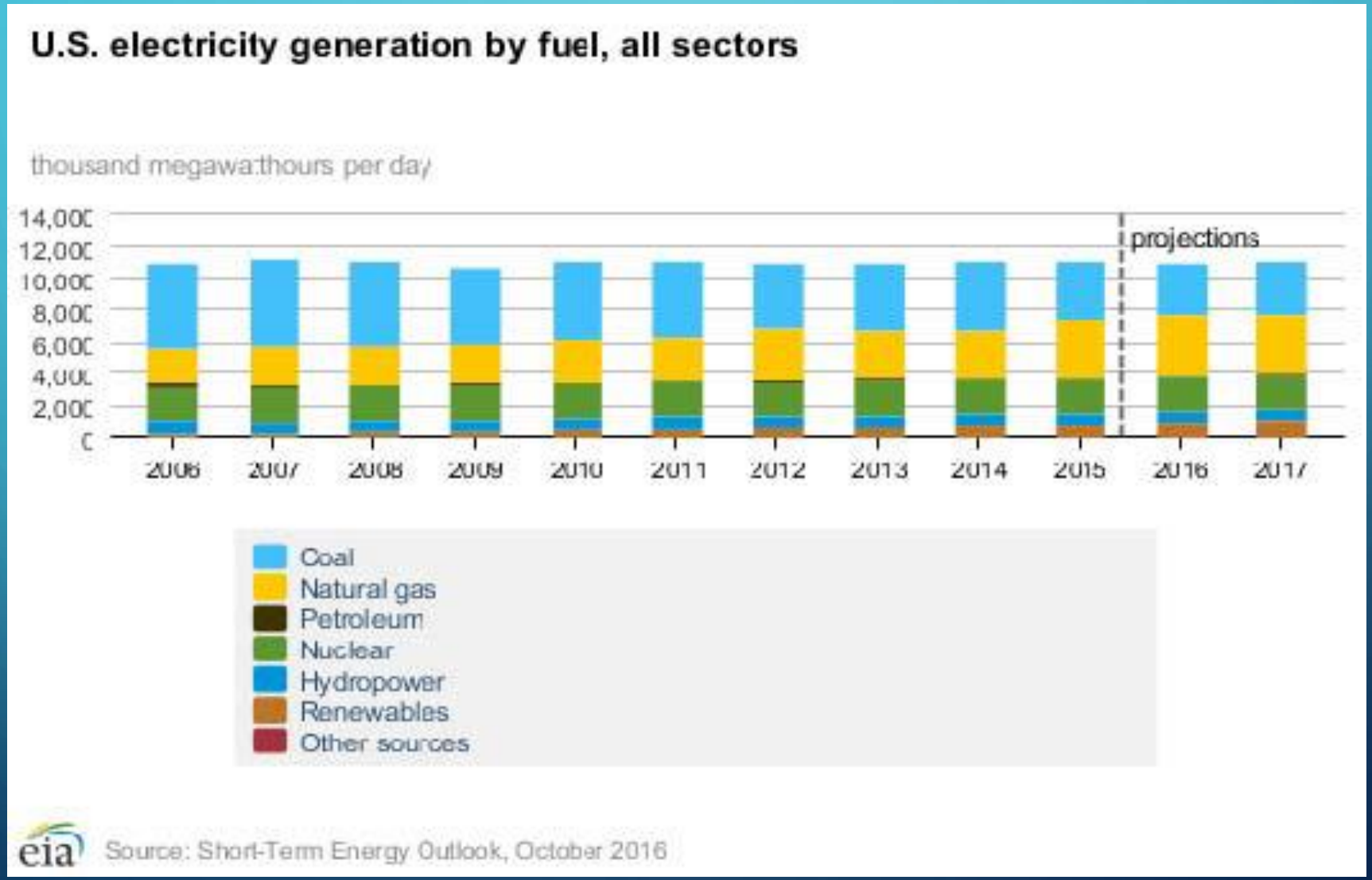
U.S. energy consumption by energy source, 2015



Note: Sum of components may not equal 100% because of independent rounding.

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1 (April 2016), preliminary data

eia


U.S. electricity generation by fuel, all sectors
thousand megawatthours per day
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
projections
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Coal
Natural gas
Petroleum
Nuclear
Hydropower
Renewables
Other sources
eia
Source: Short-Term Energy Outlook, October 2016

WIND

WIND ENERGY

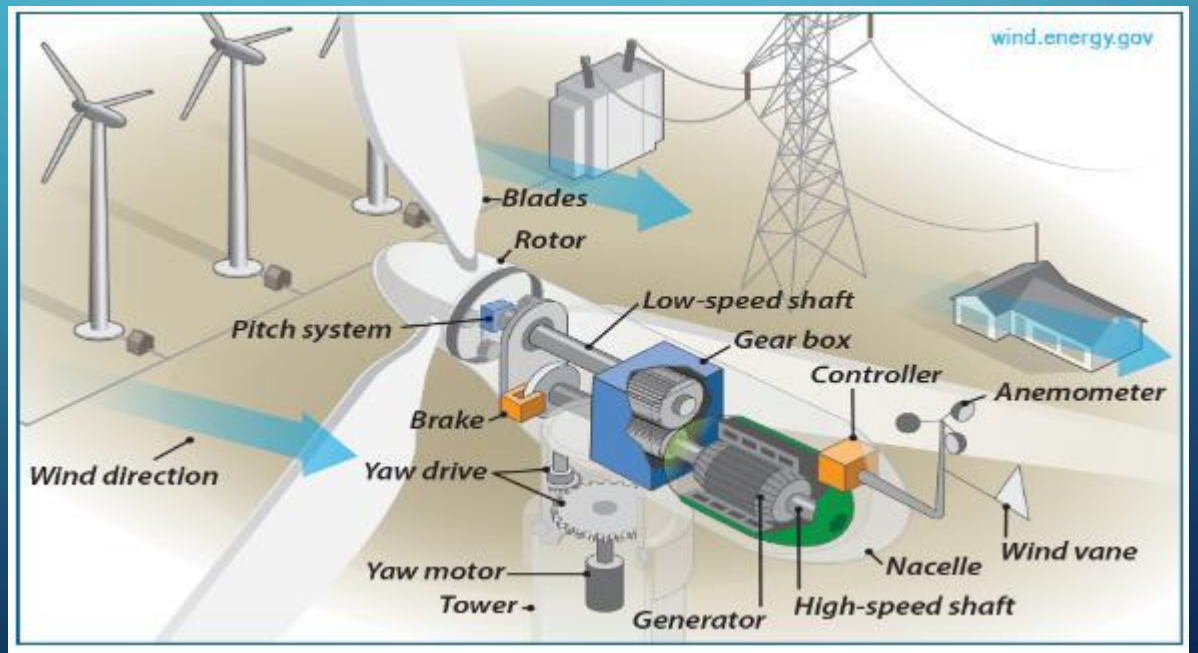
- Expected to generate 20% of the USAs electricity by 2030
- Potential and current issues
  - Bird strikes
  - Noise
  - Wake effects
  - Flicker effect
  - End of life disposal

WIND GENERATORS

- Farm sized generators
  - From 1KW to 90KW
  - 10 to 50KW is average
  - 5 to 15 KW for homes
- 11KW – power the average home annually – prices from $30,000 to $50,000
- 11 mph wind minimum
- 1 unobstructed acre needed
- Sturdy tower vs. antenna tower

HOW DO THEY WORK

- Wind turbines operate on a simple principle - The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity



