

National Western Center Regeneration Framework

Assessing District Level: Energy, Water and Waste

[Conceptual Ideas and Strategies]

September 2015

Section	Title	Page Number
1.0	EXECUTIVE SUMMARY	3
2.0	INTERNAL IDEAS SESSION AND CONCEPT DEVELOPMENT	5
3.0	THE DECISION TREE	5
4.0	DISTRICT ENERGY, WATER & WASTE	6
5.0	RENEWABLE ENERGY.....	6
6.0	HOLISTIC ENERGY PLANS: INTEGRATING ENERGY IN INFRASTRUCTURE AND LAND-USE PLANNING	6
7.0	WHAT IS “BASELINE?”	6
8.0	“TYPICAL” CENTRALIZED OR DISTRICT HEATING/COOLING.....	7
9.0	“CONTEMPORARY” CENTRALIZED OR DISTRICT HEATING/COOLING	7
9.1	ADDING RENEWABLE ENERGY – SOLAR	9
9.2	ADDING RENEWABLE ENERGY – WIND	10
9.3	ADDING RENEWABLE ENERGY – SOLAR THERMAL.....	10
9.4	ADDING RENEWABLE ENERGY – WASTE TO ENERGY	11
9.5	ADDING RENEWABLE ENERGY – WASTE TO FUEL	12
9.6	WASTE – COMPOSTING.....	13
9.7	WATER 1 – ON-SITE WASTER WATER PLANT.....	14
9.8	WATER 2 – LIVING/ECO MACHINE.....	14
9.9	WATER 3 – DENVER PURPLE PIPE NETWORK.....	15
9.10	FUEL CELL ENERGY	18
10.0	NATIONAL WESTERN CENTER MASTER PLAN PHASING OVERVIEW – LOCATING THE DISTRICT UTILITY CENTER 19	
11.0	THE WAY FORWARD.....	27
12.0	IN CONCLUSION	27
	APPENDIX A	29
	APPENDIX B	33

An eco-district needs a community whose vision matches its state of affairs.

Utopia has never been easy.

1.0 Executive Summary

District energy systems are seen as a best practice approach for providing a local, affordable and low-carbon energy supply. District energy, water and waste solutions represent a significant opportunity for developments such as National Western Center (NWC) to move towards climate-resilient, resource-efficient and low-carbon pathways.

Among the core components of the transition to a sustainable energy future are the integration of energy efficiency and renewable energy technologies, and the need to use “systems thinking” when addressing challenges in the buildings sector.

This report is in support of the development of NWC’s Sustainability and Regeneration Framework and Goals. Particularly EER 3: Create "net zero" or "closed loop" systems for energy, waste, and water at full build-out. The overarching purpose was to develop a robust State-of-the-Art regeneration framework at the district level that is integrated into the National Western Center Campus Master Plan and its core elements. Energy, water and waste systems to reduce operational energy and greenhouse gas emissions were explored.

The framework for NWC Regeneration Scope began with the Regeneration goals and objectives developed to date through the partner-led exercise of the NWC Master Plan. The framework examined energy, water, waste systems and reduction in greenhouse gas emissions across the district. The district is defined as the approximately 270-acre primary project boundary of the NWC Master Plan. The process began with a work session/charrette with the design team including NWC-MOU Partners and key stakeholders. Constraints and opportunities were identified at the work session for energy, waste and water infrastructure as well as overall goals embedded in the planning to date. We then evaluated the existing conditions, program, infrastructure master plan, and master plan and from these plans and documents developed conceptual-level district opportunities for energy, waste, water, carbon and greenhouse gas emissions.

Ideas for energy, water, waste, carbon and greenhouse gas reductions were not developed independently but rather as a holistic and interconnected vision that would better meet the goals of NWC’s Sustainability and Regeneration Framework.

This report provides an overview of the various district level technologies and their specific applications, in order to help NWC, its partners and stakeholders identify the most cost-competitive and appropriate options as they begin executing a new Master Plan that will serve NWC for the next 100 years.



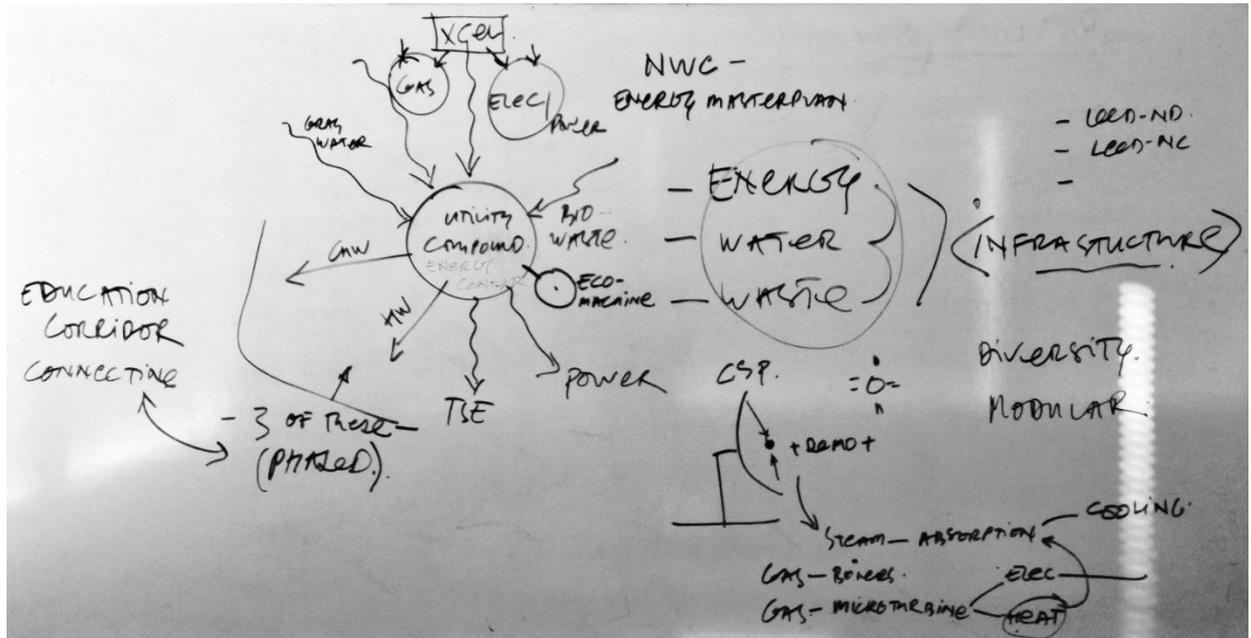
This land at the South Platte River is where people settled, worked, grew crops, built homes and an industry of agriculture emerged. Denver grew from this place. Denver grew from this history and is embracing this unique opportunity to reposition the site to advance Colorado's role in solving global food and resource issues.

The National Western Center extends this history into a promising future, bringing the National Western Stock Show, Colorado State University, Denver Museum of Nature and Science and History Colorado into partnership with the City and County of Denver to create a bold vision and a dynamic global engagement center that brings together P-12 experiential learning, research, commerce, competition, tourism and entertainment for the next 100 years.

The National Western Center will serve as a catalyst for the new west and a new way of thinking. It will set a new and higher standard that focuses on the stewardship of our land and investment in our agricultural resources to become a global leader in food production, water, energy and agriculture. It will tell the story of our frontiering spirit through strong partnerships, a celebration of our western heritage and pioneering opportunities for the future.

The development of modern (i.e., energy-efficient and climate-resilient) and affordable district energy, water & waste integrated systems on campuses such as NWC is one of the least-cost and most-efficient solutions for reducing greenhouse gas emissions and primary energy demand as set out in EER 5 (NWC Sustainability and Regeneration Framework and Goals of the Master Plan): Maintain or reduce greenhouse gas emissions (GHG) levels, including transportation, at or below 2016 GHG emissions and strive for continuous reduction over time, aiming for alignment with City and County GHG and climate goals.

2.0 Internal Ideas Session and Concept Development



The germination of the concept began with an internal (to ME Engineers) interdisciplinary work session.

3.0 The Decision Tree

These questions are used as a framework to understand and help decide the next steps needed to accelerate decision making and implementation of district energy at NWC.

Why?

- Why district energy, what is the energy demand and what are the next-available technology costs for district energy deployment?

When?

- When should district energy be developed, and what are the catalysts that take district energy from vision to reality?

What?

- What steps need to be taken to begin development of a district energy strategy at NWC?

How?

- How can NWC foster and develop district energy? How can incentives, policy frameworks, business models and tariff structures best serve district energy solutions at NWC?

4.0 District Energy, Water & Waste

District Energy, Water and Waste Solutions are being proposed because of its ability to dramatically reduce the carbon intensity of heating and cooling, lower energy costs, improve air quality, increase the share of renewables in the energy mix, reduce reliance on fossil fuels and energy imports, and increase the resilience of the NWC community.

District level systems can serve as the fundamental solution and backbone of the sustainable energy transition that NWC is seeking.

5.0 Renewable Energy

There was consensus across the board that renewable energy can provide high levels of affordable heat and cooling when incorporated into district energy systems through economies of scale and diversity of supply. This will enable (in the future) NWC to have 100% renewable energy or carbon-neutral targets for all phases of development.

District energy schemes are one of the most effective means for integrating renewable energy sources into heating and cooling sectors.

- solar thermal
- geothermal
- bio-energy
- wind-to-heat
- waste heat and
- natural, free, cooling systems

can benefit from the economies of scale that district energy provides.

6.0 Holistic Energy Plans: Integrating Energy in Infrastructure and Land-Use Planning

You often have land-use folks saying let's put the buildings here, and transport planners saying how do we get people moving around – and then almost as an afterthought, folks say, well, how do we provide energy to the neighborhood?