POTENTIAL FARM APPLICATIONS

- Residential
- Irrigation (think old school – windmills)
- Others

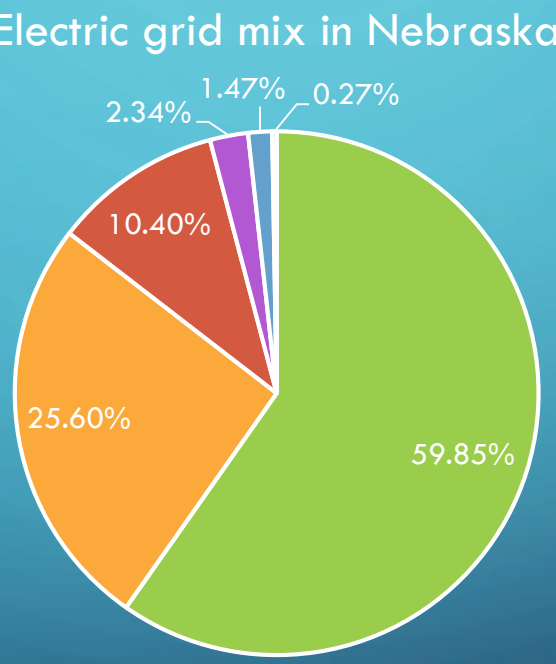
NEBRASKA DATA

- Installed capacity 1,426 MW
- Potential capacity 465,475 MW

- Wind power potentials reflect the amount of wind power that is technologically possible to have installed in a given region

  - windexchange.energy.gov/states/ne

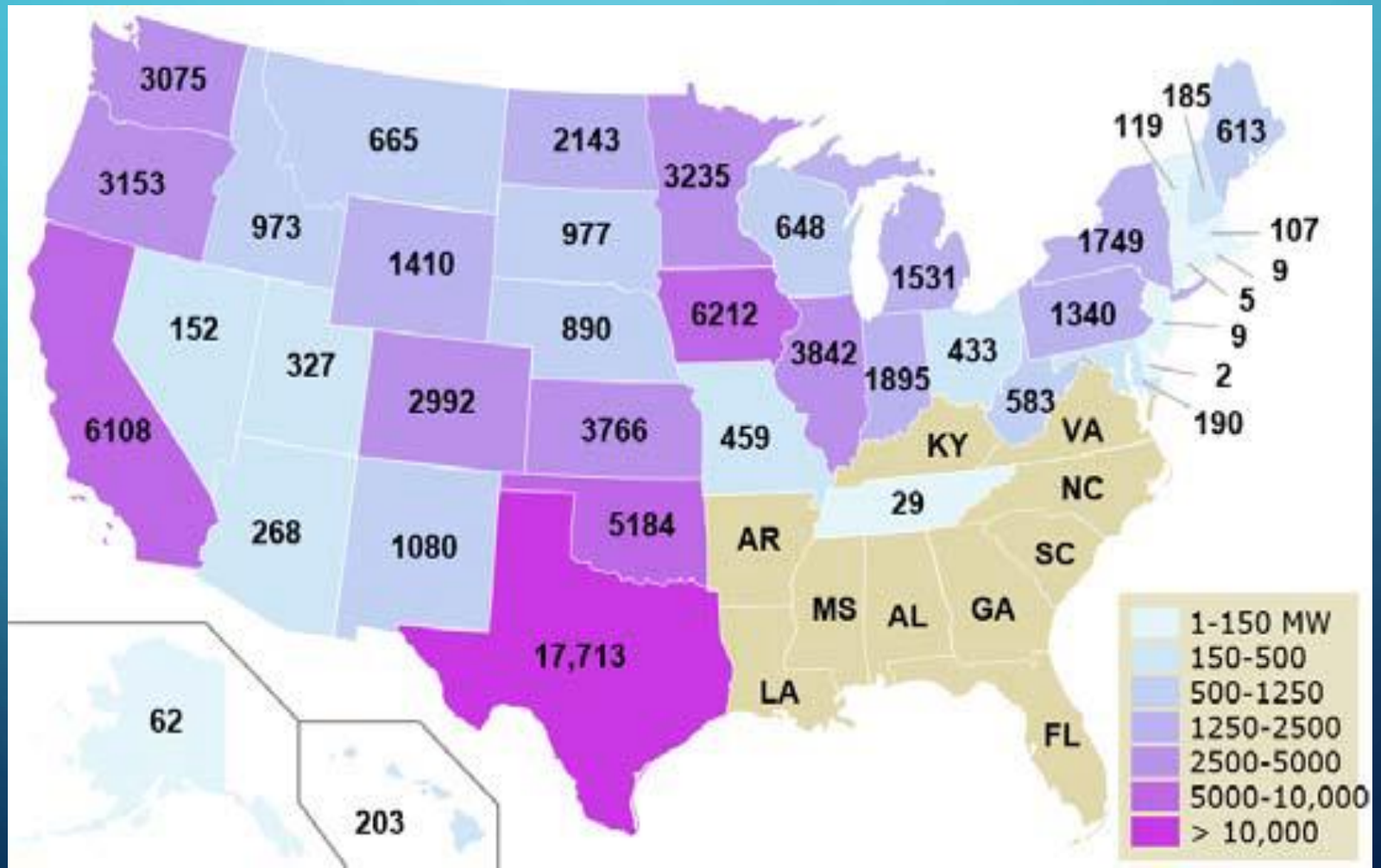
GRID MIX – ELECTRIC - NEBRASKA



PRACTICAL LIMITATIONS

- There are practical limitations on how large individual turbines can be constructed. At a certain point, the excess costs of manufacturing, transport and construction exceed the incremental benefit of MW output. Also, the largest turbines are only effective in areas of high wind speeds (largely offshore)

IT DOESN'T WORK EVERYWHERE



HAZARDS ASSOCIATED WITH WIND

- Fire
- Wind
- Impact
- Natural hazards
- Electrical and mechanical breakdowns
- Collapse

CLAIMS

- Fire – lightning, electrical, transformers
- Blade failures
- Gearbox failure
- Foundation cracking
- Natural disasters
- Nuisance liability claims

OTHER CONSIDERATIONS

- Sell power back to the grid
- Storage of power…batteries
- What perils will be insured against
- Will your underwriter understand
- Will the policy support potential claims issues

EVOLUTION OF WIND

- The early years were challenging—evolution from new demonstration technology to deployed fleets of wind turbines
- Large serial losses in the early stages included the following:
- Main bearings: spherical roller bearing problems
- Gearboxes: pitting, broken gears, bearings
- Foundations: cracks in concrete due to design of anchor cages
- Rotor-blades: Leading edge and rear edge cracks
- Insurers began to doubt that this technology could be effectively underwritten

EVOLUTION OF WIND

- Turbine manufacturers regain the trust of investors
- Industrialization and quality management
  - Full service and maintenance contracts
  - Accepting high liability limits for defects
  - Availability guarantees (time or power output)
  - Smaller manufacturers closed or merged
- Insurers agree to maintain insurance coverage
  - In combination with full service and maintenance contracts
  - With reliable and proven maintenance activities by the O&M provider
  - Annual inspection by a technical expert

INSURANCE CONSIDERATIONS

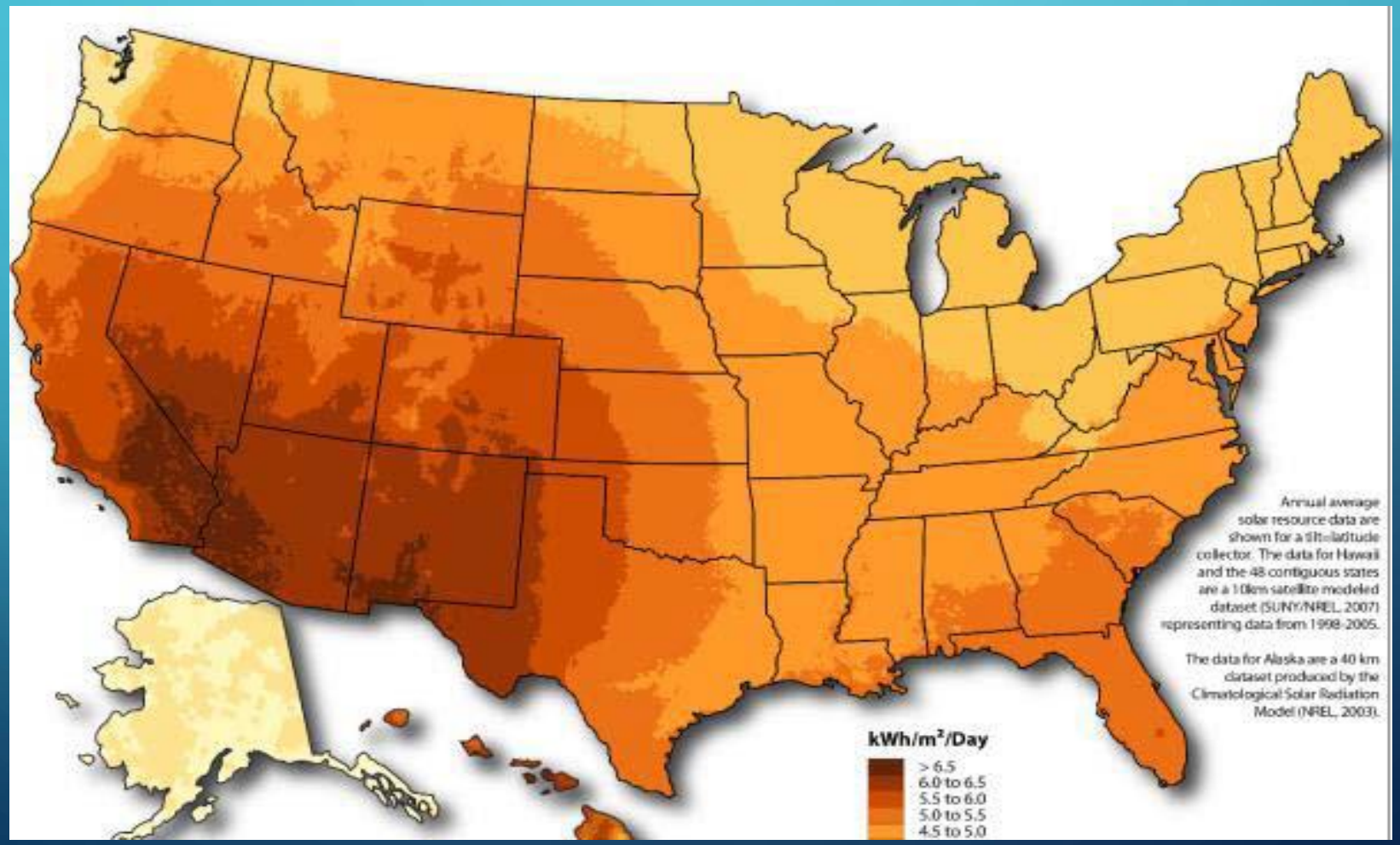
- Some insurers will not cover free-standing structures, such as a wind turbine, under a homeowners/farmowners policy

- It may be necessary to purchase additional coverage
  - Property coverage generally includes coverage for property damage resulting from windstorms, lightning, ice buildup, and fire
  - Purchased limit should be sufficient to cover the cost of replacing the wind installation

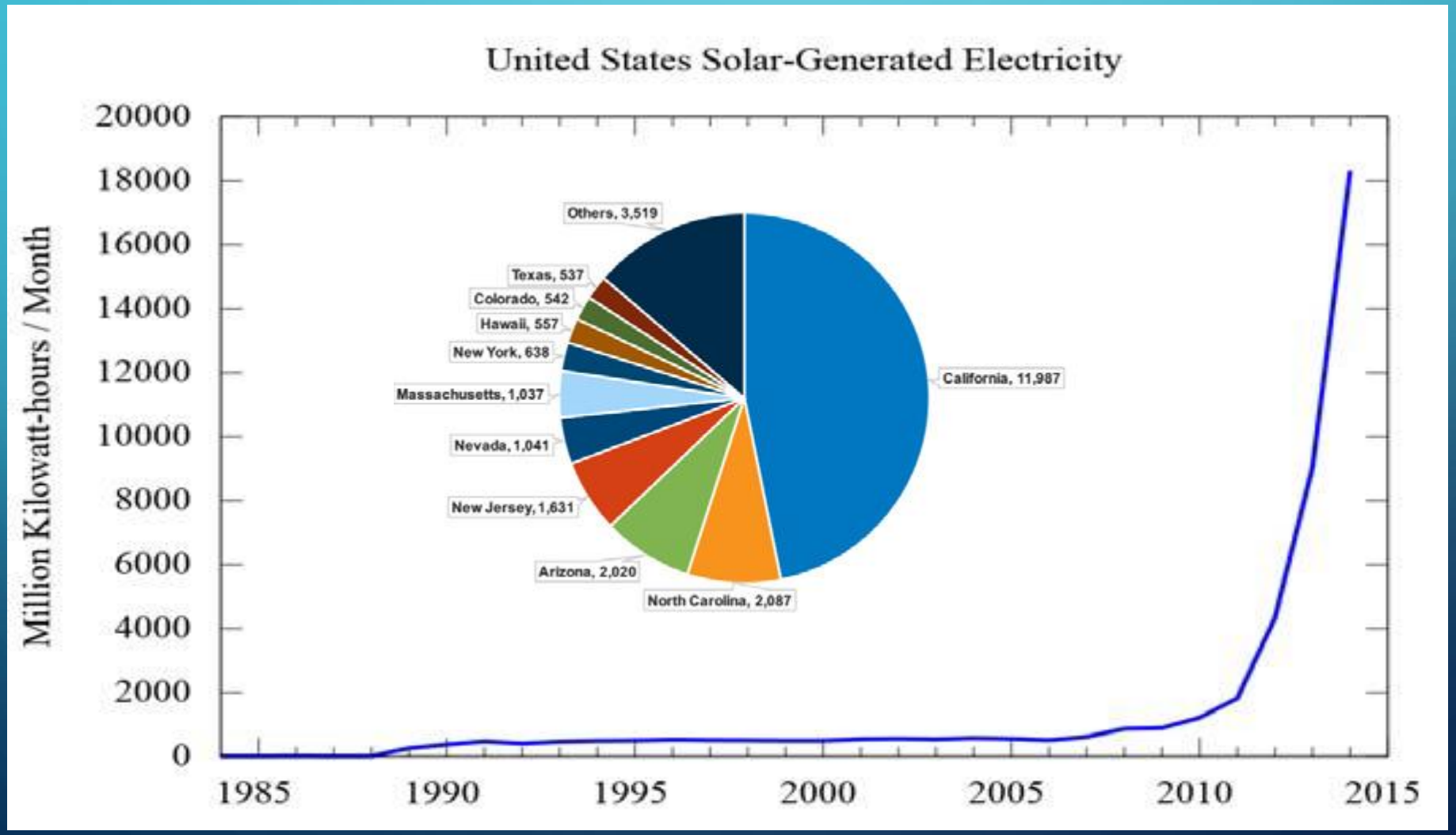
SOLAR

AKA: PHOTOVOLTAIC SYSTEMS, SOLAR PV POWER SYSTEMS, PV SYSTEMS

SOLAR IS GROWING



SOLAR GENERATED ELECTRICITY - US



INCREASED EFFICIENCY

- Solar panel efficiency increases almost yearly
- Capital costs are reducing on an annual basis
- According to the Solar Energy Industries Association (SEIA) nearly 784,000 US businesses and homes had installed solar as of mid 2015