NWC must integrate these various issues into community building and urban planning.

7.0 What is “Baseline?”

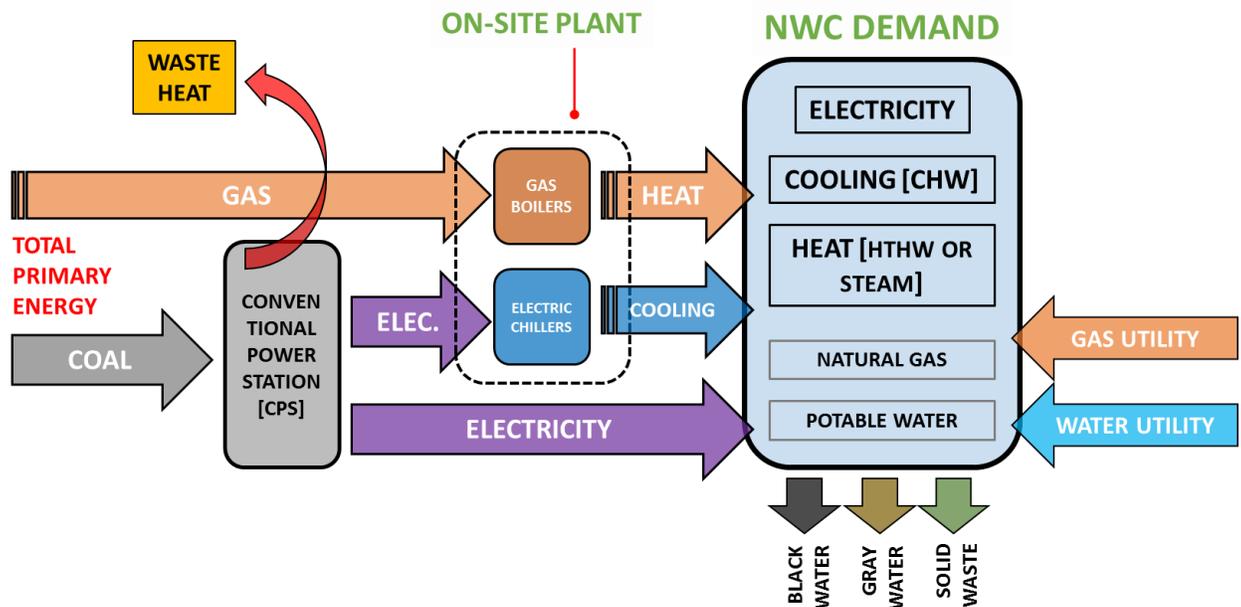
It was important to not only establish but also to understand a baseline from which to improve upon as we looked at solutions for NWC.

- De-Centralized:
 - Individual buildings and facilities served by:
 - Natural gas
 - Electricity
 - Potable water
 - Storm and Sewer (out flows)
 - Each building has its own self-contained heating and cooling systems.

This is a standard approach with perhaps the least initial cost but has higher energy and maintenance costs in addition to a large carbon footprint. This approach adds services as the overall Master Plan gets implemented in phases.

8.0 “Typical” Centralized or District Heating/Cooling

This approach can have natural gas, electric, water and sewer services arriving at a central point. A central boiler plant produces either steam or high temperature hot water (HTHW) for space heating. Central electric centrifugal chillers produce chilled water (CHW) for space cooling. Steam (or HTHW) and chilled water are piped to each individual building. Electric service is fed to a central electric meter (primary service) then routed to each individual facility. However, part of the electric, gas, water and sewer services can be de-centralized. This approach use standard technology and may be higher in initial cost but can be lower in energy and maintenance costs. This “base” centralized option allows for more flexibility to add solutions and technology for energy, water and waste conservation. Also, this approach can have the flexibility to add services as the overall Master Plan gets implemented in phases.

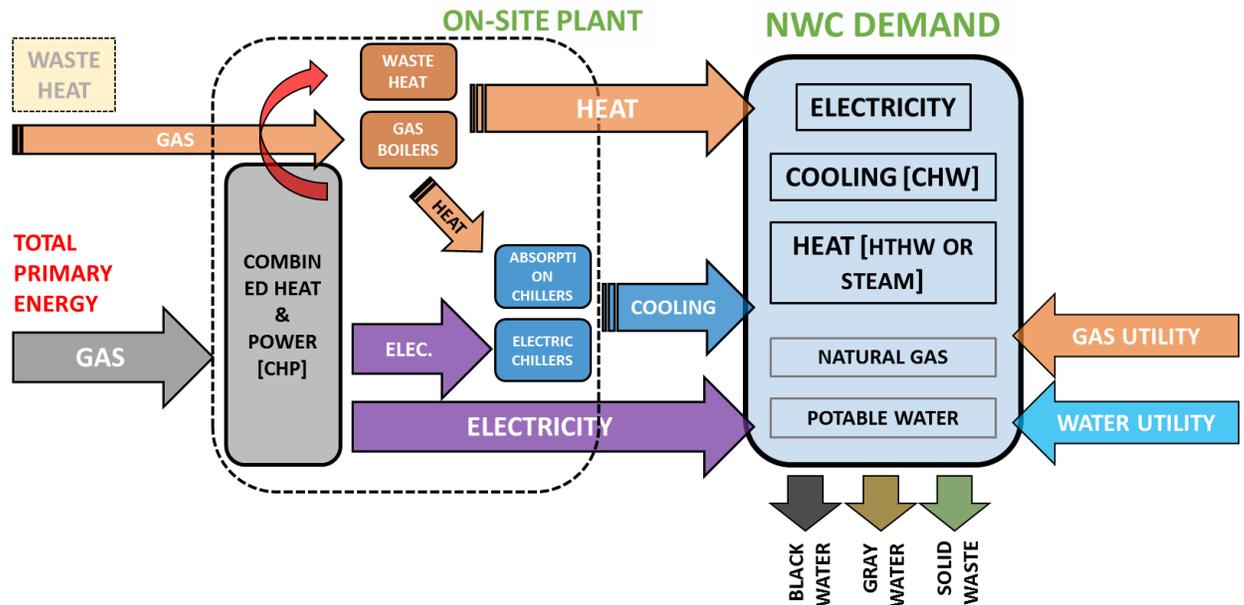


Typically average efficiency of coal-fired power stations is 33%. Much of the heat produced from burning coal is wasted. A typical coal power plant uses only 33-35% of the coal's heat to produce electricity. The majority of the heat is released into the atmosphere or absorbed by the cooling water.

9.0 “Contemporary” Centralized or District Heating/Cooling

Involves the use of a co-generation or even tri-generation plant, also referred to as combined heat and power (CHP). Electrical energy is produced with natural gas fired micro-turbines with the waste heat being captured and used to produce either steam or HTHW with the steam or HTHW used to produce chilled water (CHW) using absorption chillers. These differ from the

more prevalent chillers in that the cooling effect is driven by heat energy, rather than by mechanical energy. Use of this is also referred to as combined cooling, heat and power (CCHP). Gas CHP plants are typically 85-92% efficient but can be as high as 97% efficient in the CCHP configuration.



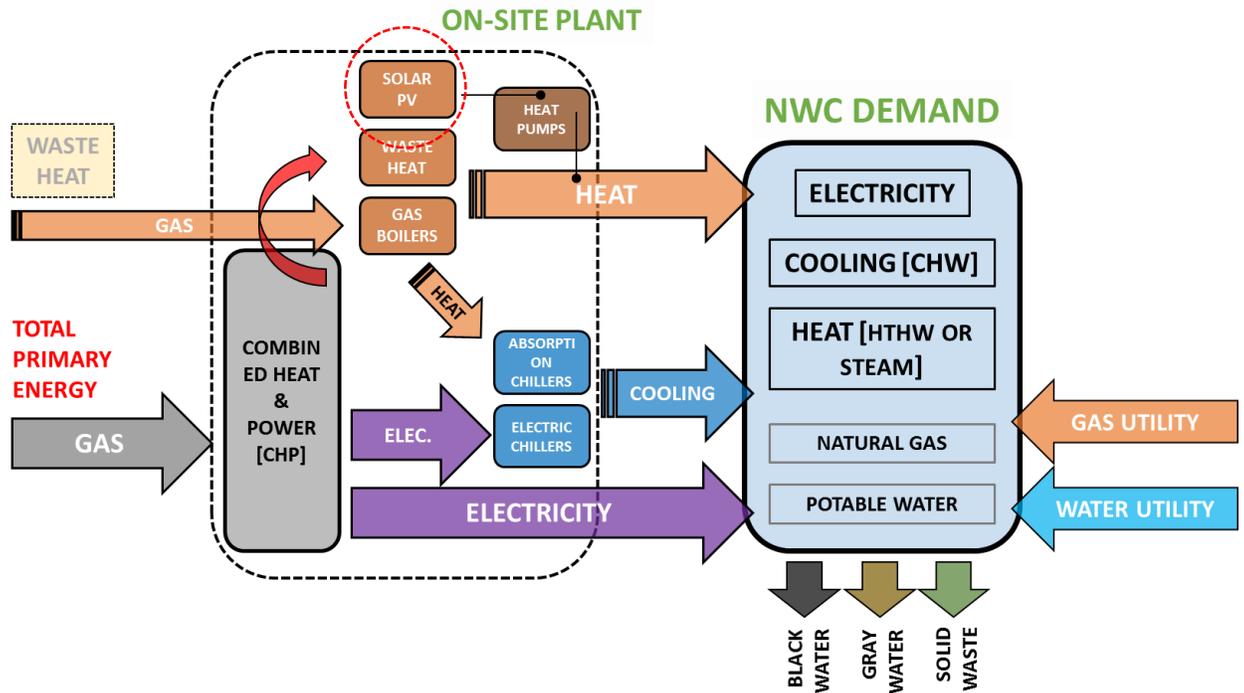
We can consider the use to 'adsorption' chillers** rather than 'absorption' chillers as they present several advantages that may work in NWC's context. Some are listed below:

- No crystallization, corrosion, hazardous leaks, or chemical disposal issues
- Low operational costs and maintenance
- Only minor service required, once every 3 years
- More than 30 years of machine life
- Low carbon emissions, eco-friendly operations
- No vibration or noise
- Simple and continuous operations
- Operates over a wide range of temperature for hot, cool and cold water

We recommend the pros and cons of each technology be further evaluated as part of the whole systems approach being pursued.