WHY SOLAR

- Environmentally friendly
- Reduced electricity costs
- Revenue generator by selling back to the grid one's excess capacity

FARM APPLICATIONS

- Solar powered electrical fencing
- Animal watering
- One example - 1000 kW Solar System—Elkhorn Dairy, Visalia, CA
  - 5 Acres of Solar Panels
  - Provides 80% of all electricity needs on the farm
  - Total installation cost—$8.5M

YOU TUBE – ELKHORN DAIRY VIDEO

SOLAR CHALLENGES

- Installing solar panels appears to be straightforward; construction risk would appear limited
- Once in place—no moving parts in most installations
- Inverter required to convert DC to AC for grid integration
- Solar panels are fragile; therefore, weather impacts create most exposure
  - Theft is also an issue, both during construction and operational phase - sometimes only of the copper interconnection cabling
  - Obsolescence is a key risk issue in view of the pace of technology
  - Performance degradation presents uncertainty
  - End of life disposal challenges

CLAIMS INFORMATION

- The average severity of insurance claims from the solar PV industry has increased by 87% over the past five years, as a result of extreme weather, according to research from renewables insurance specialist GCube UW.
- Weather related losses = 25% of claims in North America
  - Floods, tornados, windstorms, hail, lightning, wildfires
- Growth of solar continues at a 25% rate

SOLAR INSTALLATIONS - INSURANCE

- Residential solar energy installations usually covered as part of a standard Homeowners/Farmowners policy
- Typically offers protection against perils such as:
  - Theft/vandalism
  - Storm damage from high winds, lightning, tornado, or hail
  - Fire
  - Snow and ice
- Check for restrictions
- Confirm coverage during installation
- Include the value in the sum insured for the building

BIOMASS

BIOMASS = RENEWABLE?

- Biomass is considered a renewable energy source because its inherent energy comes from the sun and because it can regrow in a relatively short time. Trees take in carbon dioxide from the atmosphere and convert it into biomass and when they die, it is released back into the atmosphere
- Fossil fuels are non-renewable because they will run out one day. ... Some resources can be thought of as both renewable and non-renewable. Wood can be used for fuel and is renewable if trees are replanted. Biomass, which is material from living things, can be renewable if plants are replanted.

MANY DIFFERENT FUELS

- Wood waste
- Municipal waste
- Agricultural waste
- Pelletized fuel is an export commodity
- Gasification is also an option

AD = ANAEROBIC DIGESTER (METHANE DIGESTER)

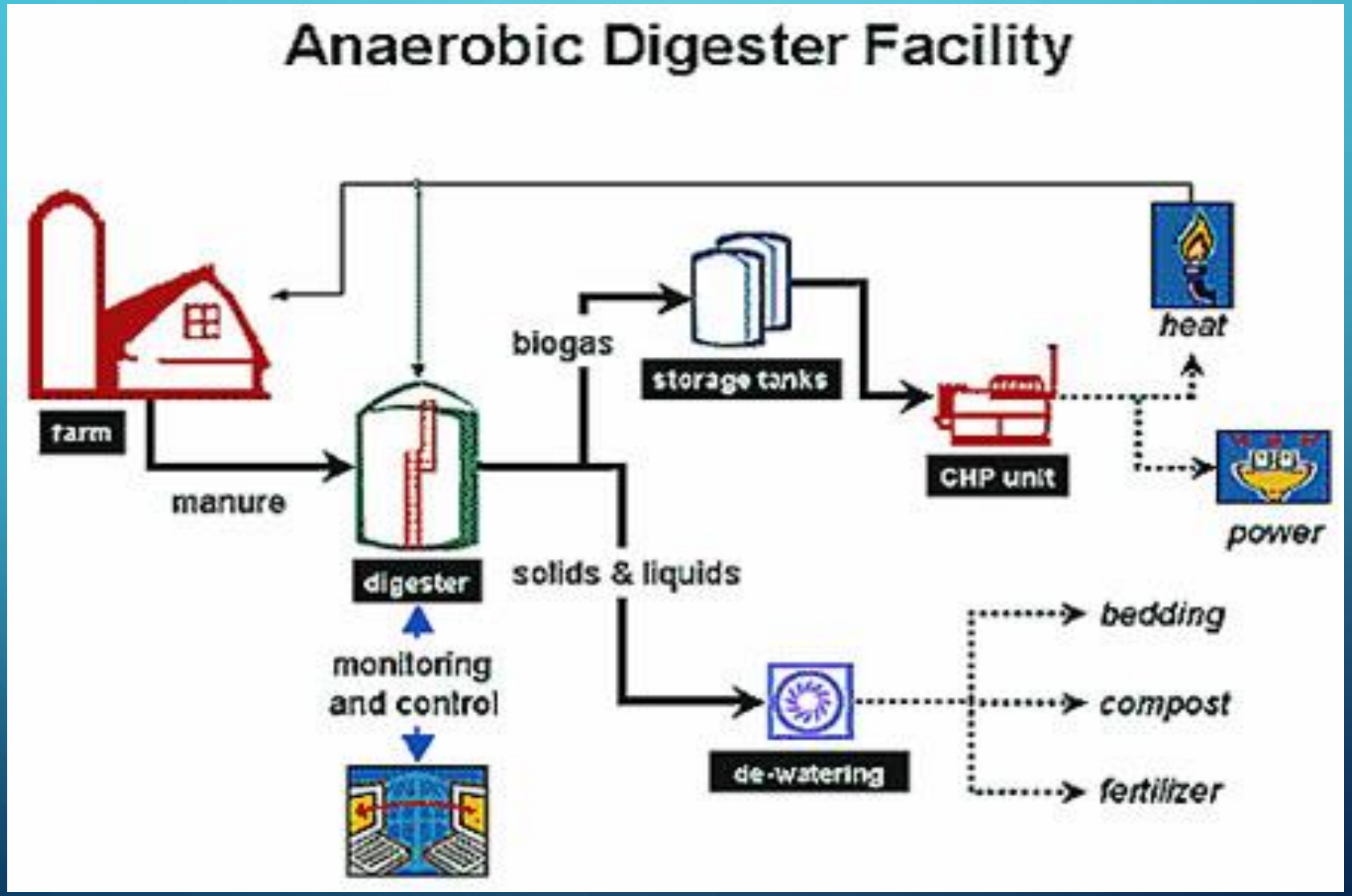
- Anaerobic manure digesters collect manure and convert the energy stored in its organic matter into methane, which is used to produce energy (gas or electricity) for on-farm or off-farm use.
- Anaerobic digestion is the process that decomposes manure, food waste, or any organic material to produce and collect biogas.
- Biogas, consisting of approximately 50-70 percent methane and 30-40 percent carbon dioxide and trace gasses, is generated when organic material degrades in the absence of oxygen.
- Since biogas is a mixture of methane (also known as natural gas or CH4) and carbon dioxide, it is a renewable fuel produced from waste materials and is part of a sustainable residuals management system.

WHY INSTALLED ON FARMS

- **Environmental benefits**
- Turns manure into a source of renewable energy
- Improves air quality by reducing odors and greenhouse gas emissions
- Protects water quality by reducing the potential for pathogens to enter surface or ground water

WHY INSTALLED ON FARMS

- Practical benefits
  - Generates energy that can be sold
  - Generates heat or other energy for on-farm use
  - May qualify for carbon credit payments
  - Aids manure management by making solid-liquid separation easier
  - Results in potentially higher-quality manure for use on crops (more nutrient-rich and fewer weed seeds)
  - Enables animal bedding to be reused
  - Reduces feedlot problems with flies


Anaerobic Digester Facility
farm
manure
digester
biogas
storage tanks
heat
CHP unit
power
solids & liquids
monitoring
and control
de-watering
bedding
compost
fertilizer

METHANE DIGESTERS – RISK ISSUES

- Biogas is comprised of methane and carbon dioxide with lesser amounts of hydrogen sulfide, ammonia & other gasses
- Biogas risks include all of the following:
  - Fire
  - Explosion
  - Asphyxiation
  - Disease
  - Hydrogen sulfide poisoning

RENEWABLE ENERGY – STRATEGIC RISK ISSUES

- Developmental risk
- Technology risk
- Performance risk
- Obsolescence risk
- Weather risk
- Political & regulatory risks

SOME RENEWABLE ENERGY MARKETS

- PERse
- Gcube
- Allianz
- Liberty Mutual
- ACE
- engergi
- XL
- Zurich
- AIG
- Travelers
- Hartford

DRONES

NUMBER OF DRONES GROWS

- As of March 21, 2017, FAA data indicates there are more than 37,000 drone operators certified under Part 107 & 44,000 commercial drones registered in the US

- Part 107 addresses:
  - Operational Limitations
  - Remote Pilot In Command Certification and Responsibilities
  - Aircraft Requirements
  - Model Aircraft – does not apply

AG USES EVOLVE

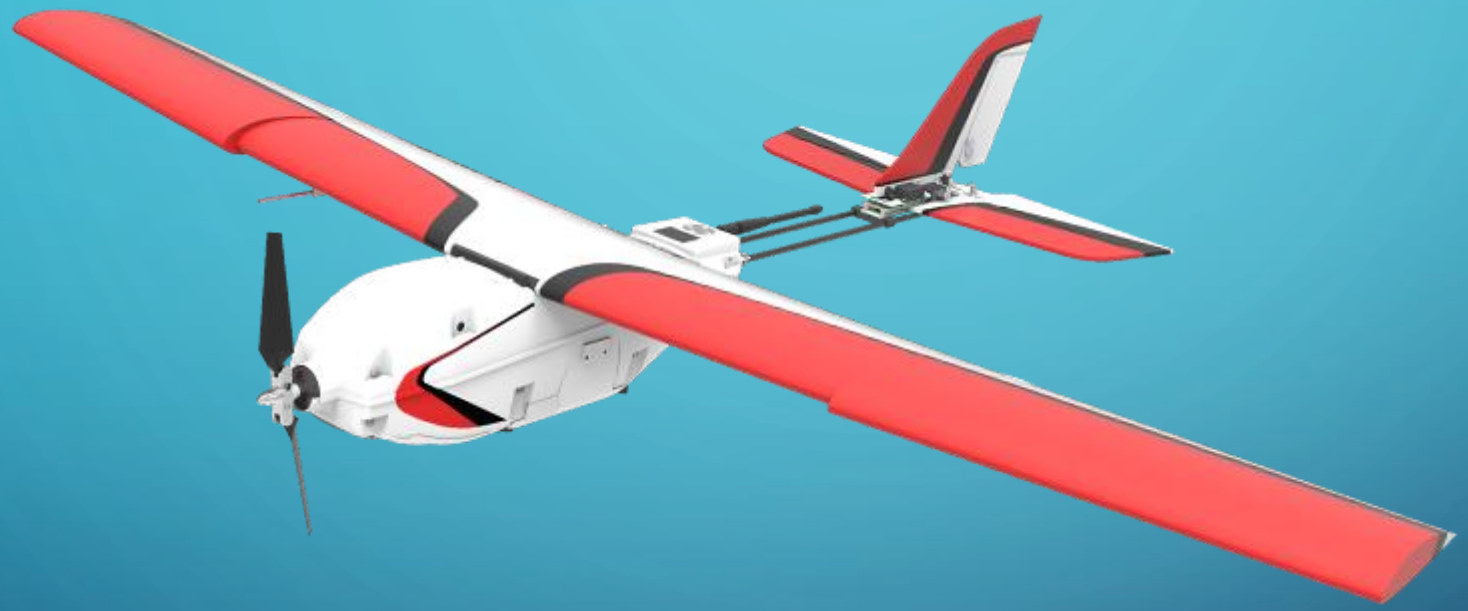
- According to PwC, six potential uses during the Crop Cycle:
  - Soil & Field Analysis
  - Planting
  - Crop Spraying
  - Crop Monitoring
  - Irrigation
  - Health Assessment

DRONE COSTS VARY

- 3 of the Best Priced Drones For Ag (drone price only):
  - DJI Phantom 3 Standard $499.00
  - Phantom 4 Pro $1499.00
  - DJI Inspire 1 $1999.00
    - Droneguru.net
- Or you can get a whole set up for about $26,000

DJI MATRICE 600 AGSTAR - $25,780

OR…PRECISION HAWK "LANCASTER 5"