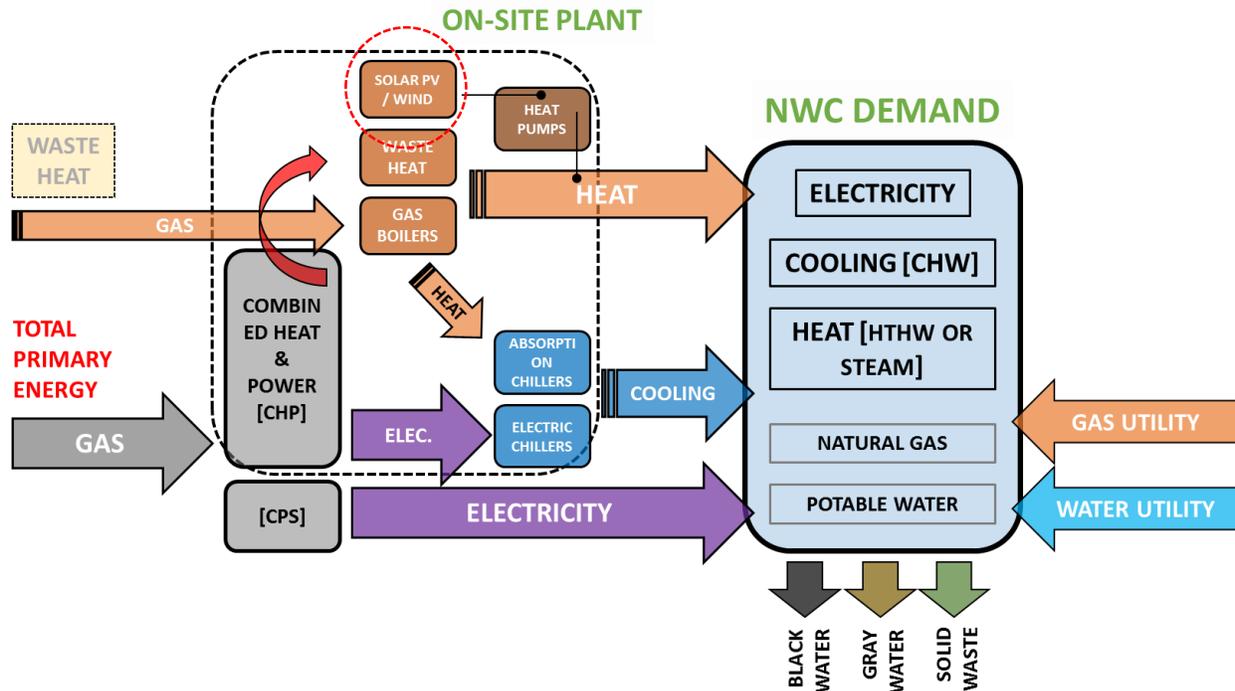
** Adsorption chillers work on the principle of adsorption using solid sorption materials such as silica gel and zeolites. While absorption type chillers use a solution containing water and lithium bromide salt to absorb heat from the surroundings. Adsorption chillers have no liquid desiccants at all. By not using chemicals such as lithium bromide and ammonia, the potential for hazardous material leaks, aggressive corrosion, and chemical testing requirements are eliminated. Also, adsorption chillers use municipal tap water as the refrigerant, compared to absorption chillers that require distilled water.

9.1 Adding Renewable Energy – Solar



Additional variable electricity production such as through the use of solar PV panels, can be utilized and stored using district energy, providing valuable demand response for the power system. This renewable source of electricity can be used to power heat pumps, which capture low-grade heat (such as from the ground or from Delgany Interceptor) to produce hot water to be stored or fed directly into the district heating network as shown above.

9.2 Adding Renewable Energy – Wind

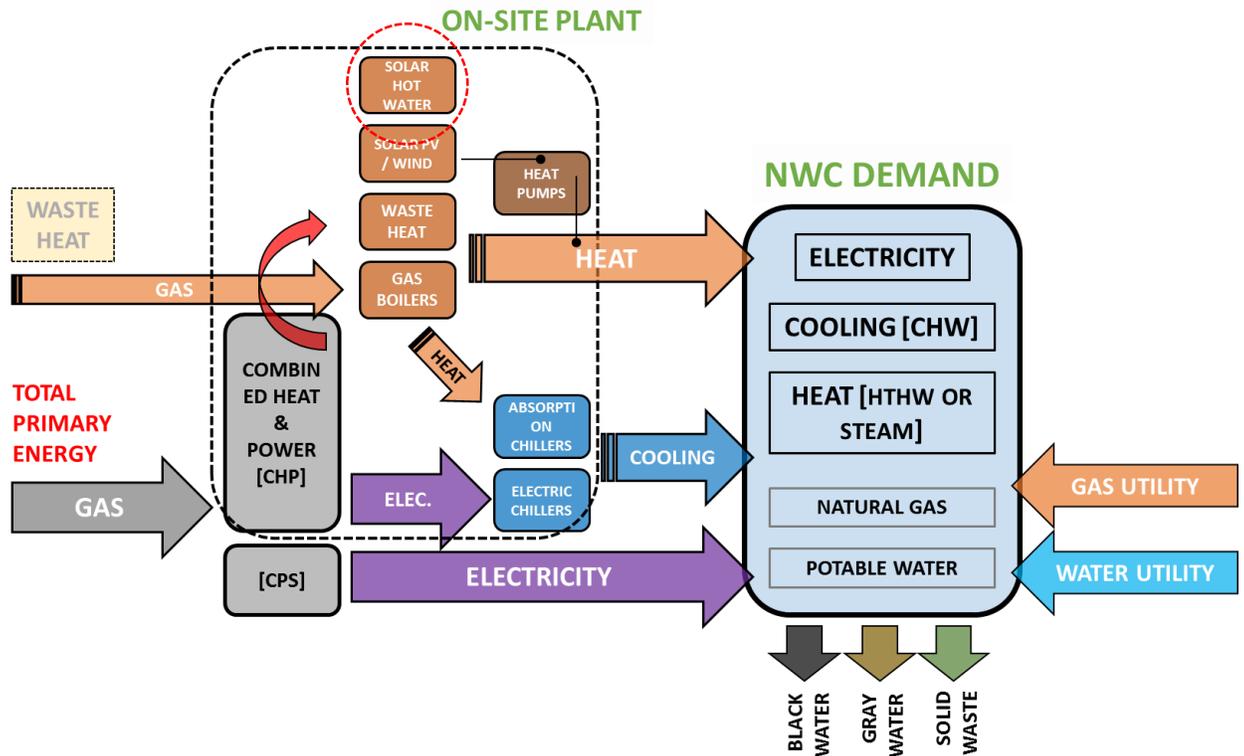


The major advantage of solar / wind hybrid system is that when solar and wind power production are used together, the reliability of the system is enhanced. Additionally, the size of battery storage can be reduced slightly as there is less reliance on one method of power production. Often, when there is no sun, there is plenty of wind.

Wind speeds are often low in periods (summer) when the sun resources are at their best. On the other hand, the wind is often stronger in seasons (winter, in many cases...) when there are less sun resources. Even during the same day, in Denver or in some periods of the year, there are different and opposite patterns in terms of wind and solar resources. And those different patterns can make the hybrid systems the best option in electricity production i.e. reduce variability.

9.3 Adding Renewable Energy – Solar Thermal

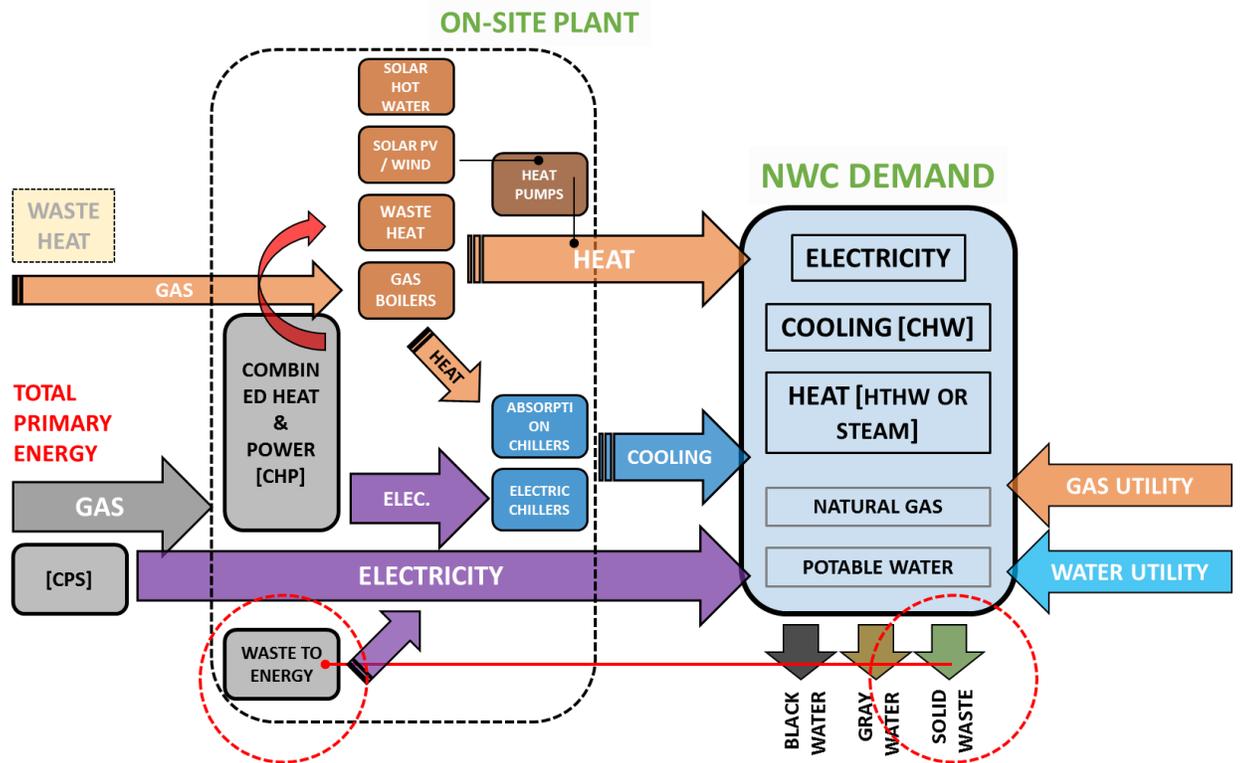
Solar thermal can be added to support the district heating loop either as a centralized solution or even as decentralized. For example, individual building-mounted solar thermal systems can be designed such that it allows for providing heat to the district heating loop in times of surplus, to be used elsewhere on the NWC campus.



9.4 Adding Renewable Energy – Waste to Energy

Instead of hauling off non-recyclable municipal solid waste (MSW) to landfills, there are several options to convert it to energy. NWC can incinerate it on-site. The waste heat can be used to generate steam. One option is to use steam turbines to produce electricity. The exhaust fumes of the incinerator must be controlled so it's not contributing to local air pollution.

The other option: 'gasification' is a unique process that transforms any carbon-based material, such as MSW, into energy without burning it. Instead, gasification converts the materials into a gas by creating a chemical reaction. This reaction combines those carbon-based materials (known as feedstocks) with small amounts of air or oxygen, breaking them down into simple molecules, primarily a mixture of carbon monoxide and hydrogen, and removing pollutants and impurities. What's left is a clean 'synthesis gas' (syngas) that can be converted into electricity and valuable products. With gasification, MSW and other types of wastes are no longer useless, but feedstocks for a gasifier. Instead of paying to dispose of and manage the waste for years in a landfill, using it as a feedstock for gasification reduces disposal costs and landfill space, and converts those wastes to electricity and fuels.



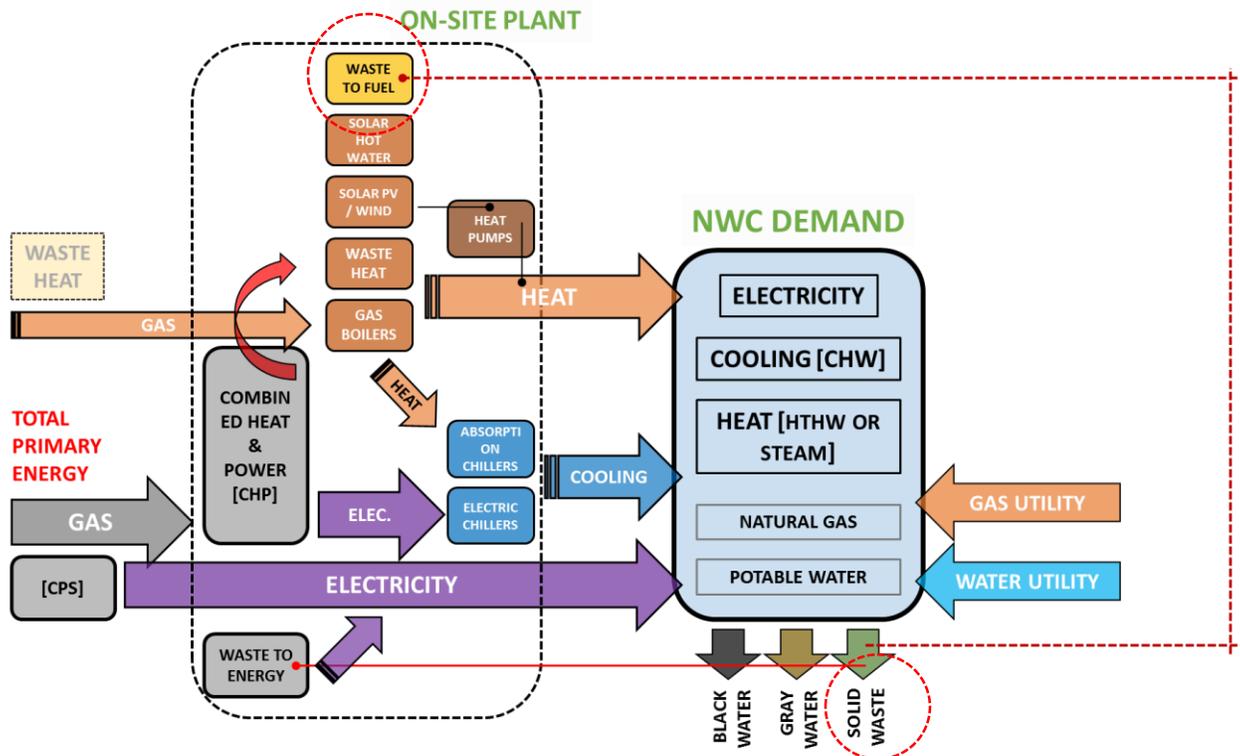
On average, conventional waste-to-energy plants that use mass-burn incineration can convert one ton of MSW to about 550 kilowatt-hours of electricity. With gasification technology, one ton of MSW can be used to produce up to 1,000 kilowatt-hours of electricity, a much more efficient and cleaner way to utilize this source of energy.

The Denver Zoo, 3 miles to the south of NWC, is using the ‘gasification’ option to manage their waste responsibly.

9.5 Adding Renewable Energy – Waste to Fuel

Using a relatively newly developed thermochemical process we can also convert municipal solid waste, or MSW, feedstock into low-carbon renewable transportation fuels including jet fuel and

diesel. And in a district configuration as the one we are looking at, the renewable fuel can be used in several ways.



9.6 Waste – Composting

The following organic materials generated on the NWC campus to be considered:

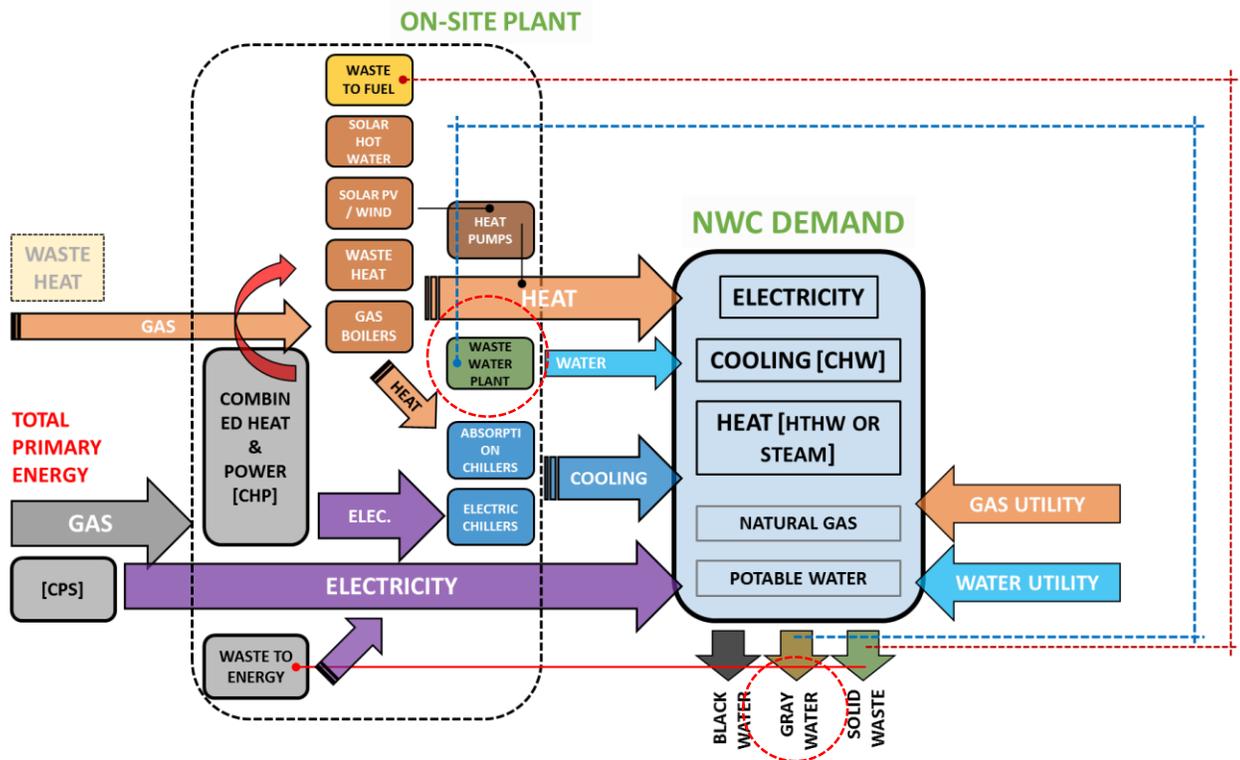
- Grass Clippings
- Leaves
- Weeds
- Flowers
- CSU Garden Waste
- Wood/limbs
- Sawdust
- Wooden Crates
- Brush and Tree Trimmings
- Food Waste
- Shredded paper
- Food-Soiled Paper (waxed cardboard, napkins, paper towels, paper plates, paper milk cartons, tea bags, coffee grounds/filters)
- Animal waste

Procurement and supply chain – upstream considerations are keys to success. Characteristics of the various waste streams to be used as fuel are extremely important to take into account, not

only when looking at on-site composting but also when designing waste to energy gasification systems (Section 9.4).