- Or spend $25,000 on this drone, and then……

VIDEO

- http://www.precisionhawk.com/lancaster

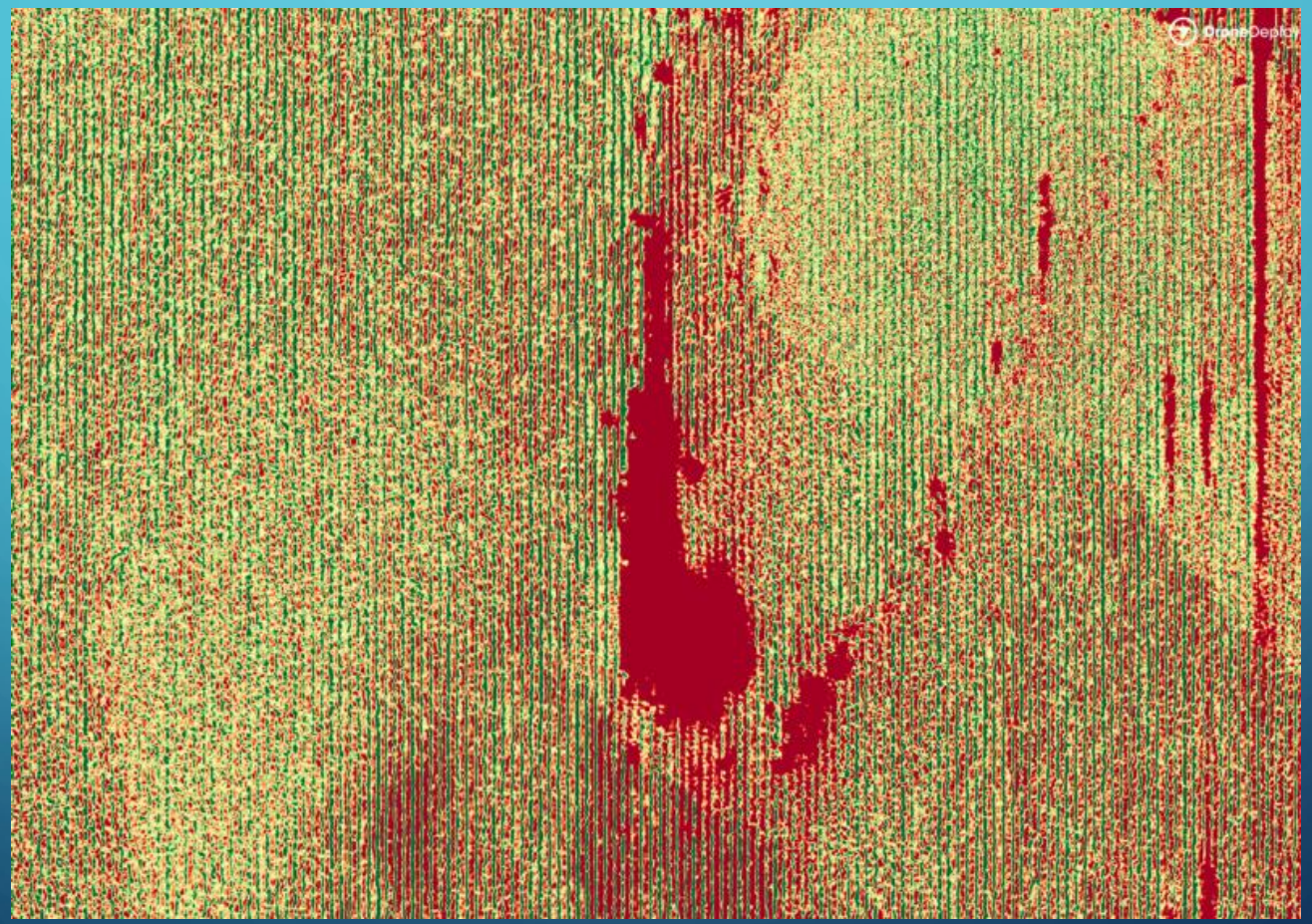
HOW THEY WORK - NDVI & OTHER TERMS

- **NDVI** – Normalized Difference Vegetation Index – a graphical indicator used to analyze remote sensing measurements – assessing whether the target being observed contains live green vegetation or not
- **NDVI** – describes vegetation by showing the difference between near infrared (strongly reflected by vegetation) and red light (which is absorbed by vegetation)
- **NDVI** – is an equation that takes into account the amount of infrared reflected by plants
- **INDEX** is calculated as the reflection difference in the near infrared and red spectrum divided by its total

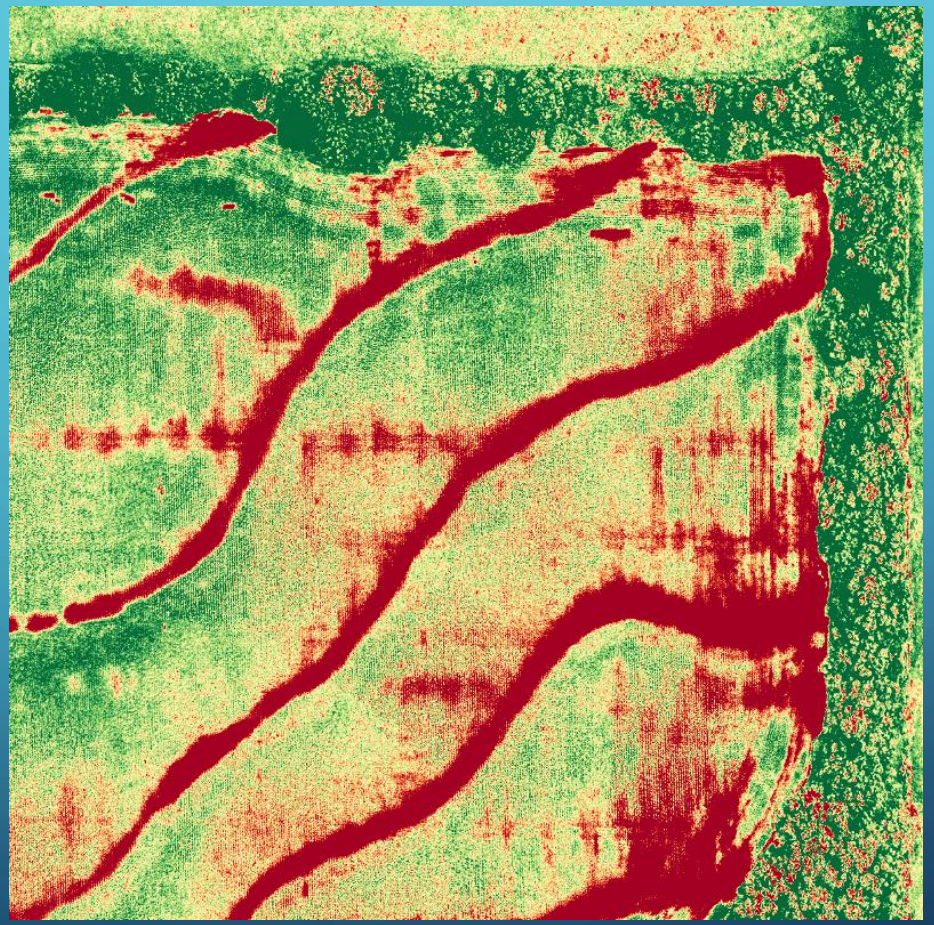
WHAT THE COLORS MEAN…

Object type	Reflectance * in the red spectrum	Reflectance in the near-infrared spectrum	NDVI value
Dense vegetation	0.1	0.5	0.7
Scarce vegetation	0.1	0.3	0.5
Bare soil	0.25	0.3	0.025
Clouds	0.25	0.25	0
Snow and ice	0.375	0.35	-0.05
Water	0.02	0.01	-0.25
Artificial materials (concrete, asphalt)	0.3	0. 1	-0.5

NDVI IMAGERY FROM A DRONE MOUNTED CAMERA



NDVI IMAGERY FROM A DRONE MOUNTED CAMERA



IT'S JUST A TOOL

- NDVI has been used as early as early 1980's in agriculture
- Green normally good – Red normally bad – but not always
- The main value is variability – quicker recognition = quicker decisions
- An agronomist in the field still has value
- Aerial imagery is a tool – not an end all and be all
- If you look at a farm as a crop factory – this measures your factory
- Ground-Truthing is still needed
- Still need to know: crop varietal, history of field, growth stage, fertilization, pesticide use, plant growth environment

PROS & CONS

PROS

- Analysis
- Monitoring
- Spraying
- Irrigation
- Health Assessment
- Ease of Deployment

CONS

- Flight Time & Flight Range
- Initial Cost of Purchase
- Federal Laws
- Interference with Airspace
- Connectivity
- Weather Dependency
- Knowledge & Skill