9.7 Water 1 – On-Site Waster Water Plant

To help with NWC’s goal of creating a "net zero" district for water use, a good place to begin is to look at ‘gray water’ discharge and running it through a central on-site water treatment plant as shown below. Wastewater treatment is a process to convert wastewater, which is water no longer needed or suitable for its most recent use – into an effluent that can be either returned to the water cycle with minimal environmental issues or reused on-site for landscaping and other similar non-potable needs.

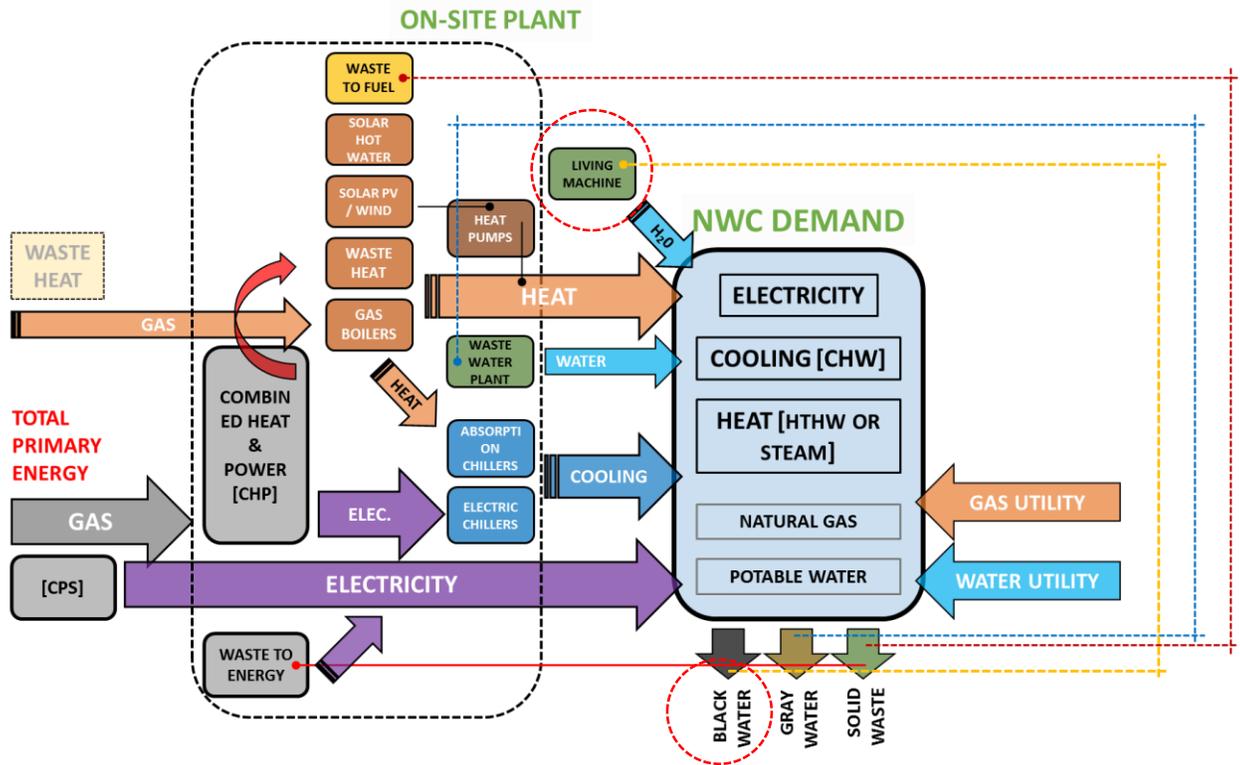


9.8 Water 2 – Living/Eco Machine

An Eco Machine/Living Machine is a water reclamation system that cleans water by mimicking the processes of the natural world.

All the water from the NWC campus, including water used in toilets, showers, and sinks, can flow to the Eco Machine/Living Machine system, where it will be purified by microscopic algae, fungi, bacteria, plants, and snails. This natural water reclamation process cleans the water using zero chemicals. The purified water can be returned to the aquifer deep beneath campus or discarded directly into South Platte River.

With additional treatment, this water can be utilized on-site in numerous ways thus further offsetting the use of municipal supplied potable water.



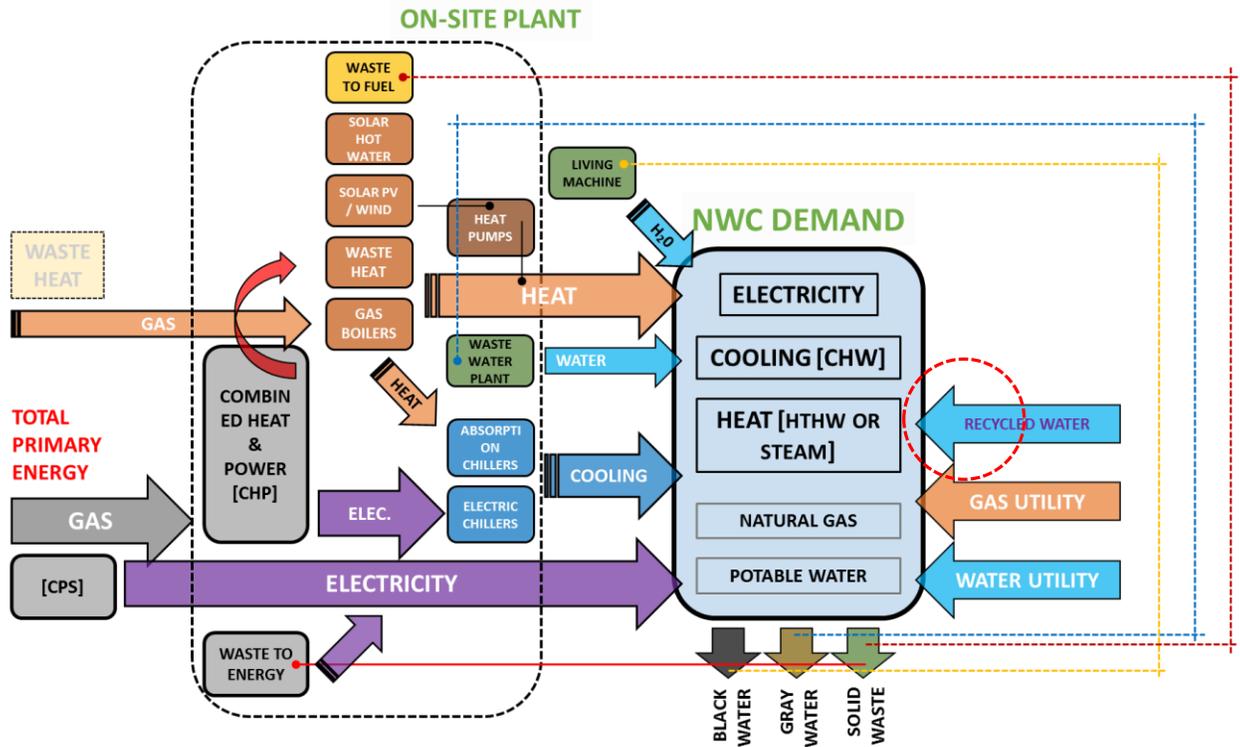
9.9 Water 3 – Denver Purple Pipe Network

Needless to say, water is a precious resource here in the West, much too precious to use just once. That’s why Denver Water has started a program to treat and recycle wastewater. Once build-out is complete, the project will supply more than five billion gallons of recycled water every year — water for irrigation, for industrial use, for lakes in our parks and for golf courses — water we don’t have to take from a reservoir.

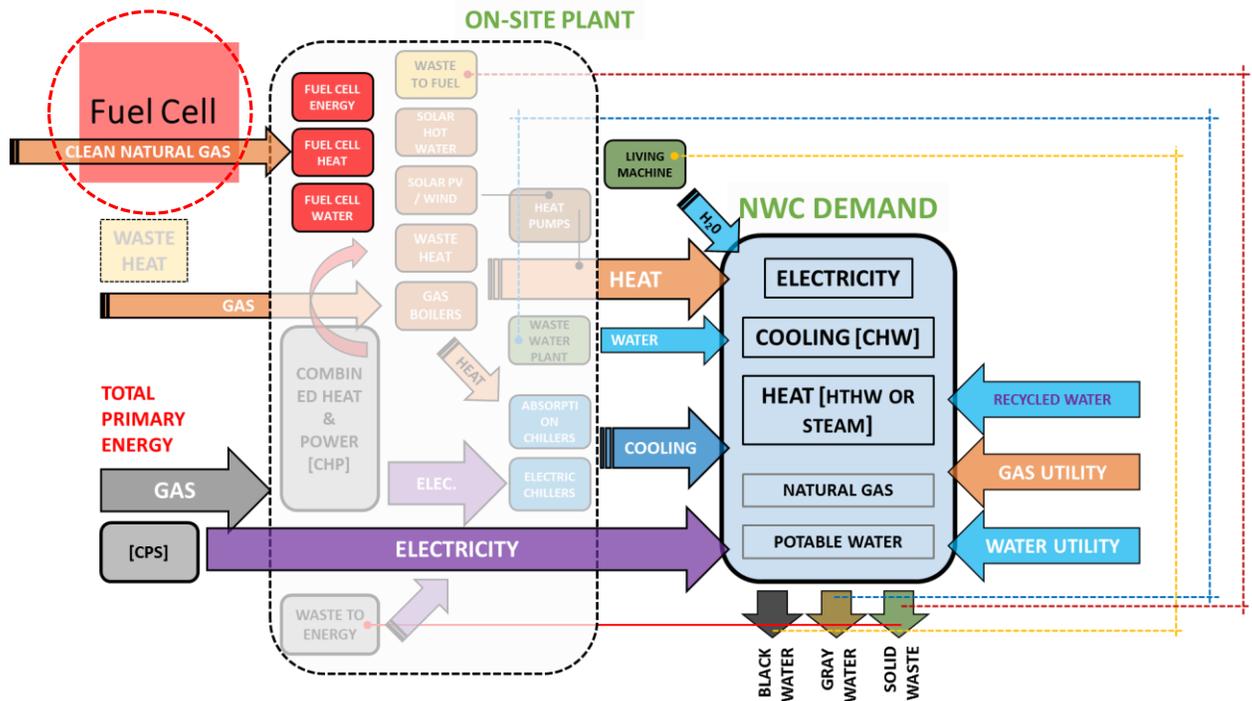


The Denver Zoo is among the many local organizations that are taking advantage of Denver Water's Purple Pipe recycled water distribution network to reduce their use of potable water for several uses on-site.

Similarly, NWC will need to engage with Denver Water to extend their distribution pipe to the site. Once built, NWC can look to use it not only for landscaping needs but also for cooling tower evaporation.



9.10 Fuel Cell Energy



When a hydrogen-rich fuel such as clean natural gas or renewable biogas enters the fuel cell stack, it reacts electrochemically with oxygen (i.e. ambient air) to produce electric current, heat and water. While a typical battery has a fixed supply of energy, fuel cells continuously generate electricity as long as fuel is supplied.

Fuel cell energy plants generate reliable power 24/7 while producing almost zero pollution or particulate matter. They have a wide variety of applications for commercial facilities and can offer economic as well as environmental advantages.

The electrical power output of the fuel cells can be used to provide base-load power for the NWC campus. However, fuel cell technology works most efficiently when implemented as part of a combined heat and power (CHP) application, where the thermal energy from the fuel cell exhaust is recovered and used to heat or cool district energy systems and commercial buildings as highlighted in Section 9. The CHP application can increase overall system efficiency and reduce carbon dioxide (CO₂) and other emissions by decreasing natural gas boiler operations.

Rethinking energy production at the grand scale has been the biggest challenge for eco-districts.

10.0 National Western Center Master Plan Phasing Overview – Locating the District Utility Center

PHASE I-NEIGHBORHOOD CONNECTIVITY, RIVER EDGE ACCESS AND STOCKYARDS

Facilities

- Stockyards Auction and Show Arenas
- Stockyards Event Pavilion/Outdoor Event Space

Streets

- 51st Avenue and river bridge
- 49th Avenue and river bridge
- National Western Drive (new)
- Rail Consolidation (off river)
- Temporary NWD connection from Bettie Cram Drive to 46th Avenue
- 49th Avenue between Brighton Blvd. and High Street

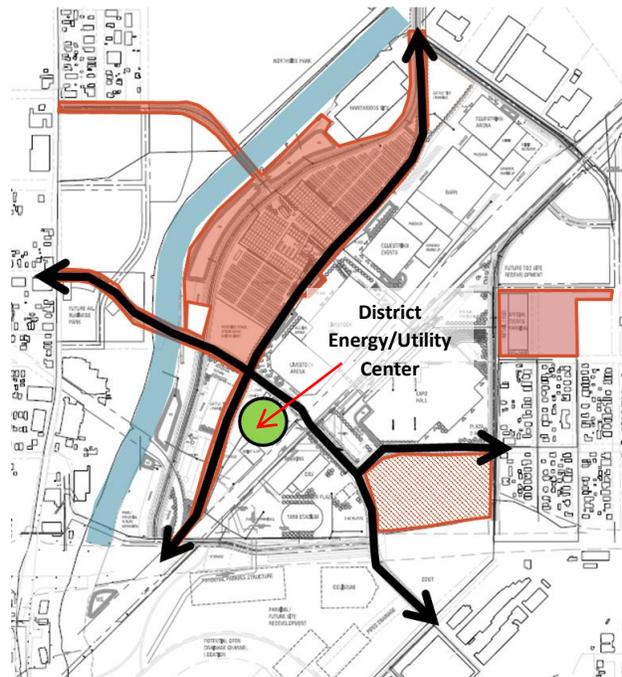
Other

- River edge on east side
- Property purchase and temporary surface parking at New Arena site
- New shared use/TOD parking structure at DPS site w/ retail TOD, Temp. NWC/CSU Welcome Center with interim surface parking
- Storm sewer improvements
- Bury Delgany Interceptors

Construction Duration

- 18-24 months

*CSU Water Resources Center could be built at any time. Earthwork and site prep would occur in Phase I



NATIONAL WESTERN CENTER

The *potential* location of the district energy / utility compound – on the southeast corner of proposed Bettie Cram Drive and National Western Drive/consolidated Rail Line was arrived at based on easy accessibility to/from main arterial roads, utility lines, anticipated functions in that triangular piece of land and after discussion with the various NWC stakeholders and partners. Location to be further vetted based on the components and size of utility center/compound.

PHASE 2-LIVESTOCK CENTER AND EQUESTRIAN CENTER

Facilities

- Livestock Stadium Arena
- Livestock Hall
- Equestrian Events Center
- Horse Barn
- Equestrian Arena
- CSU Equine Clinic
- Enclosed Equestrian Warm Up
- Covered Equestrian Warm up
- Maintenance Facility
- Cattle ties

Streets

- Elevated Walkway (NWD to RTD Station)
- Portion of Bettie Cram Drive to BNSF (Maintain access to new Stockyards during construction)
- Race Court
- Brighton Blvd., 44th to 50th

Other

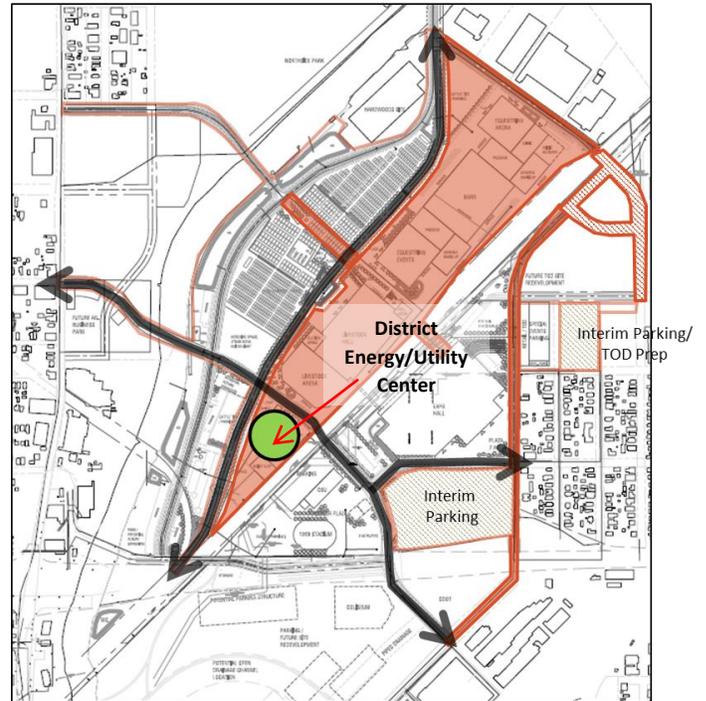
- Brighton/Race improvements could be a different phase
- Public Space at Livestock and Equestrian Centers (all or portions)

Construction Duration

- 24 to 30 months

*Phase can't start until stockyards is complete

*Building livestock facilities first could provide earlier access to Stadium Arena in Phase 3



NATIONAL WESTERN CENTER

PHASE 3-1909 STADIUM ARENA RESTORATION AND MARKET

Facilities

- Renovation of both interior and exterior of the 1909 Stadium Arena (CSU/Partner space, temporary use)

Streets

- None

Other

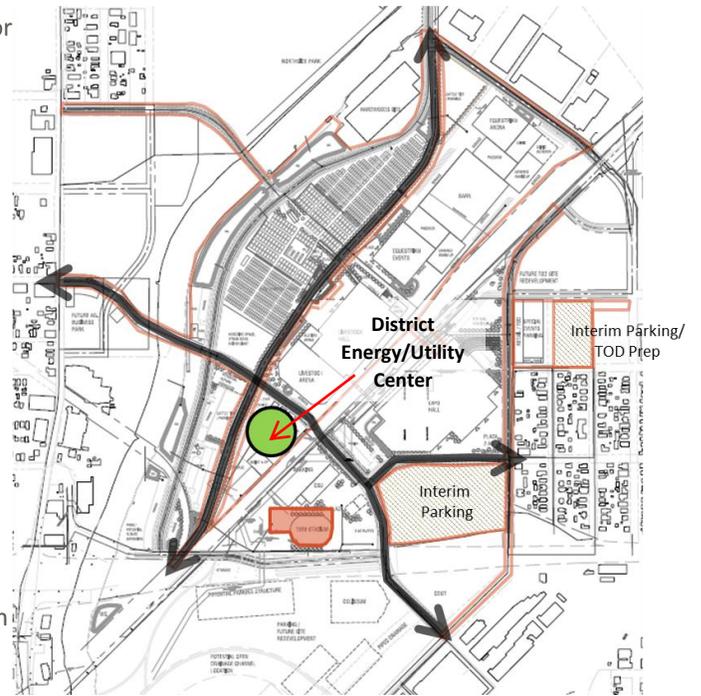
- Temporary enclosure of existing Expo Hall where connector building between Expo Hall and Stadium Arena is currently to be able to rehab the exterior of Stadium Arena

Construction Duration

- 18 to 24 months

*This phase could also occur in conjunction with Phase 6 .