PRECISION AGRICULTURE

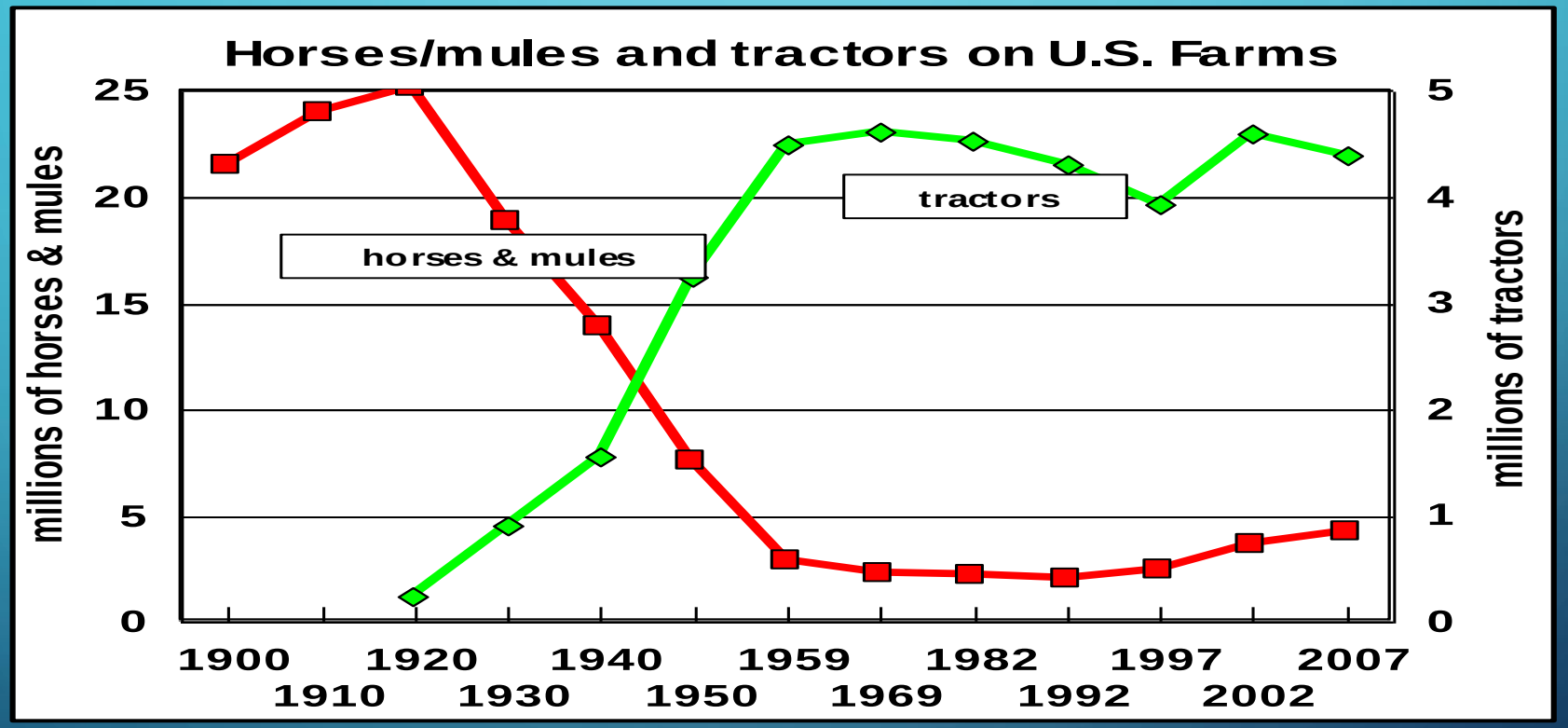
PRECISION FARMING

- Let's agree on a definition:

- A farming management concept based on observing, measuring & responding to inter & intra field variability in crops.
  - An ability to take large fields (or a number of large fields) and them manage them as though they were a group of smaller fields

- AKA: Satellite farming – site specific crop management (SSCM) – site specific ag

FARMING HAS ALWAYS UNDERGONE CHANGE



PRECISION AG TECHNOLOGIES

- GPS Guidance & AutoSteer
- Section Control on Sprayers
- Row Control on Planters/Seeders
- Yield Monitoring
- Remote Sensing
- In-Field Sensing
- LIDAR
- Variable Rate Applications
- Telematics
- Robotics
- Data Management

HOW & WHY IT HAS GROWN

- It has been around about 20 years in Ag
- It has been enabled by these factors:
  - Crop yield monitors on GPS equipped combines
  - Variable rate technology (VRT) like seeders, sprayers and the like
  - An array of real time vehicle mountable sensors that measure everything from chlorophyll levels to plant water status
  - Multi & hyper spectral aerial and satellite imagery from which products like NDVI maps can be made

WHY UTILIZE PRECISION AG

- Reduced stress – it can make managing a farm and the farm's output easier. Reduces potential for human error. Higher knowledge of what is going on in one's fields, more run time, less operator fatigue
- Assist in protecting the environment – better application of products, less waste & overlap of spraying & various other applications, higher fuel efficiency
- Maximize profits – less overlap in the fields, increased yields due to better management and application of products, less labor needed
- Better opportunity to meet the growing demand of our populations along with the shrinking agricultural footprint

GEO REFERENCING TOOLS

- A large number of Geo Referencing tools are utilized
- GPS Tractors
- GPS Harvesters
- Aerial Imagery
- Crop & Soil Color Index Maps
- Crop Yield Data Collection
- Soil Characteristics & Soil Types
- Drainage Levels and Water Application
- Electromagnetic Soil Mapping

HOW IT HELPS

- Each of those previously referenced data layers allows the farmer to subdivide a large field area into smaller management zones
- They will use Grids or Zones
- Using small management zones reduces waste while increasing potential production – some examples
  - Less application of fertilizers and other nutrients
  - Less (and more focused) application of pesticides, herbicides etc.
  - More dense plantings (better utilization of available cropland)
  - Better water application and management of available irrigation

AN EXAMPLE

- Automatic Section Control (ASC) for Agricultural Sprayers
- ASC (aka: auto swath technology) has readily been adopted over the past few years. This very simply eliminates overlap when applications are applied in the fields.
- The technology turns spray nozzles ON and OFF in areas that have been previously sprayed, at headland turns, point rows, terraces, waterways and any other areas marked for NON-pesticide or nutrient applications
- Comes with currently manufactured equipment or after-market applications

PRECISION AG SAVINGS

- Alabama Cooperative Extension estimated in 2014
- GPS technology saves approximately 10% per year in costs
- Variable Rate Applicators approximately saves 7% per year
- Automatic Section Control saves approximately 5% per year

ROBOTICS & AUTOMATION

IT'S HARD TO SEPARATE THEM

WHY ROBOTICS/AUTONOMOUS

- Speed of work
- Can work in all types of conditions
  - Hazardous
  - Dangerous
- Temperature doesn't bother the Bot
- Repetitive tasks – doesn't get bored easily
- Accuracy of work

AUTONOMOUS ADVANTAGES

- They can work 24/7 – don't demand breaks
- Can collect all sorts of soil and crop samples
- Probably smaller in size than some current machinery – smaller carbon footprint
- They are being rapidly developed and costs will come down with greater competition and demand
- Potential uses: Weeding, spraying, harvesting, what will they not be able to perform

AUTONOMOUS DISADVANTAGES

- Technology not quite ready…but,
- Currently too costly…but
- Sensors probably will need to be improved
- Reliability will need to be proven
- Periodic human presence is currently required – that is expected to change in the near future

VIDEO

- http://www.farmindustrynews.com/tractors/autonomous-tractor-update

HOW ROBOTIC EQUIPMENT WORKS

1. LiDAR unit is mounted on hood of machinery.
2. LiDAR unit is wired to a computer that sends any alerts to the in-cab computer.
3. LiDAR unit can send wireless messages to a cell phone or computer to alert the farm manager.

LiDAR unit can detect crop height changes, field wash outs, surface water, livestock and wildlife, and other obstacles.

CURRENT OPTIONS & TESTING OPERATIONS

- Wirelessly connected implements
- Driverless tractors

- Agrobot SW6010

AGROBOT SW6010

AGROBOT SW6010

- AGB® manages a set of robotic manipulators able to locate and identify your strawberries, selecting them based on their size and degree of ripeness.

- This system analyzes your fruit one by one, and it is responsible for ordering cutting movements that guarantee accuracy, smoothness, and sensitivity in the strawberry treatment. The fruit, picked with the strictest hygiene conditions, is driven by our FlexConveyor System to the packaging area.

AGROBOT SW6010

- Select the ripeness you would pick up.

- AGvision ® is an artificial vision system that identifies your fruit with maximum accuracy and consistency. Its advanced technology, implement in real time a protocol for morphological and color analysis which systematically return the ripeness of the fruit, discriminating exclusively those strawberries which meets the quality standards previously set by the farmer.