*Phase can start as soon as new Livestock Center is complete.



NATIONAL WESTERN CENTER

PHASE 4-TRADE SHOW/EXPOSITION HALL

Facilities

- Trade Show Exhibition Hall
- Underground Parking
- Water Resources Center

Streets

- None

Other

- Public Space at Transit Station and Elyria Plaza

Construction Duration

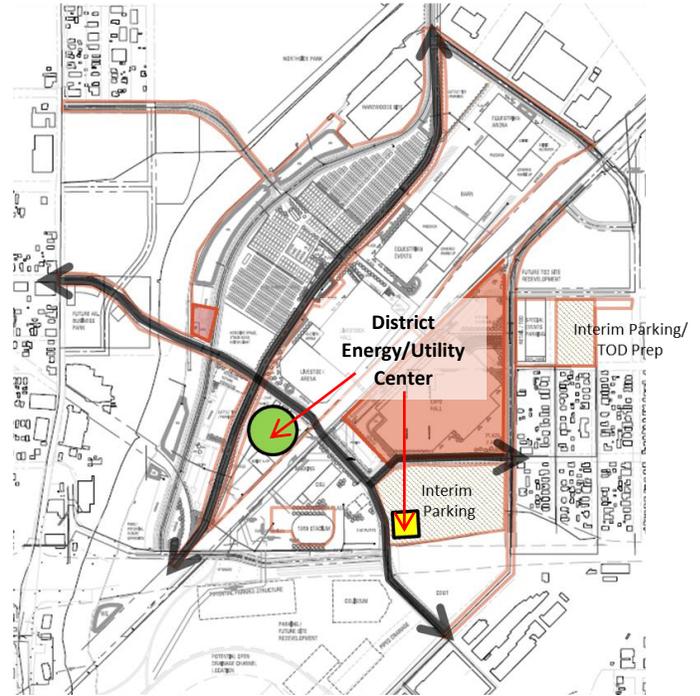
- 24-30 months

*Phase can't start until new Equestrian Center is complete.

*Southwest portion of parking structure can't be completed until existing Expo Hall is demolished.

*Need to maintain access to RTD Station during construction

*Demolition of Phase 6 existing buildings could occur at the end of this phase to speed up implementation of CSU Center.



NATIONAL WESTERN CENTER

A second smaller district energy/utility center to be developed during this phase to support additional phased build out of the Master Plan. Proposed location – on the east of Bettie Cram Drive; the site of the new arena (Phase 5). This energy/utility center will communicate and work synergistically with the first district plant using smart-grid principles – one that uses digital information and communications technology to gather and act on information – such as information about the behaviors of suppliers and consumers – in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of energy and water throughout the NWC campus.

PHASE 5-NEW ARENA

Facilities

- New Arena
- Portion of Trade Show/Exposition Hall

Streets

- Bettie Cram Drive completion
- 47th Avenue

Other

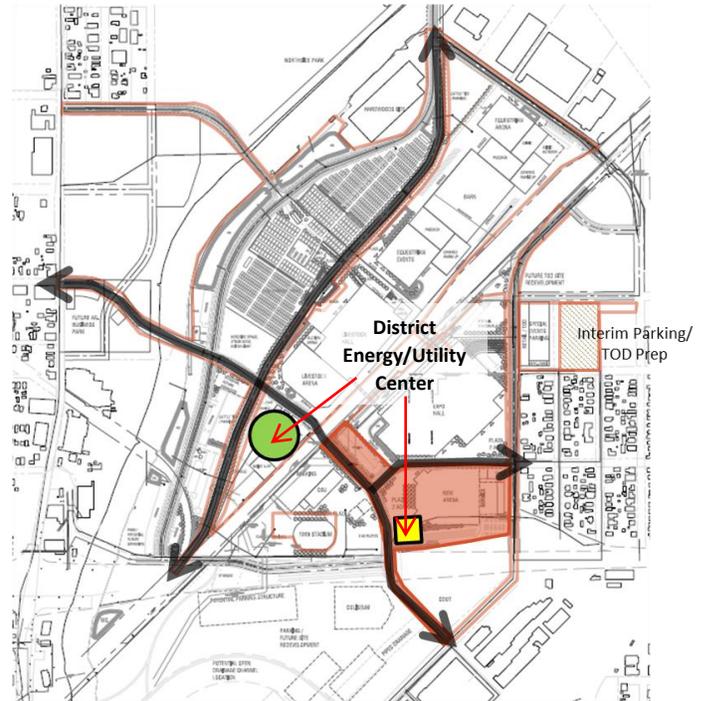
- Public Space at Exhibit Plaza

Construction Duration

- 24-30 months

*Phase could switch with Phase 4 except for Bettie Cram Drive.

*New Arena could start at any time after property purchase. Bettie Cram Drive would need to wait until Trade Show/Exposition Hall is complete.



NATIONAL WESTERN CENTER

PHASE 6-CSU CENTER and COLORADO COMMONS

Facilities

- CSU Center/Parking Structure
- Retail Pavilions

Streets

- 46th Avenue lowering and connection to Washington Street

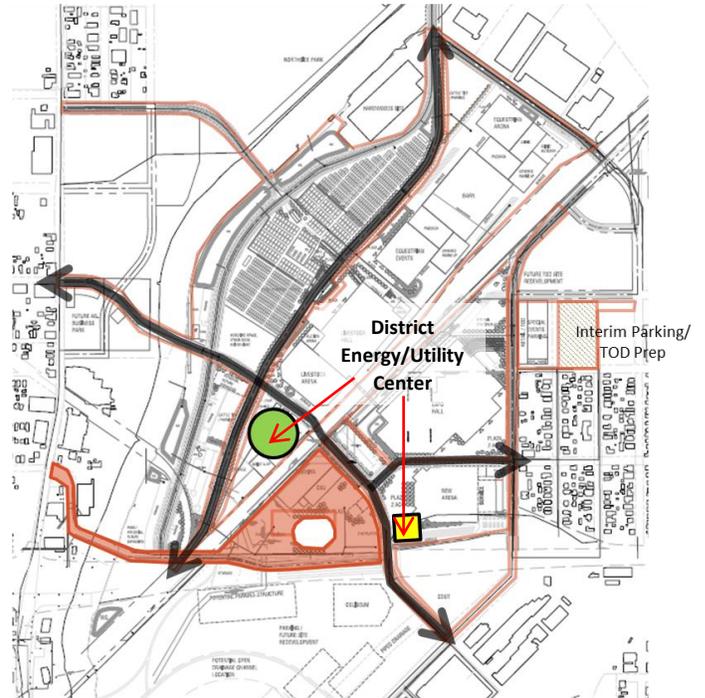
Other

- Colorado Commons
- Demonstration and Growing Plots/
Community Gardens

Construction Duration

- 18-24 months

*Phase can't start until new Trade Show/
Exhibition Hall is complete.



NATIONAL WESTERN CENTER

PHASE 7-RIVER FRONTAGE/NATIONAL WESTERN DRIVE

Facilities

- Future expansion and development

Streets

- Completion of National Western Drive

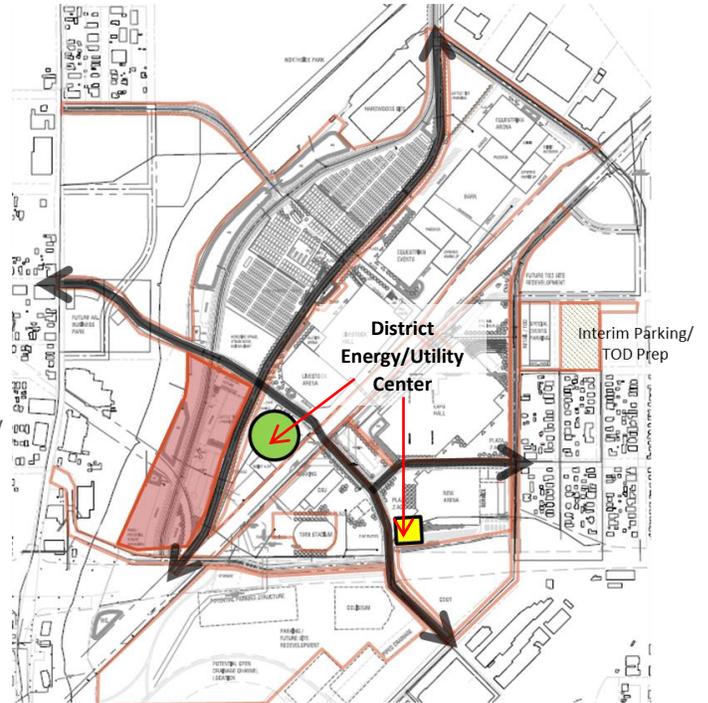
Other

- River frontage park
- New rail crossing at Jersey Cutoff

Construction Duration

- 16 months

*Phase can start at any time after property purchase.



NATIONAL WESTERN CENTER

PHASE 8-COLISEUM REDEVELOPMENT

Facilities

- Coliseum site redevelopment

Streets

- Arkins Court/McFarland Drive

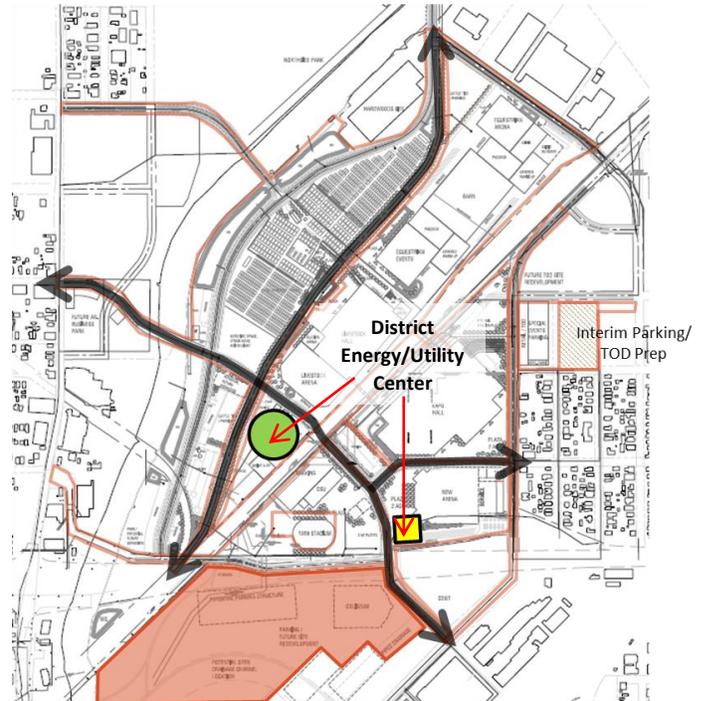
Other

- Globeville Landing Park

Construction Duration

- TBD

*Phase can't start until site remediation and New Arena are complete.



NATIONAL WESTERN CENTER

11.0 The Way Forward

Steps to develop the NWC District Energy System:

1. Assess (ideas and strategies)*
2. Facilitate (finance)
 - a. Cost benefit and payback analyses
3. Further develop
 - a. Multi-stakeholder coordination framework
4. Integrate
 - a. Into NWC Phasing
5. Map
 - a. NWC energy demand and evaluate local energy resources*
6. Determine
 - a. Relevant policy considerations
7. Carry out
 - a. Project feasibility analysis
8. Develop
 - a. The business plan
9. Analyze
 - a. Procurement options/network
10. Set (quantifiable, reportable and verifiable success indicators)

** Exercise and/or step completed*

These steps can be taken individually or packaged to meet specific NWC conditions and needs.

12.0 In Conclusion

Realizing the Vision

The NWC Master Plan sets forth a transformational vision for the future of the National Western Stock Show Complex and Denver Coliseum sites, which includes strategically aligned planning efforts with the other NDCC projects – Globeville, Elyria-Swansea neighborhoods, improvements within the RiNo neighborhood, RTD stations, I-70 east, and Brighton Boulevard, containing numerous recommendations aimed at achieving that vision for the NWC project and the broader Corridor of Opportunity. The Master Plan implementation will take place over a decade or more and will be the result of large and small actions by the public and private sectors, sometimes in partnership. It is understood that the future will bring unforeseen opportunities and challenges as the plan moves into implementation.

Comprehensive energy master planning provides the road map that will guide NWC in making the right decisions about maintaining and expanding NWC's campus infrastructure and controlling utility mix and demand. Implementing a robust comprehensive energy master plan will not only adhere to NWC's vision and guiding principles but also provide environmental compliance, energy efficiency, adequate capacity for growth, reliability, redundancy, flexibility, sustainable infrastructure and lowest life-cycle system cost for NWC and its partners.

This exercise suggests tangible ways to comply with the NWC Sustainability and Regeneration Framework and Goals of the Master Plan with district level ideas for energy, water and waste that can grow modularly and flexibly to support the needs of the campus for the next several decades in a climate-responsive and environmentally sustainable manner.

The NWC Partners through their Vision for the National Western Center Campus (NWCC) have the opportunity to be the clear champion to demonstrate how district level energy, water and waste solutions can contribute to local air pollution reductions, energy efficiency improvements, resilience and energy access, use of local and renewable resources, a green economy and greenhouse gas emissions reductions.



Appendix A

Brainstorming Session Notes (Tuesday, Feb 24, 2015)

- Public Outreach & Education & Environmental Stewardship
 - Composting on-site
 - Small %
- Site Constraints and Assessment
 - Tunnel construction
 - Railroad movement
- LEED Master site
 - Who takes ownership?
- Infrastructure
 - See Eric's email
 - Proposed
 - Layout in a tunnel system
- **Water [Opportunities]**
 - Rainwater collection?
 - Rainwater balanced budget
 - Measured by how much rainwater makes it onto site
 - Water treatment
 - Living machine (eco-machine)
 - Recycled water (purple pipe)
 - Treatment center just north of site
 - Connect with Denver Water
 - Capacity necessary (zoo example)
 - → piping strategies
 - Toilets on separate line, can use recycled water
 - Daylighting storm water
 - Augmentation agreement?
 - Metrics to "payback" water user
 - Storm water
 - No net impact on quality or quantity
 - Urban drainage pilot
 - Sterling Ranch rainwater
- **Water [Constraints]**
 - Water Rights and Water Laws
 - Who owns the water rights?
 - Denver Water authority → they own theirs
 - Animal waste run-off?
 - (most into bedding)
 - Can hold for 72 hours

- Work-arounds (water laws)
 - → pilot projects
 - → augmentations
- Gray Water
 - Water budget
- Waste water
- **Waste [Opportunities]**
 - Compost
 - In-place agreement currently
 - On-site opportunities?
 - Shavings
 - Wood for horse & livestock
 - Paper for smaller animals
 - [most out of Canada]
 - Procurement
 - Waste, materials, & resources
- **Water Sources**
 - Rain/snow
 - Stormwater
 - →purple pipe
 - X well water (to check Eric S.)
 - →potable water
 - Graywater
 - Waste water
- **Waste [Constraints]**
 - Compost
 - More than can be handled on-site
 - (particularly during stock show)
 - How much livestock activity throughout year?
 - Procurement
 - Of shavings, other things that will become waste
- **Energy [Opportunities]**
 - Central utility plant[s] to go along w/ phased development
 - Accounts for diversity
 - Communication between them
 - Microturbines
 - (River, w/in pipes?)
 - River as heat-rejection
 - *Army Corps study
 - Small-scale hydro
 - Solar
 - PV
 - CSP

- Thermal
- Wind
 - Horizontal
 - Vertical axis (Quantum product)
 - Denver metro
 - Wind capacity analysis?
- Closed-loop
 - GSHP
 - WSHP?
 -
- Whole campus wired for DC
 - Less transformation
 - Can have transformations right at plug loads
- CSP
 - Absorption cooling
- Early on
 - Switching away from Xcel electricity
 - Natural gas → microturbines
 - Co-gen
- Waste-to-energy
 - Talk to Denver Zoo
- **Energy [Constraints]**
 - Scheduling usage
 - What if everything is at full-capacity all at once?
 - Xcel jurisdiction
 - Collaboration with Xcel?
 -
- **Utility Compound (Energy Center)**
 - Inputs
 - Blackwater
 - Graywater
 - Electricity (Xcel)
 - Renewables
 - Wind
 - Hydro
 - Solar
 - Bio fuels
 - Fuel cells
 - Bio waste (gasified)
 - Outputs
 - TSE
 - CHW
 - HW

- Eco-machine
 - Electricity (power)

Appendix B

NWC Regeneration – Energy, Waste and Water Brainstorming Session Attendees

First brainstorming session, February 24, 2015

1. Chad Riley
2. Jenn Hillhouse, City & County of Denver (CCD)
3. Jocelyn Hittle, Colorado State University
4. Brian Dunbar, CSU Institute for the Built Environment
5. Eric Anderson, Parsons Brinkerhoff
6. Sonrisa Lucero, CCD Office of Sustainability
7. Laura Aldrete, Parsons Brinkerhoff
8. George Pond, Denver Zoo
9. Sarah Anderson, CCD Public Works
10. Celia VanDerLoop - CCD – Department of Environmental Health
11. Paul Andrews, National Western
12. Josh Radoff, YRG
13. Eric Shafran, CCD NDCC
14. Carol Dollard, CSU
15. Ron Rohr, National Western
16. Caitlin Anderson, ME Engineers
17. Mohit Mehta, ME Engineers

Second brainstorming session, May 22, 2015

1. John Lucero, CCD Office of Economic Development
2. Catherine Cox Blair, NRDC
3. Ron Rohr, National Western
4. Jocelyn Hittle, CSU
5. Celia VanDerLoop - CCD – Department of Environmental Health
6. Carol Dollard, CSU
7. Eric Shafran, CCD NDDCC
8. Sonrisa Lucero, CCD Office of Sustainability
9. Laura Aldrete, Parsons Brinkerhoff
10. Chad Riley
11. Josh Radoff, YRG
12. Jenn Hillhouse, City & County of Denver (CCD)
13. Brian Dunbar, CSU IBE
14. Kate Taft, CCD GS Strategic Initiatives
15. Sarah Anderson, CCD Public Works
16. George Pond, Denver Zoo
17. Caitlin Anderson, ME Engineers
18. Mohit Mehta, ME Engineers