AGROBOT SW6010

- Save time by optimizing your processes.
- SW 6010 has two workstations qualified to monitor and pack the picked fruit.
- An ergonomic design provides dynamic access and outstanding conveniences that streamline the procedures for forming and weighing your clamshells.
- Take advantage of a flexible and versatile work resource, which marks the rhythm of new trends in the field functions.

AGROBOT SW6010

MECHANIZATION…WHY NEEDED?

- Shrinking labor pool
- Immigration issues
- Expense of labor in farms and agriculture

EXAMPLE - VINEYARD OPERATIONS

- According to one source: Duff Bevill, Bevill Vineyard Management
- Historically vineyard harvesting is the most labor intensive task
- Labor is approximately 65% of a vineyard's operating costs
- In descending order vineyard costs are:
  - Harvesting
  - Pruning
  - Crop thinning
  - Leaf removal

  So doesn't it make sense to mechanize these operations…and then get robotic &/or autonomous processes in place?

UCD – COSTS FOR VINEYARDS, 2016 SACRAMENTO & SAN JOAQUIN COUNTIES

- Hypothetical farm
- 200 contiguous acres located on the valley floor in Crush District 11, San Joaquin & Sacramento counties is owned and operated by the grower.
- 60 acres of winegrapes are being established and are the basis of this study
- In addition, 135 acres of mature vineyards are in production and roads, irrigation systems, fencing and farmstead occupy 5 acres.

ESTIMATED LABOR COSTS - 2016

- $14.00 per hour for machine operators & $11.00 per hour for non
- Add in 39% for employers' share of Federal & State payroll taxes, insurance (WC) brings the rates closer to $19.46 and $15.29
- Operating costs per acre - estimated and include the following:
  - Equipment time - $6.56
  - Fuel - $52.00
  - Material costs - $629.00

  Labor Costs - $1176.00

  Lube & Repairs - $30.00

  Custom work &/0r Rentals - $890.00

  Cash Overhead per acre at $1163.00

  Non-Cash overhead per acre at $2483.00

  ANNUAL COSTS PER ACRE ESTIMATED AT $6,103.00

MECHANICAL HARVESTING - USA

MECHANICAL PRUNING IN THE VINEYARD

MECHANIZED PRUNING IN THE VINEYARD

MECHANIZED WINE GRAPE SUCKERING REMOVAL

LEAF REMOVAL - VINEYARD

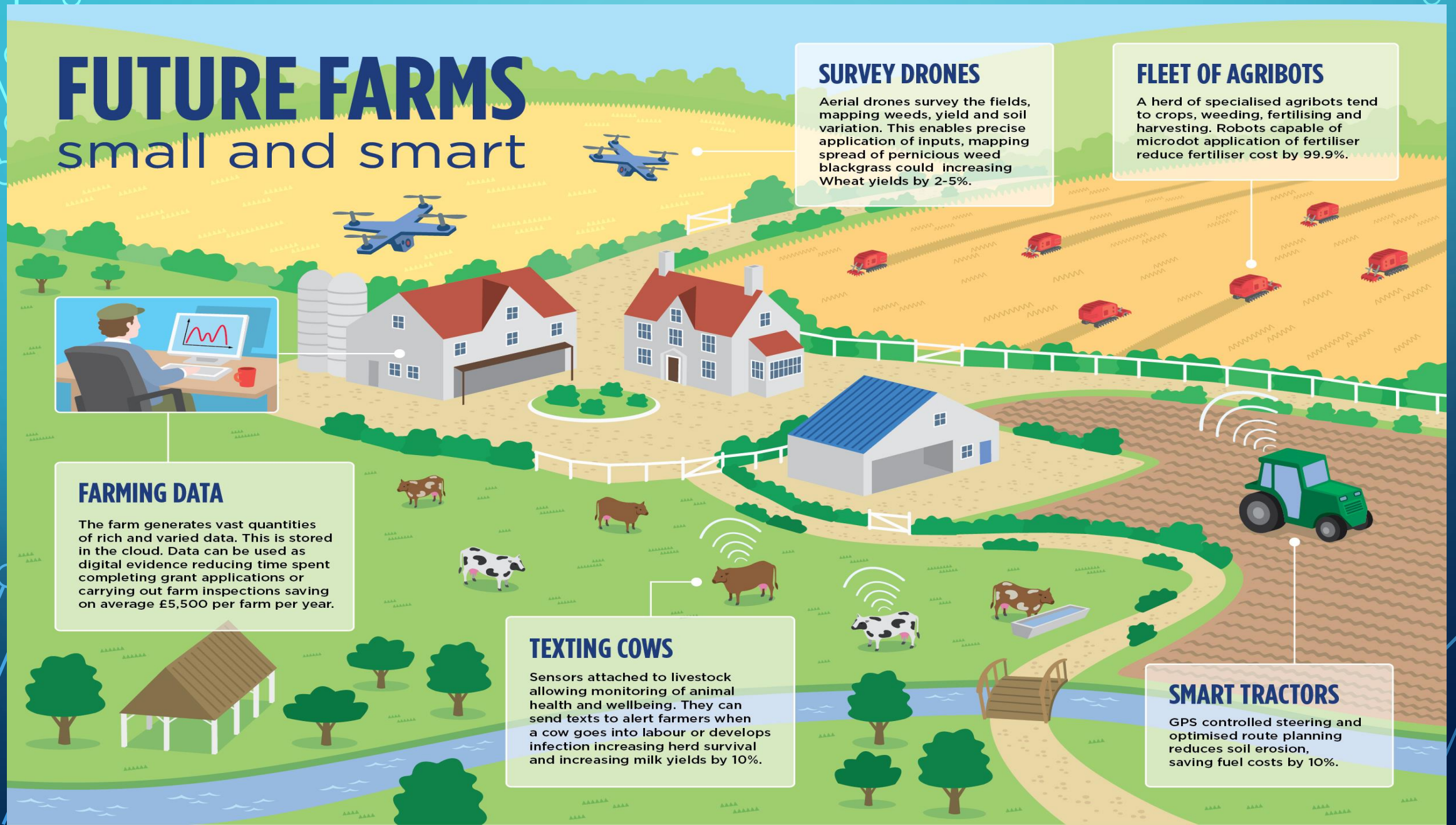
SHOOT THINNING

SOME FINAL CONSIDERATIONS

CYBER ANYONE

- How many of you have spoken with your farmers about Cyber coverage
- Have you sat with them and have them inventory ALL of their equipment that is subject to computer input
- What if their data falls into the wrong hands
- What if they get “hacked…just for fun”
- What “other” concerns can you foresee?

FUTURE FARMS
small and smart



SURVEY DRONES

Aerial drones survey the fields, mapping weeds, yield and soil variation. This enables precise application of inputs, mapping spread of pernicious weed blackgrass could increasing Wheat yields by 2-5%.

FLEET OF AGRIBOTS

A herd of specialised agribots tend to crops, weeding, fertilising and harvesting. Robots capable of microdot application of fertiliser reduce fertiliser cost by 99.9%.

FARMING DATA

The farm generates vast quantities of rich and varied data. This is stored in the cloud. Data can be used as digital evidence reducing time spent completing grant applications or carrying out farm inspections saving on average £5,500 per farm per year.

TEXTING COWS

Sensors attached to livestock allowing monitoring of animal health and wellbeing. They can send texts to alert farmers when a cow goes into labour or develops infection increasing herd survival and increasing milk yields by 10%.

SMART TRACTORS

GPS controlled steering and optimised route planning reduces soil erosion, saving fuel costs by 10%.